ORAL AND DENTAL MANIFESTATIONS

OF

ADULT RHEUMATOID ARTHRITIS

A Clinical and Radiological Study

by

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OF

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ACKNOWLEDGEMENTS

George Washington is reputed to have advised: "Associate yourself with men of good quality if you esteem your own reputation: for 'tis better to be alone than in bad company". I could not possibly have carried out a study such as this had I been alone but fortunately neither could I have been associated with men of higher calibre during its completion than, in fact, I was.

It is a pleasure for me to record my gratitude to Professor T. C. White, Director of Dental Studies, Professor D. K. Mason, Professor of Oral Medicine and Professor J. C. MacDougall, Professor of Dental Surgery, who not only provided facilities but also were a constant source of assistance and encouragement.

All the patients described in this thesis were examined by me personally, and I have also reported all the radiographs taken of them. This would not have been possible had it not been for the kind and willing co-operation of Dr. W. N. Mason, Head of the X-ray Department in Glasgow Dental Hospital and School, and Dr. J. K. Davidson, Director of the Department of Radiodiagnosis in the Western Infirmary, Glasgow. Nevertheless the very high standard of radiography, to which I have become totally accustomed, was due to the skill, patience, tolerance and co-operation of Miss A. Carson, Superintendent Radiographer, Glasgow Dental Hospital and School and Miss J. O. S. McDermid, Deputy Superintendent Radiographer, Western Infirmary, Glasgow and their members of staff. In addition, their kindness to, and concern for, the patients I examined was heart-warming as, indeed, was that of the Sisters and Nurses of the Glasgow Dental Hospital and School and the Centre for Rheumatic Diseases Glasgow.

A great deal of background reading was necessary in the preparation of this thesis. In spite of prolonged harrassment the staffs of the libraries of Glasgow University Glasgow Dental Hospital and School, the Royal College of Physicians and Surgeons, Glasgow, and the British Dental Association, never complained and went to considerable trouble to obtain for me a variety of dental and medical literature some of which was very old and almost forgotten.

The preparation of this thesis may have been solely my responsibility but its presentation is the result of a number of happy associations. I thank most warmly Mrs. B. Fernie for typing assistance and Mr. John B. Davies, Senior Medical Photographer, Glasgow Dental Hospital and School, and each and every member of his staff for their painstaking care and patience in producing the illustrations. The help and advice of Miss Lois Young and of my wife, Isabel, were also valuable in this respect.

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To say thank you most sincerely to everyone I have mentioned, and to any I have inadvertently omitted, seems to me to be barely adequate in the circumstances. However, if, in the future, we are able to materially improve the well-being of this long-suffering, cheerful and co-operative section of our population, members of which I have examined in this study, I am certain we will all feel amply rewarded.

PREFACE

More than six years ago Professor D. K. Mason asked me to assist him in performing a number of sialographic examinations each week. One result of this was that I developed a deep curiosity about rheumatoid arthritis and associated diseases, with especial reference to their oral and dental manifestations. The search progressed from salivary glands to temporomandibular joints and into the mouth and was given a considerable forward surge by the installation of excellent equipment in the large, new extension of Glasgow Dental Hospital and School. As a result, five years study of salivary glands, and more than two years study of temporomandibular joints and teeth have led to some of the data, contained in this Thesis, being published, accepted for publication or presented at scientific meetings.

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disease in Sjøgren's syndrome (1971)
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Some methods of investigating salivary gland function (1967)
British Association of Oral Surgeons, Annual Conference (1967)
(with D. K. Mason)

Parotid salivary flow studies and sialography in patients with Sjogren's syndrome

International Association for Dental Research, British Division, 18th meeting (1970)

(with D. M. Chisholm)

GLOSSARY OF TERMS USED

Definitions

Focal Spot	Area on anode or target which is bombarded by a stream of electrons from the hot filament, or cathode, when the X-ray tube in in action.
Central Ray	X-rays are radiated in all directions from the focal spot. A circular hole in a screen of lead allows a cone of rays to emerge in the desired direction, the other rays being absorbed in the X-ray tube. Those X-rays travelling in exactly the centre of this cone constitute the central ray.
Sialography	Radiography of the major salivary glands whose duct systems have previously been outlined by a radiopaque contrast medium.
Hydrostatic	Of the equilibrium of liquids and the pressure exerted by liquids at rest.
Sialogram	Radiograph produced by sialography.
Tomogram	Radiograph produced by tomography.

Subluxation of the Temporomandibular Joint	Clinical:- Spontaneous, gradual and noticeable alteration of dental occlusion. Radiological:- Closed: Absence of the condylar head from the articular fossa when the teeth are in normal occlusion.. Open: Hypermobility of the condylar head associated with signs or symptoms of abnormality in the same joint.

Synonyms

Submandibular Gland	Submaxillary Gland
Articular Fossa	Mandibular Fossa; Glenoid Fossa
Medial Pterygoid	Internal Pterygoid
Lateral Pterygoid	External Pterygoid
X-ray	Roentgen ray
Radiology	Roentgenology
Radiologist	Roentgenologist
Radiography	Roentgenography
Radiography (verb)	X-ray; Roentgenograph
Radiography (noun)	Film; X-ray; Roentgenogram; Roentgenograph; Radiogram
Sialogram	Sialograph
Tomogram	Tomograph

Bisecting Angle Technique	Bisection of Angle Technique; Short Cone Technique
Paralleling Technique	Long Cone Paralleling Technique; Right Angle Technique; Long Cone Technique; Fitzgerald Technique

<u>Abbreviations</u>

KV	kilo-Volts or kilo-Voltage	
mAs	milli-ampere seconds	
mA	milli-amperes or milli-amperage	
mm.	millimetre	
cm.	centimetre	
"	inch	
χ^2	chi-squared	
N.S.	not significant	
A.P.	antero-posterior	in Volume II only
L.O.J.	lateral oblique jaw	in Volume II only

<u>Statistics</u>

I determined the significance of the results of the various examinations by the chi-squared test using a 2 x 2 contingency table, the Student's t test for paired variables or the Student's t test for unpaired variables, as and when appropriate, and described these results as:-

(i) not significant

(ii) almost, or slightly, significant ($p<0.05$ and $p<0.02$)

(iii) significant ($p<0.01$ and $p<0.005$)

or (iv) highly significant ($p<0.001$ and $p<0.0005$)

INTRODUCTION

Adult rheumatoid arthritis is a disease which remains shrouded in mystery at the present time. Probably, the oral and dental manifestations of this condition have been the least well studied and, consequently, are the most poorly understood. A number of studies on aspects of this topic have been under--taken in the past, but some of these are inconclusive while the evidence produced by others is conflicting. Many of the rheumatic diseases have not been considered at all and, even in those that have, no great attention has been paid to the validity of the methods of examination used. Certainly, no-one has ever considered all the features, of any of these systemic diseases, which would be of particular interest to the dental profession. I, therefore, considered that such a study could prove to be valuable and, in view of this absence of comprehen--sive knowledge, focused my attention on the most frequently occurring rheumatic disease, namely adult rheumatoid arthritis.

My first requirement was to establish the validity of these statements. Therefore, Section I of this thesis is devoted to this aspect of my study. It is divided into three chapters. The first is concerned with the vital functions of those structures I examined. It is, in other words, an exposition of basic anatomy and physiology and explains, by a consideration of the normal, the important part they play in routine day to day life. The second details the many and varied methods which have been used to obtain radiographs of the salivary glands, the temporomandibular joint and the teeth, and shows the absolute necessity of establishing sound and exact methods of completing these examinations. The third summarises the historical knowledge available of those rheumatic diseases with which I am, particularly, concerned and refers, especially, to previous accounts of their oral and dental complications.

A study such as this demands the co-operation of others interested in this field of medicine. The results of my work are meaningless unless certain background information, which they supplied, is fully understood. Section II consists, therefore, of one short explanatory chapter which describes, as briefly as possible, those procedures which must be completed before a diagnosis of one or other of the rheumatic diseases is reached and relates their relevance to my particular study. Details of ophthalmologic and oral examinations, which, although not immediately relevant to this work, have a bearing on it and are used in the diagnosis of Sjøgren's syndrome, are also included.

The methods I used and the results I obtained are divided into four discrete sections. The first considers the salivary glands, the second the temporomandibular joint, the third the mouth and teeth and the fourth related topics which show the need for continued study yet, also, provide substantial support for some of my earlier conclusions.

Section III considers the salivary glands and is divided into two chapters. The first of these details the materials and methods I used in their examination and analyses these methods in detail. The second, firstly, considers those changes demonstrable in salivary glands in a population suffering from rheumatoid arthritis, then details them more particularly by considering a group of patients with Sjøgren's syndrome, before differentiating between those patients who have Sjøgren's syndrome complicated by rheumatoid arthritis and those with sicca syndrome. The relative values of sialogr--aphy and salivary flow rate estimations in the detection of the salivary component of Sjøgren's syndrome are, in addition, compared.

Radiographic examination of the temporomandibular joint appears to be,largely, empirical. I considered it essential, therefore, to establish my own method of performing such examinations and, having done so, to analyse it critically. Chapter 7, the first chapter in section IV, is devoted entirely to this. Chapter 8 describes the materials and methods I used as a result of this preliminary work and, also, includes details of how I defined the terms "normal opening" and "subluxation", terms which have been subject to a variety of interpretation in the past. The final chapter in this section includes details of my results and a full discussion of them.

It was important to eliminate observer bias from this study and so a number of patients with primary osteoarthrosis were, also, examined. These results are included, not only because this group of patients proved to be extremely useful in the broad analysis, but also because, apparently, no-one has ever before considered whether or not the temporomandibular joint is involved in this process.

The dental study is confined to two chapters, which comprise section V, and which follow a similar pattern to those concerned with the salivary gland study. Chapter 10 details the materials and methods used, referring, especially, to some of a clinical nature not described before, and Chapter 11 includes all the results and discusses the need for general dental care in the United Kingdom. At no time, however, in this thesis is the question of treatment or treatment planning specifically considered.

Section VI is intentionally, if tersely, called Supplement. Psoriatic arthritis is a disease which has received scant attention in the dental literature. Therefore, reference is made to some of the findings I made, incidentally, as part of the main study, in the hope that they may add to this knowledge and provoke further study. I am continuing my own studies in the hope of producing information which may be readily and simply of use to clinicians in the future. An example of these is included in the concluding chapter, not only because it substantiates some of my results, but also because it succinctly explains a basis for this continuing work.

SECTION I

THE BACKGROUND

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CHAPTER 1

ESSENTIAL ANATOMY AND PHYSIOLOGY

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1.i) INTRODUCTION

A sound basic knowledge of the anatomy and physiology of any structures which are to be studied further is essential. Only with such knowledge can the changes wrought by disease be fully appreciated. The acquisition of this knowledge requires study but not research because the results of a wealth of research in these subjects are readily available in a large number of standard reference and text books. I have made free use of Brash's (1958) edition of Cunningham's Manual of Practical Anatomy, Davies' (1967) edition of Gray's Anatomy, Last's (1963) Regional and Applied Anatomy, the Physiology and Biochemistry of Bell, Davidson and Scarborough (1968) and McNaught and Callander's (1963) Illustrated Physiology. The dentally orientated works of Jenkins (1966), Scott and Symons (1971), Sicher (1966) and Wheeler (1969) have also proved valuable. Particular references are made to these works in addition to this general one. In addition reference is also made, where pertinent, to several highly regarded research workers who have made noteworthy contributions to the knowledge of these subjects in the periodic literature.

1.ii) THE SALIVARY GLANDS

The salivary glands are exocrine glands classified as compound merocrine in type. These compound tubulo-alveolar glands may have a secondary excretory function disposing of, for example, urea, nitrogen and creatinine in addition to their major secretory function. They produce and discharge complex substances such as mucin and salivary amylase (or ptyalin) which are not found in the circulating blood. The term applied to the accumulated secretory and excretory products which they discharge into the oral cavity is saliva.

Saliva has a number of functions including a buffering action, an antibacterial effect, a protective flushing of the teeth and mucous membranes, a reduction of the clotting time of blood, and, of course, the initial processes of digestion. It is a solvent which facilitates the stimulation of the organs of taste. Its fluid natures assists mastication and promotes speech. In addition ptyalin is responsible for the primary breakdown of carbohydrate and mucin, by counteracting dessication, aids the lubrication of each bolus and the action of swallowing. The salivary glands may also play a significant role in the metabolism of iodine and store "nerve growth factor" which affects the growth, and differentiation of the sympathetic nervous system. Krikos (1966) stated that they may be functionally interrelated with the sex organs, the thyroid gland and the hypophysis. The researches of the Japanese worker Ogata (1935) led to the isolation of the hormone parotin from animal salivary glands. Ito (1960) considered that this substance might enhance the calcification of dentine. Jenkins (1966) has described the work carried out in these fields pointing out that removal of the salivary glands does not affect the metabolism of thyroxine and diiodotyrosine nor reverse the effects of ingested parotin. He added that further study is needed including a comparison of the effects of parotin and extracts prepared in a similar way from other tissues.

Small salivary glands are found on the inside of the lips and cheeks, on the floor of the mouth, tongue and palate. In addition three large paired glands, the parotid, the submandibular (occasionally referred to as the submaxillary) and the sublingual glands are situated around the oral cavity (Figure 1) (T. & I. 1). Of these, the parotid, readily, and the submandibular glands may be delineated by special radiographical techniques. Occasionally, by chance, some or all of a sublingual gland may be seen on such a radiograph of a submandibular gland.

The parotid gland, which produces a purely serous secretion, is the largest of the salivary glands. Brash (1958) described the very irregular shape which this gland assumes in order to accommodate to its surroundings. It is wedged into a triangular hollow behind the ascending ramus of the mandible extending upwards to the external acoustic meatus, downwards below the angle of the mandible to overlap the carotid sheath, medially to the styloid process (that is, almost to the side of the pharynx) posteriorly to overlap the sterno-mastoid muscle and anteriorly for a variable distance over the masseter muscle. A portion of this facial process is usually more or less detached and is named the "accessory parotid gland" or "secondary parotid of Chievitz" (Chievitz, 1885). The gland and its relations are illustrated in Figures 1 to 4 (T. & I. 1 - 4). The gland is enclosed in an upward prolongation of the deep cervical fascia which is closely adherent to the superficial surface of the gland and is attached to the zygomatic arch. The fascia is thickened in part on the deep surface to form the stylo-mandibular ligament which extends from the lateral border of the styloid process to the posterior border of the mandible above the angle.

Different parts of the parotid gland are usually described separately for clarity. The superior surface, or glenoid lobe (Last, 1963) from which emerge the auriculo-temporal nerve and the superficial temporal vessels is wedged between the external acoustic meatus and the back of the temporomandibular joint. The lower extremity lies on the posterior belly of the digastric muscle between the angle of the mandible and the sterno-mastoid muscle. The cervical branch of the facial nerve and the two branches of the posterior facial vein emerge at the lower end which is separated from the submandibular gland only by the stylo-mandibular ligament. The superficial surface is flat and of irregular outline. It is covered by skin and superficial fascia which contains the facial branches of the great auricular nerve, the superficial parotid lymph glands and the posterior border of the platysma muscle (Davies, 1967). It extends upwards to the zygomatic arch, downwards below the angle of the mandible, backwards to overlap the anterior border of the sterno-mastoid muscle and forwards across the superficial surface of the masseter muscle. The antero-medial portion of the deep surface is highly concave as it clasps the posterior parts of the masseter muscle, the mandible and the medial pterygoid muscle whereas the postero-medial portion is very uneven being related to the mastoid process and the sterno-mastoid muscle and more deeply to the posterior belly of the digastric muscle, the stylo-hyoid muscle and the styloid process.

The secretions of the parotid gland are carried to the mouth through the Parotid Duct (Stensen's Duct*). This thick-walled tube is formed by the progressive union of the intralobular, intercalated and striated ducts, the interlobular and the lobar excretory ducts. It runs

* Niels Stensen (1638 to 1686), a Danish priest-physician, anatomist, physiologist and theologian.

forward across the masseter muscle from the anterior border of the gland. It lies below the accessory parotid at the level of the lobule of the ear. It turns sharply medially around the anterior border of the masseter muscle to pierce, in turn, the buccal pad of fat, the bucco-pharyngeal fascia, the buccinator muscle and the mucous membrane of the cheek before opening into the mouth on the apex of a little papilla opposite the crown of the second upper molar tooth.

A number of structures are contained within the gland. The important facial nerve divides into its terminal temporal, zygomatic, buccal, mandibular and cervical branches. Communicating branches are sent from the great auricular and auriculo-temporal nerves to the facial nerve. Small superficial and deep lymph nodes are found and the posterior facial vein and external carotid artery run through it. This artery divides into the maxillary artery, which leaves by the antero-medial surface, and the superficial temporal artery which gives off its transverse facial branch before ascending to appear at the upper limit of the gland.

The second largest salivary gland, the submandibular, almost fills the "digastric triangle". It is a mixed gland, although predominantly serous, lying partly between the mandible and hyoid bones and partly wedged between the mylo-hyoid muscle and the mandible under cover of that bone. Superiorly it reaches the mylo-hyoid line and below the posterior part of that line it is related to the mucous membrane of the floor of the mouth. Inferiorly it may overlap the bellies of the digastric muscle reaching, perhaps, to the level of the hyoid bone. Posteriorly it is separated from the parotid gland in the region of the angle of the mandible by fascia alone as previously described. Anteriorly it extends as far as a line between the mental foramina. The gland is partially enclosed in a sheath of cervical fascia which extends from the greater cornu of the hyoid bone to the lower border of the mandible and, deep to the main part of the gland, to the mylo-hyoid line.

The medial surface of the gland is by far its largest. It lies on the mylo-hyoid muscle anteriorly and further back on the hyo-glossus muscle; it is here that the upper part of the gland is related to the oral mucous membrane. The posterior end, indented by the facial artery, is related to the stylo-glossus muscle, the stylo-hyoid ligament and the glossopharyngeal nerve which separate it from the wall of the pharynx. The inferior border is related to both bellies of the digastric muscle and to the stylo-hyoid muscle. The lateral surface, smaller in area, is associated with the medial pterygoid muscle and the facial artery and, in front of these structures, the mandible below the mylo-hyoid line. The superficial infero-lateral surface is covered only by skin, superficial fascia containing the platysma muscle, and deep fascia.

Saliva passes from this gland through the Submandibular, or Wharton's * Duct, which, although much thinner than the parotid duct, is formed in similar fashion. It emerges from the medial surface of the gland to lie on the hyo-glossus muscle under cover of the mylo-hyoid muscle from which it is separated by a thin tongue-like process termed the "deep part of the submandibular gland". It passes forward onto the genio-glossus muscle coursing between it and the sublingual gland to its small oral orifice situated on the sublingual papilla. This papilla is a small elevation placed at the anterior end of the sublingual fold of oral mucous membrane. Garusi (1964) described a well defined sphincter of circular muscle fibres associated with this orifice which corresponds to the sphincter of the parotid duct which is in direct communication with fibres of the buccinator muscle according to Guerrier and Bolönyi (1948).

Apart from some lymph glands no structures lie within the submandibular gland. However, in addition to the facial artery and glossopharyngeal nerve a number of structures lie close to it. The important cervical branch of the facial nerve and the anterior facial vein are related to the infero-lateral surface. The deep lingual vein, hypoglossal nerve, submandibular ganglion and lingual nerve lie between the hyo-glossus muscle and the medial surface of the gland whilst the mylo-hyoid nerve and vessels

* Thomas Wharton (1614 to 1673), an English physician and anatomist.

and branches of the submental vessels separate this surface from the mylo-hyoid muscle.

A brief mention should be made of the smallest major salivary gland, the predominantly mucous sublingual gland. It is covered by the mucous membrane of the floor of the mouth which it raises in the form of the sublingual fold and it rests against the genio-glossus muscle medially and the deep surface of the mandible immediately lateral to the symphysis above the mylo-hyoid line. It is actually in contact with its fellow of the opposite side above the anterior border of the genio-glossus muscle. The mylo-hyoid muscle supports the gland. It does not have a main duct. Many, eight to twenty, small ducts open directly into the mouth on the summit of the sublingual fold. Some may open into the submandibular duct. Garusi (1964) mentioned that two of these ducts may be more pronounced than the others. The larger has been called Ductus Bartholini and the smaller Ductus Rivini.

The salivary glands receive an excellent blood supply from the neighbouring vessels. Thus the parotid gland is fed by the external carotid artery and those of its branches associated with the gland and is drained by the posterior facial and external jugular veins. Branches from the facial, lingual and submental arteries supply the submandibular gland and from the sublingual branch of the lingual artery and the submental artery the sublingual gland. Venous blood is drained from these two glands by the common facial vein, and the lingual and submental veins respectively.

These salivary glands are peculiar in the alimentary tract in that their secretion is controlled exclusively by nerves (Jenkins, 1966). Parasympathetic fibres are secretory and vasodilatory and sympathetic fibres are vasoconstrictor in their action. Krikos (1966) stated that there is uncertainty about whether these fibres have also some secretory function. In addition these glands receive a sensory nerve supply derived from nerve fibres arising in the Trigeminal Ganglion. The capsule of the parotid gland receives its nerve supply from a further source, the Great Auricular nerve. The parasympathetic supply to the parotid gland is derived centrally in the Inferior Salivary Nucleus and to the other major salivary glands in Superior Salivary Nucleus. The sympathetic supply to all these glands comes from the Superior Cervical Ganglion. I have tried to illustrate this complete nerve supply diagrammatically in Figure 5 (T. & I. 5).

1.iii) THE TEMPOROMANDIBULAR JOINT

The temporomandibular joint is one of the most frequently used human joints yet, as Uotila (1964) continued structurally and functionally it is also one of the most intricate. It is capable of two basic movements, rotation and gliding; in other words it is a ginglymo-arthrodial joint. As a result the mandible may be opened and closed, protruded and retruded, and moved from side to side. The joint is the articulation of the condyle of the mandible and the articular fossa and articular eminence of the squamous part of the temporal bone. It lies immediately in front of the external acoustic meatus in close relationship with the upper part of the parotid gland. It is a synovial joint complex in nature being divided into a larger upper and a lower compartment by an intervening fibro-cartilaginous articular disc. The joint and its immediate relations are illustrated in Figures 1 to 4 and 6 to 11 (T. & I. 1 - 4, 6 - 11).

The long axis of the mandibular condyle is set at right angles to the plane of the ascending ramus beyond which it projects slightly laterally and considerably medially (Figures 11 and 14) (T. &. I. 11 & 14). Its articulating surfaces, the upper and anterior, like the rest of the condyle, are markedly convex from before,back and slightly so from side to side (Figures 9 & 11) (T. & I. 9 & 11). The articular eminence which is the medial root of the zygomatic arch, on the other hand, although also markedly convex antero-posteriorly is slightly concave in its medio-lateral direction (Figure 10) (T. & I. 10). Posteriorly the eminence is continued into the articular fossa which is separated from the non-articular tympanic part of the temporal bone by the squamo-tympanic fissure (Figure 10) (T. & I. 10). This fissure is divided medially into the petro-squamous and petro-tympanic fissues by the interposition of the inferior edge of the tegmen tympani. Both articular surfaces are thickly covered by fibro-cartilage identical with that of the articular disc.

A loose fibrous capsule is attached superiorly to the temporal bone around the margins of its articular surface and inferiorly to the neck of the mandible. Laterally it is thickened into the temporomandibular ligament which extends from the zygoma and the tubercle of the root of the zygoma to the roughened lateral pole of the condyle and the lateral side of the neck of the condyle. Choukas and Sicher (1960) described this as the only true ligament of the joint. The capsule which is for the most part rather thin is lined by the synovial membrane which does not, however, extend onto the bony articular surfaces and is reflected onto the articular disc to cover its peripheral portion only. In addition to the capsule and temporomandibular ligament two accessory ligaments whose importance according to Shapiro (1950) has been overstressed also link the mandible and the cranium. The spheno-mandibular ligament is a long membranous ribbon extending from the spine of the sphenoid bone to the lingula and the lower border of the mandibular foramen. The stylo-mandibular ligament has already been described.

The oval articular disc, concave below, concave-convex above in order to mould upon the joint surfaces, is fused to the capsule anteriorly only. Medially and laterally it is attached to the poles of the condyle and posteriorly as Choukas and Sicher (1960) described it is continuous with a thick layer of vascular connective tissue which fuses with the capsule. It is thicker peripherally than centrally and indeed its centre is on occasion found to be perforated. Uotila (1964) indicated that neither blood vessels nor nerves are found in this thin centre.

The nerve supply to the joint capsule is derived posteriorly from the auriculo-temporal nerve and anteriorly by branches of the nerve to the masseter in the majority of cases and/or of the posterior deep temporal nerve (Thilander, 1961) and so largely satisfies Hilton's Law* (Last, 1963).

When the mouth is opened the condyle at first rotates about the articular disc. When the teeth are parted a few millimetres this movement in the lower compartment of the joint is accompanied by a forward gliding of the

* John Hilton (1805 to 1878) was a London surgeon who suggested that the motor nerve to a muscle tends to give a branch to the joint moved by the muscle and another branch to the skin over the joint.

articular disc and condyle on the superior articular surface. They finally take up a position below, or in front of, the articular tubercle. Closure is the reverse of this process. These movements probably occur around the mandibular foramen thereby protecting the inferior dental nerve and vessels from undue stretching (Brash, 1958). Protrusive and retrusive movements are chiefly confined to the upper compartment of the joint, side to side movements being unilateral expressions of these accompanied by a slight forward and outward or backward and inward movement of the "passive" condyle.

Only one of the muscles of mastication, the lateral pterygoid, is actually inserted into the joint and only the medial and superior part of its upper head is attached to the fused capsule and disc (Choukas and Sicher, 1960). This insertion is especially important in maintaining the stability of the mandible to the disc, and, during closure, holding their position relative to the posterior slope of the articular eminence. The muscles of mastication, the lateral pterygoid, medial pterygoid, masseter and temporalis, are aided in their actions by the muscles of the floor of the mouth and, indirectly, by the infra-hyoid muscles which are responsible for "fixing" the hyoid bone. These actions are illustrated in diagrammatic form in Figures 12 to 20 (T. & I. 12-20). Thus, when the lower jaw is depressed (Figures 12 to 14) (T. & I. 12-14) the lateral pterygoid muscles are assisted by the digastric, mylo-hyoid, genio-hyoid, stylo-hyoid and even the platysma muscles. Last (1963) pointed out that the last four named muscles are, however, only of value during very forced movements. Freese and Scheman (1962) considered that gravity also aided depression but most authorities appear to agree with Copland (1960) that this is not in fact the case. Elevation of the mandible (Figures 15 and 16) (T. & I. 15 & 16) is a function of the masseter, temporalis and medial pterygoid muscles. Protrusion (Figures 17 to 19) (T. & I. 17-19) is probably the duty of the pterygoid muscles although Brash (1958) and Shapiro (1950) also attribute some of this function to the superficial fibres of the masseter muscle. Last (1963) described the posterior fibres of the temporalis muscle as those responsible for retrusion to which Brash (1958) and Shapiro (1950) added the deep fibres of the masseter muscle (Figure 20) (T. & I. 20). Davies (1967) agreed with Last but added that the middle and deep fibres of the masseter muscle and the digastric and genio-hyoid muscles may be of assistance in forcible retrusion. Side to side movements occur when unilateral protrusion and retrusion alternate, the most important muscles being the pterygoid muscles which also produce the necessary inward pull on the mandible.

1.iv) THE TEETH

The mouth is constructed to take in food and prepare it for swallowing. The principle action of the incisor teeth is to cut the food being eaten while the more powerful canine teeth are suitable for any tearing which may be necessary. The premolars and molars grind and macerate the ingested mouthful. During this masticatory activity saliva is mixed with the food moistening it and binding it into a bolus which is then swallowed.

The human dentition is not specialized for any particular diet. It copes equally well with fleshy meat and vegetable fibres. In other words human teeth and masticatory movements are adapted for an omnivorous diet. The canine is still present, unlike herbivora, but is short and so permits lateral jaw movements, unlike carnivora.

Each human normally has two sets of teeth. The deciduous teeth appear progressively between the ages of about six months and twenty-four months. The deciduous dentition finally consists only of two incisors, one canine and two molars in each quadrant as shown in Figures 21 and 22 (T. & I. 21 & 22). With this limited dentition the child learns the muscular movements associated with efficient mastication. As the diet becomes more varied and tougher and as the muscles of mastication and the jaws increase in power it requires to be and is replaced and added to by the stronger and more extensive permanent dentition. The permanent incisore, canines and premolars which erupt between the ages of seven years and twelve years replace the deciduous teeth and the permanent molars which appear during the sixth year of life and between the ages of about twelve years and twenty-one years add to the deciduous dentition. This finally results in a permanent dentition of thirty-two teeth, there being two incisors, one canine, two premolars and three molars in each quadrant as illustrated in Figures 23 and 24 (T. & I. 23 & 24).

Newly erupted teeth exhibit a complicated but characteristic arrangement of cusps and ridges, pits and fissures. These play a very important part in establishing occlusal inter-relationships in the developing jaws and in determining future patterns of masticatory movements during the period of facial growth. A levelling of the more prominent aspects of the occlusal surfaces occurs with use and this permits greater freedom in lateral masticatory movements as one grows older.

The form and alignment of the teeth is also important in the protection of their investing tissues. Wheeler (1969) indicated that this protection is further assisted by normal development of the dental arches and by the carect relationship of the teeth to each other during functional movements. Thus the original morphology of teeth assumes an added importance. The normal relationship of one tooth to another, in addition to initiating the complex process of digestion, plays an important part in the formation of certain sounds. The teeth are, therefore, essential in the production of normal speech.

The bulk of each tooth is composed of dentine. It is of mesodermal origin and is in some respects similar to bone. It is, however, harder and cannot be repaired. A loose connective tissue richly supplied with nerves and blood vessels which enter through a foramen at the apex of root lies centrally within the dentine. If this pulp tissue is in danger of exposure to external influences it may be defended by a blocking off of dentinal tubules and by further depositions of dentine on the threatened surface. Coronally the dentine is covered by enamel, the hardest and most highly calcified tissue in the body. It is of ectodermal origin. It can neither be repaired nor added to during life as those cells responsible for its formation disappear from its surface following eruption. Cementum surrounds the root portion of each tooth. It is the dental tissue which most closely resembles bone. It is of mesodermal origin and has limited powers of repair but differs from bone in not being subject to a continuous process of internal reconstruction although constant additions are made to its outer surface. The fibres of the periodontal membrane which retain each tooth in its socket of alveolar bone are attached by the cementum. Jenkins (1966) described in detail how this arrangement permits slight movement of each tooth during function.

The maxillary teeth are supplied by the superior dental branches of the maxillary nerves, the mandibular teeth by the inferior dental branches of the mandibular nerves. The upper anterior teeth derive their blood supply from the anterior superior dental branches of the infra-orbital artery. The upper posterior teeth and the lower teeth are also supplied by branches of the maxillary artery, the posterior superior and inferior dental arteries respectively. Venous drainage is accomplished by the accompanying veins.

CHAPTER 2

RADIOGRAPHY

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2.i) INTRODUCTION

In November 1895, Wilhelm Konrad Röntgen, Professor of Physics at the German University of Würzburg, discovered a new kind of rays which he called "X-rays".

This discovery was one of the results of an era of intense scientific research. Michael Faraday, a British chemist and physicist, and Joseph Henry, an American physicist, continuing the studies of eighteenth and early nineteenth century scientists discovered, quite independently in 1831, electromagnetic induction. This discovery led to the construction of the induction coil and apparati utilized to generate currents of great potential. It is of interest to relate that Faraday introduced the now familiar terms "anode" and "cathode", "electrolyte", "electrode", "ion", "anion" and "cation" seven years after this discovery.

The association of Plücker, Geissler and Hittorf proved to be a fruitful one especially during the years 1850 to 1875. The invention of mercurial air pumps in 1850 enabled higher degrees of vacuum to be obtained than was possible hitherto. Professor Julius Plücker, a German physicist and methematician, observed green-glass fluorescence opposite the negative electrode in such a vacuum tube later that year. About ten years later he instructed Heinrich Geissler, a gifted instrument maker and inventor, in the development of the vacuum tube later to be called the Geissler tube after its manufacturer. The phenomenon of luminosity accompanying the discharge of electricity through various rarefied gases was demonstrated using such tubes. Plücker's pupil Johann Wilhelm Hittorf, who also became a Professor of Physics, observed in 1869, the year following his master's death, many of the properties of cathode rays.

William Crookes, whose contributions to science were recognised by his being knighted in 1897 and awarded the Order of Merit in 1910, was another pioneer of the work which led to Röntgen's discovery. Unaware of Hittorf's work he, too, discovered and experimented with cathode rays. In 1879 he developed the most perfect vacuum tube then known and discovered that cathode rays could be deflected by a magnet. It was in fact the result of an experiment with cathode rays when Röntgen observed the production of a bright fluorescence of some barium platinocyanide crystals lying some distance from a Crookes-Hittorf tube which proved to be the basis of his monumental discovery.

Since that time research in this field has prospered and no disrespect is intended if only the manufacture of the Coolidge Tube and the construction of oil-immersed shockproof high tension generators with enclosed Coolidge tubes are additionally mentioned. W. D. Coolidge, in 1913, built the first successful X-ray tube with a hot filament and a tungsten target while working for the General Electric Company in Schenectady, New York, and H. J. Waite improved the apparatus six years later. Today's tubes are basically Coolidge Tubes.

Dentists in Europe and the United States of America were quick to realise the potential of Röntgen's discovery. Dr. Otto Walkoff of Braunschweig, Germany completed the first dental radiograph in December 1895 (Ennis, Berry and Phillips, 1967). This radiograph was of his own mouth and was the result of a most hazardous exposure lasting twenty-five minutes. McCoy (1918) and Raper (1923) credit Dr. C. Edmund Kells of the United States of America with producing the first intra-oral radiograph in 1896, whereas Glasser (1961), a most interesting and reliable historian of radiography and radiology, credits W. König in Europe and W. J. Morton across the Atlantic with this distinction. Kells certainly appears to have been the first dentist to advocate the use of routine radiography in dental practice (McCall and Wald, 1957). The fact that papers, many of which were illustrated, were published in the English language dental literature by Benedict, Cattell, Clark, who introduced dental radiography to this country, Gish, Harrison, Hill and McLean, Kells, Morton, Perry, Rollins, Smith, Van Rensselaer and Whimsey during 1896 on aspects of radiography and radiology is emphatic evidence of the enormous interest which was immediately generated in these subjects within the dental profession in many countries of the world.

The radiographic techniques which I used in this study were introduced and developed throughout the years which have passed since that time.

2.ii) THE SALIVARY GLANDS

Arcelin (1912) was probably the first clinician to attempt sialography. Shortly before the Great War he injected a Wharton's duct with bismuth in order to demonstrate a salivary calculus. Charpy (1900), however, who illustrated his text-book with a magnificant reproduction of an early radiograph of an isolated parotid gland into which mercury had been injected (Figure 25) (T. & I. 25) could fairly be described the father of sialography. The clinical potential of this examination was, nonetheless, not realised until Sicard and Forestier (1921 and 1922) demonstrated the use of iodized oil as a satisfactory contrast medium. More than three years later Barsony (1925), Carlsten (1926) and Uslenghi (1925) independently claimed that they had completed the first successful parotid sialograms. Carlsten used the iodized oil Lipiodol whereas Barsony injected very irritant 20 percent Potassium Iodide, a factor which may have delayed, in some quarters at least, the immediate advancement of the technique (Ollerenshaw and Rose, 1957). Wiškovský (1926) became the first to successfully complete a submandibular sialogram and about the same time Jacobivici, Popolitza and Albu (1926) and Keith (1928) reported further examples of sialography. In this country, however, the technique only became generally accepted after Payne (1931) published the first of his classical papers on the subject.

Gullmo and Böök-Hederström (1958) suggested that contrast media should not be injected into salivary glands but should be allowed to run in under hydrostatic pressure. This was a major change in a technique which had altered little in thirty years. During the intervening period Rocchi (1930) and Blady and Hocker (1938) had attempted to determine exactly how much contrast medium should be used to fill each individual gland; Magnoni and Cristiani (1940) showed that iodised oils could have in their own right a beneficial therapeutic value which Bataille (1951) considered might be augmented by the addition of an antiseptic - "Un lipiodol goménolé à 5p 100 de goménolé"; Londe and Pelz (1933) and Pearson (1935) used the technique successfully in the examination of children.

Gullmo and Böök-Hederström (1958) continued to insert blunted metal needles into the ducts of the glands being examined in the fashion of the majority of workers before, and after, them. Payne (1931) used glass cannulae and Carlsten (1926) and Putney and Shapiro (1950) rubber catheters. Eckart-Mobius (1957), Rubin and his colleagues Blatt, Besse and Holt (1955 and 1957) and Hettler and Louth (1961) improved on these by advocating the use of polyethylene catheters. Liverud (1959) described such a catheter in detail and further suggested that a black nylon suture or fine horse hair could be used to guide very fine catheters. Five years later Drevattne and Stiris (1964) combined the ideas of Gullmo and Böök-Hederström (1958) and Liverud (1959). The modification of their method described by Park and Mason (1966) is fundamentally the one I have used in this study.

A further significant advance was the concept of "secretary sialography" introduced by Rubin, Blatt, Holt and Maxwell (1955). They recommended that additional radiographs should be exposed five minutes after the completion of sialography. If a contrast medium of low viscosity and surface tension had been used and thereafter salivary flow stimulated detection of any residual dye on these later radiographs indicated a pathological lesion.

Several of these new techniques demanded contrast media of lower viscosity than the iodized oils in general use at the time of their introduction but also, simultaneously, overcame the objection of Rose (1950) to water soluble contrast media that they escaped from the glands being examined before the essential radiography could be completed. The irritability of the earlier water soluble contrast media was eliminated with the introduction of the tri-iodinated compounds (Garusi, 1964). Trester (1968) published a pertinent review of the development of the various contrast media used in sialography. Although hand injection techniques and liposoluble contrast media have been widely employed in the last decade (Eisenbud and Cranin, 1963; Verstraeten, 1963; Cook and Pollack, 1966; Einstein, 1966; Osmer and Pleasants, 1966; White, 1966; Carlin and Seldin, 1967; Fast and Forest, 1968; Sazmová, 1969 and Mandel and Baurmash, 1971) the use of water soluble contrast media is recommended in the light of reports of adverse effects of the oil-based dyes. Their prolonged retention within successfully examined salivary duct systems has for long been recognised (Magnoni, 1937), the only controversy being in fact how long this retention lasted. It has been claimed that it is as short as ten to fifteen minutes (Gauwerky, 1957) or three to four hours (Leroux, 1948) or as long as forty-eight hours (Putney and Shapiro, 1950). It had been claimed that an advantage of this retention was that more than sufficient time for any radiography required was permitted (Rose, 1950 and Ollerenshaw and Rose, 1957); Epsteen and Bendix (1954), however, reported a marked foreign body reaction within the substance of salivary glands following the use of liposoluble contrast media. Marked granulomatous changes and prolonged retention of such dyes in the soft tissues of the mouth following their accidental deposition there have been described by Mandel and Baurmash (1962) and Douglas (1956) respectively. Moreover, more recently Lilly, Cutcher and Steiner (1968) detailed the ill effects of some of the oily contrast media used in experimental studies with dogs.

2.iii) THE TEMPOROMANDIBULAR JOINT

Although Dr. M. H. Cryer (1905) reported to the Fourth International Dental Congress held in August, 1904 that "the movement of the condyloid process within the glenoid fossa and its relation to the eminentia articularis ...... can be studied fairly well by the ordinary X-ray" a large number of different methods have been introduced since then in an attempt to produce radiographs which are satisfactory with reference to the diagnosis of changes both of structure and of function of the temporomandibular joint. It has, in fact, proved to be extremely difficult to produce such radiographs even at the present time, a difficulty aggravated both by the form and position of the joint (Uotila, 1964).

Smith and Harris (1970) summarised those methods in common use at the present time. Postero-anterior views include the Occipito-mental Projection and the Reverse Towne's Projection. The Trans-orbital View is an oblique antero-posterior view and the Transpharyngeal and Transcranio-oblique Projections are both lateral projections. Ortho-pantomography and Tomography are also useful techniques. Uotila (1964) in addition mentioned Arthrography (Norgaard, 1947) and Cinefluorography, a method first discussed by Klatsky (1939) shortly before the Second World War, considered further by Berry and Hofman (1956) who intensified the image one thousand times and Lindblom (1960), and described in great detail by Lundberg (1963). This cineradiographic technique has in-built limitations as does the use of contrast media injected into joint spaces.

Artur Schüller (Leidler and Schüller, 1910) a Viennese neurologist and Professor A. Cieszyński (1911-12) a Polish dentist would appear to have been the first to attempt to radiograph the temporomandibular joint rationally. Both devoted sections of their text-books (Schüller, 1912; Cieszyński, 1913) to the subject shortly after the publication of their original descriptions. Unfortunately the joint and the cervical spine were superimposed on radiographs produced by Cieszyński's lateral oblique projection and future developments were primarily based on Schüller's (Leidler and Schüller, 1910) and Pirie's (1912-13) techniques of radiographing the mastoid air sinuses. Law (1917) continued this work. A slight alteration of the centring of the tube brought the temporomandibular joint onto the radiograph. Granger (1924) probably presented the earliest demonstration of the use of an "angle board", a device commonly used at the present time as an accessory in temporomandibular joint radiography, although Granger, also, introduced it as a means of facilitating mastoid radiography.

Gillis (1935) and Riesner (1936) described early lateral oblique projections of the temporomandibular joint only to be criticised by Lindblom (1936) either because he disagreed with the angulation of the central ray or because the patient's head and neck were not held erect. Higley (1936 A.B.) recognised the need for a repeatable technique and devised one the value of which was substantiated by Speidel and Maxon (1939). Prior to this time Pordes (1916), Bullitt (1926), Zanelli (1929), Leman (1932), Parma (1932), Sproull (1933) and Steinhardt (1934) had contributed to the thinking on this difficult radiographic problem.

Many of these thoughts were at variance and such variety continued to be contributed to the literature with the result that at least eight basic lateral or lateral oblique jaw views of the temporomandibular joint evolved. Briefly these, together with their earlier advocates, are:-

1) Central ray directed through the contra-lateral condyle. Parma (1932) described such a projection;

2) Central ray directed obliquely downwards above the contra-lateral condyle. This technique which is used fairly widely at the present time and is well described by Smith and Harris (1970) appears to have been originally advocated by Gillis (1939);

3) Five methods use the external acoustic meatus

of the side opposite that of the joint being radiographed as the reference point:

(i) Central ray directed obliquely downwards and backwards by centring the tube above and in front of this landmark; Gillis (1935), Beckwith (1940), McCall and Wald (1940) and Perkins (1955);

(ii) The tube is directed towards the condyle from above the reference point; modifications of this method have been described fairly frequently following Sproull's (1933) article; later authors include Abt (1943), Stockard (1950), Ferro (1952), Fuchs (1953), Grewcock (1953) and Richards and Alling (1955);

(iii) Central ray directed obliquely downwards and forwards; Ernst and Costen (1938), Schier (1943), Craddock (1953), Grant and Lanting (1953), Donovan (1954, Brandrup-Wognsen (1955) and Lawther (1956) have all used similar angulations to those described by Bullitt (1926), Zanelli (1929)and Lindblom (1936);

(iv) Central ray directed obliquely upwards and forwards; Leman (1932) would appear to have been the originator of this rarely described technique;

(v) The central ray is directed through a point in front of and below the external acoustic meatus upwards, or horizontally, and backwards towards the joint being examined; Steinhardt (1934) and Ennis and Berry (1959) followed Pordes (1916) very early attempt to obtain an unobstructed radiograph;

4) Altschul (1927) probably recognising the difficulty of radiographing a structure lying close to the dense bony structures of the middle and internal ear and the base of the middle fossa of the cranial cavity, as Bishop (1929) later described, introduced a further technique not dissimilar to the last-mentioned. He suggested by-passing these obstructions by directing the rays, from a tube placed close to the face, through the sigmoid notch. McQueen (1937) and Toller (1969) further described the scope and value of this Transpharyngeal Projection.

As these varied techniques were presented the controversy about whether the head need be held erect or not if accurate radiographs were to be produced continued and further angle-board devices were described by Maves (1938), Updegarve (1950 and 1953) and Spear and Grayson (1952)

The Trans-orbital anter-posterior view has been developed from a technique introduced by Zimmer (1941).

The other antero-posterior view sometimes used is well described by Caldwell and Schrieber (1964) who called it the "versatile Chamberlain-Towne Projection" thereby acknowledging radiologist Dr. W. E. Chamberlain in addition to his surgical colleague E. B. Towne who is frequently given sole credit for its development. The Reverse Towne's Projection is a postero-anterior reversal of this projection usually called the Towne's (1926) projection. The other commonly described postero-anterior view is the Occipito-mental although the merits of the Verto-occipito-mental and Occipito-frontal views have been proclaimed by Schier (1962) and Clarke (1964) respectively.

Tomography has for some time been considered to be potentially the best method for radiographing the temporomandibular joint as this technique excludes everything from the final film except the object or plane at the centre of the field. I have assessed the value of these methods as part of this study and therefore feel that it is pertinent to outline the development of Tomography and Orthopantomography in slightly greater detail.

Bocage (1922) and Ziedes des Plantes (1931) both claimed that they invented techniques in 1921 whereby radiographs of plane sections of solid objects could be made. Portes and Chausse (1922) and Pohl (1927) followed Bocage's example and were granted patents but Vallebona

(1930) was actually the first to publish on the subject calling his technique "stratigraphy". Ziedes des Plantes (1932) introduced the name "planigraphy", Grossman (1935) "tomography" and Kieffer (1938) "laminagraphy" in further early papers. Chaoul (1935) discussed the value of the technique in the diagnosis of lung disease and Moore (1938) and especially Andrews (Andrews, 1936 and Andrews and Stava, 1937) who described the early history of the technique also made valuable contributions. Buffé (1937) was probably the first to foresee the worth of tomography in the study of the temporomandibular joint. Petrilli and Gurley (1939) an apt partnership of radiologist and dentist published an extensive paper on the subject. Gough (1944) used tomography to aid the diagnosis in cases of ankylosis and trauma to the temporomandibular joint and Ricketts (1950 and 1953) also advocated the use of the technique applying it especially in the field of orthodontics.

The work of Grossman (1935) who considered how the new techniques might be applied to curved surfaces and of Olsson (1942) who pioneered rotational tomography are of especial interest as they formed the basis of Paatero's work on the Orthopantomograph. Paatero first published his thoughts on "panoramic tomography" in 1949 and applied to patent the principle of "pantomography" in 1950. His early techniques used a stationary tube and revolving patients and films but his later technique involved movement of the tube and the film. His first results on the use of this technique of"orthopantomography" were published in 1958, dry skulls having been the subject of his investigations. The following year (Paatero, 1959) he reported on the clinical potential of the method. A diagrammatic representation of the principles of tomography based on Paatero's orthopantomography is illustrated in Figures 26 to 29 (T. & I. 26 - 29).

This technique records on one film both jaws from mandibular condyle to mandibular condyle. Two other tomographic techniques were developed about the same time with similar aims. The Rotagraph was modified by Blackman (1956 and 1960) as a result of Paatero's (1949 and 1954) early work and the Panorex was introduced by Hudson, Kumpula and Dickson (1957) and modified four years later (Kumpula, 1961). In addition Blackman (1960 and 1961) advanced the Panoral intra-oral technique of radiographing the tooth-bearing area of one jaw or the other. This technique was pioneered in Switzerland by Dr. Walter Ott in Berne. Updegarve (1963) has described and compared these techniques in a most interesting manner.

2.iv) THE TEETH

The anatomic variations encountered in different parts of the mouth present difficulties if a faithful reproduction of any tooth together with the tissues immediately surrounding it is required on a radiograph. Dr. Weston A. Price (1904) recognised this when he stated "the correct image can be secured in two ways, by holding the film away from the crowns of the teeth the same distance that it is away from the roots or by raising the source of the rays." He noted that the shape of the arch made the former method extremely difficult except in the lower premolar and molar regions and then stated that the source of the rays should be raised so that the rays were "directed at right angles to a plane half way between that of the long axis of the teeth and of the film" if the latter method was used. Thus at this early stage in the life of dental radiography the bases of the two techniques of intra-oral periapical dental radiography - the Long Cone Paralleling and Bisecting Angle techniques (Figure 30) (T. & I. 30) - used at the present time were laid.

(a) <u>The Bisecting Angle Technique</u>

Three years after Price's article Professor A. Cieszyński (1907A) of the Johann Casimir Universität, Lwów, Poland, and already mentioned in the immediately preceding section, introduced his principle "Isometrieregel von Cieszyński". Unfortunately this was translated into English as "The Rule of Isometry" (Cieszyński, 1924) as the principle of Bisecting Angle depends, in fact on the creation of an isosceles triangle defined by Dickinson (1967) as a triangle which has two sides equal in length. As the sum of the three angles of any triangle is 180 degrees (Dickinson, 1967) Cieszyński's method establishes one large isosceles triangle (Figure 31) (T. & I. 31). Hislop (1960) reaffirms the ancient proof that if two angles of a triangle are equal then the sides opposite these angles are also equal, those sides being represented in this technique by the long axis of the tooth being radiographed and its image on the film (Figure 31) (T. & I. 31).

Although Richards (1949) gave due credit to both these pioneers, Price and Cieszyński have been afforded scant regard for their outstanding work in this field of dentistry. Wuehrmann (1957) described Cieszyński as an engineer and Dieck (1911), Satterlee (1931), widely referred to as the original author of the technique (McCall and Wald, 1957), and Raper (1918) described the principle without reference to either the American or the Polish dentist, while Reinmöller and Burchard (1914) ascribed the principle to Dieck. McCoy (1918), who refers to Price, and Robinsohn and and Spitzer (1909), Eisen and Eisen (1913) and Ennis, Berry

Phillips (1967), who cite Cieszyński, helped to redress this imbalance if not doing so quite as forcefully as Pordes (1919) who mentioned that the law named after Dieck was in fact first formulated by Cieszyński.

The plane of the film in the patient's mouth (i.e. the side of the triangle represented finally by the radiograph of the tooth being examined) can be seen but the long axis of the tooth has to be gauged. In addition dentists have found difficulty in estimating the bisecting angle between these and then directing the central ray through the tooth's apex at right angles to the imaginary plane so created. Cieszyński (1907, 1912 and 1925), Raper (1923), Simpson (1928) and Pollia (1930) evolved and improved fairly simple mathematical methods which used definite angles for each individual tooth and straightforward indicators to measure these angles. Wuehrmann and Manson-Hing (1969) have pointed out that it is now necessary to direct the central ray through the middle of the tooth being examined because of the size of the small present day beam of radiation. This produces slight tooth elongation on the radiograph.

(b) <u>The Paralleling Technique</u>

Donald W. McCormack (1937), a San Francisco dentist, objected to this Bisecting Angle Technique. He reviewed the earlier doubts of Raper (1923), Simpson (1928) and Pollia (1930) but maintained, contrary to the thoughts of these and almost all other dental radiologists prior to this time, that the film should be held parallel to the long axis of the tooth being examined with the central ray directed at right angles to both (Figure 32) (T. & I. 32). He denied that the image produced by the Bisecting Angle Technique could be anatomically or proportionately correct (Figure 31) (T. & I. 31) or that the bony contours of the jaws (Simpson, 1928; Pollia, 1930) and especially the palate (Raper, 1923) debarred the use of a paralleling technique.

A carefully prepared series of experiments proved that an anode-film distance of thirty-six inches overcame differences in the size or shape of the focal spot, reduced penumbra and enlargement on the resultant radiograph and gave an accurate reproduction of similar objects held in contact with the film or at varying distances up to one inch from it. The reason was that those rays which passed through the objects on their path to the film were very nearly parallel when such a distance was used. Previous writers, apparently, had used empirical anode-film distances. Raper (1923) advocated eight inches for dental units, fifteen inches to eighteen inches for other units, Cieszyński (1926) twelve inches to twenty inches, Parma (1930) fourteen inches and Simpson (1928) and Pollia (1930) eighteen inches, for example. Small anode-film distances resulted in a spreading of the rays and so necessitated close apposition of the film to the tooth being examined if marked elongation of the image was to be prevented. McCormack conceded finally that his method presented difficulties to the average dental surgeon because of the space required although he felt that this problem did not arise when it was used in hospitals and other larger clinics.

The procedures described in this paper were the fruits of a quarter of a century's experience and study. McCall and Wald (1957) state that this study was started in 1913 by Franklin W. McCormack a San Francisco radiographer. He collaborated with nine dentists and presented his first results in 1920 after seven years' work. A thirty-six inch anode-film distance for intra-oral radiography, but only for the upper molar teeth, was first proposed in this paper. Higley (1936B) in the years between these two papers, in the introduction to his own paper on the Temporomandibular Articulation stated that the most ideal situation ensued if the film could be held parallel to the object being radiographed and at right angles to the central ray.

The Long Cone Paralleling Technique was not really accepted until Fitzgerald (1947) published a further series of articles about it. He gradually reduced the anode-film distance, an inch at a time, from thirty-six inches until as a result he was able to show that twenty inches was a practical distance from all standpoints. His experiments used similar objects set in contact with the film and at varying distances up to 2.5 inches from the film, his reasoning being that although the maximum intra-oral object-film distance appeared to be 1.5 inches the zygoma was a further one inch from the film and had to be taken into account when the upper molar teeth were being examined. He experimented with different sizes of focal spots and examined the differing effects of using eight inch, eleven inch, fourteen inch, sixteen inch, eighteen inch and twenty inch anode-film distances concluding that a distance of fourteen inches was absolutely essential if a 0.5" object-film distance was used. A twenty inch anode-film distance was, moreover, proven to be practicable in general dental surgeries.

Waggener (1947 and 1951) also advocated this distance of twenty inches and queried why the right angle technique used in bite-wing radiography was not used in periapical radiography. McCormack (1950) at about the same time described some accessories including a film holder and a "Target Distance Localizer" which further simplified the technique. Updegarve (1959) continued this trend when he described an easily used yet accurate method of holding the film correctly in the mouth and positioning the X-ray tube at right angles to it.

The controversy still rages. Greater milliamperage, kilovoltage and/or exposure time are needed with the

Paralleling technique. Space, economics, facility and ability to use one or other of the techniques successfully are important considerations. Everything else being equal, however, the fundamental principles described by Wuehrmann (1957) and Wuehrmann and Manson-Hing (1969) which are necessary if a good radiograph is to be produced can be considered the basis of a fair summing-up. These principles are:-

(i) The source of the X-rays must be as small as possible;

(ii) The distance of this source to the object being radiographed must be as large as possible;

(iii) The distance between this object and the recording surface (i.e. film) must be as small as possible;

(iv) The object and the film must be parallel;

(v) The X-rays must strike both the object and the film at right angles.

The first principle is constant to either method and the third is more fully satisfied by the Bisecting Angle Technique. The Paralleling technique is, however, superior with regard to the other three principles and so would appear to be the more satisfactory technique.

It must be remembered, finally that no matter which method is used the X-rays must be directed in the horizontal plane so that they are parallel with the interproximal surfaces of the teeth being examined if their overlapping on the resultant radiograph is to be prevented.

CHAPTER 3

THE RHEUMATIC DISEASES

"Rheumatoid arthritis is one of the great mysteries of medicine" (Cecil, Nicholls and Stainsby, 1930). This is probably as true today as it was when first stated and perhaps its greatest relevance is in the field of dentistry. The condition has been defined as "a chronic inflammatory disease of connective tissue which affects principally the joints and may lead to permanent deformity and chronic invalidism" (Anderson, Buchanan and Goudie, 1967). Its aetiology remains unknown and although there are three principal fields of study at the present time - the auto-immune or autoallergic, the genetic and the infective hypotheses - some rheumatologists consider other fields equally likely to reveal the cause. Although May (1897) reported the discovery of an Egyptian mummy of the period 2750-2625 B.C. which showed evidence of rheumatoid involvement of many joints including the temporomandibular joint, rheumatoid arthritis is generally considered to be a disease of modern times. Evidence for this assumption is that it was not clearly described before the nineteenth century (Parish, 1963), the Bible does not refer to it, the classical European masters did not paint it (Boyle and Buchanan, 1971) and none of Shakespeare's characters suffered from it (Ehrlich, 1967). It is a disease unique to the human species although Bywaters (1967) has shown that primates suffer from a not dissimilar form of arthritis.

Rheumatoid arthritis is, therefore, quite unlike the ancient degenerative joint disease, osteoarthrosis, which affects those joints lined with a synovial membrane and which is further characterised by bony eburnation and the formation of bony marginal proliferations (Boyle and Buchanan, 1971). Skeletons of ape men two million years old (Osgood, 1940) as well as of Egyptian mummies (Hollander, 1966) show evidence of the condition; indeed it probably affected the dinosaur one hundred million years ago judging from their skeletal remains (Hollander, 1966). As then, nowadays it affects many animals and birds. It is found, for example, in horses (Mackay-Smith, 1962), mice (Silberberg and Silberberg, 1961) and in whales and dolphins as well as birds (Sokoloff, 1963). Karsh and McCarthy (1960) produced a fascinating historical account of the rheumatic diseases, much fuller and more comprehensive than I intend to include in this chapter.

Rheumatoid arthritis is one of a group of five conditions collectively described originally as the "collagen diseases" (Klemperer, Pollack and Baehr, 1942) but now more appropriately as the "connective tissue diseases" because the lesions affect the cells and ground substance of the connective tissues in addition to the collagen component (Anderson, Buchanan and Goudie, 1967). The other four conditions which complete the group are (i) systemic lupus erythematosus, (ii) progressive systemic sclerosis (sometimes called scleroderma after the skin component of the condition although a localised cutaneous form of the disease is also found), (iii) dermatomyositis (called polymyositis when the muscular component of this condition predominates) and (iv) polyarteritis nodosa. Cases have been reported of the structures which are of particular interest to me in this study being affected by systemic lupus erythematosus and, more frequently, progressive systemic sclerosis. Marbach and Spiera (1969) reported temporomandibular joint changes associated with systemic lupus erythematosus in a young nurse. The most frequently reported dental finding in progressive systemic sclerosis is Blackburn's sign or characteristic widening of the periodontal membranes of, especially, the permanent molar teeth (Stafne and Austin, 1944; Rosenthal, 1948; Krogh, 1950; Gores, 1957; Mitchell and Chaudhry, 1957; Smith, 1958 and Traiger, 1961). This is an inconstant finding, however, Stafne and Austin (1944) only detecting it in nine mouths of a total of one hundred and twenty-seven diagnosed cases; it does not appear to necessarily involve all the teeth to the same extent (Monroe and Krauer, 1962) and may even, in the later stages of the disease, disappear (Krogh, 1950). Stafne (1953) reported cases of Blackburn's sign and also cases of scarring, or depression and atrophy, of the alveolar process, a feature previously noted by Looby and Burket (1942) who also described the failure of the upper left permanent central incisor to erupt into the affected area of an eight year old girl's mouth. Other features of progressive systemic sclerosis are microstomia resulting from the rigidity and thinness of the lips and the consequent difficulty encountered in retracting them (Traiger, 1961). This makes maintenance of adequate oral hygiene very difficult especially if, as is usually the case, the fingers are also involved (Smith, 1958) and may also interfere with speech and mastication by preventing adequate opening (Afonsky, 1948; Rosenthal, 1948), a factor which may be further insulted by lingual stiffness (Frank, 1937; Truelove and Whyte, 1951). Despite the foregoing I mention these four conditions which, with rheumatoid arthritis, constitute the connective tissue diseases primarily because of their association with Sjøgren's syndrome.

Sjøgren's syndrome is named after the Swedish ophthalmologist Hendrik Sjøgren who described it in detail in a monograph published in 1933. The syndrome consists of the clinical triad of keratoconjunctivitis sicca or dryness of the eyes, xerostomia or dryness of the mouth with or without salivary gland enlargement, and a connective tissue disease usually rheumatoid arthritis (Bloch, Buchanan, Wohl and Bunim, 1965). The presence of two of these features is sufficient for a positive diagnosis, the alternative term "sicca syndrome" being used if the connective tissue element is the one which is absent (Bloch, Buchanan, Wohl and Bunim, 1965). If dermatomyositis is present it is so as polymyositis. Von Mikulicz (1888) described what became known to be Mikulicz's disease towards the end of the last century and published his report four years later in 1892. Also in 1888 Hadden reported the clinical details of a sixty-three year old woman suffering from what is now called Sjøgren's syndrome. Prior to this Leber (1882) described filamentary keratitis such as occurs in kerato-conjunctivitis sicca but did not recognise its nature. Fuchs (1919) noticed the association between dryness of the eyes and filamentary keratitis, the fifty-four year old female subject of his observations also demonstrating xerostomia and bilateral parotid gland enlargement. Gougerot (1926) described three patients with progressive atrophy of the salivary glands and also of the mucous glands of the conjunctivae, mouth, nose, larynx and vulva and suggested that these features constituted a new clinical syndrome and Houwer (1927) the following year stressed the association between filamentary keratitis and arthritis. As a result of these various reports two conditions came to be described - Mikulicz's disease and Sjøgren's syndrome sometimes alternatively called the Gougerot syndrome, the Gougerot-Houwer-Sjøgren syndrome and the Gougerot-Sjøgren syndrome amongst other names - which Morgan and Castleman (1953) and Morgan (1954) showed to be one and the same thing.

Not surprisingly the oral factors of this syndrome have created a considerable interest in the study of the salivary glands. Sialography and salivary flow rate investigations have both been used to assess the severity of the salivary component of the disease (Bloch, Buchanan, Wohl and Bunim, 1965; Maynard, 1965; Mason, Harden, Boyle, Jasani, Williamson, and Buchanan, 1967; Hertram, 1967; and Ericson, 1968) as have minor salivary gland biopsy techniques (Chisholm and Mason, 1968) and scanning methods (Harden, Alexander, Shimmins and Russell, 1968). The opinion, however, that sialography is the investigation of choice if it is wished to demonstrate salivary gland abnormalities in this disease (Boyle and Buchanan, 1971) is amply supported by the large number of reports, published since the Second World War, of such abnormalities detected using sialography (Koumrouyan, 1948; Bercher, Belz and Parret, 1949; Cadman, 1953; Parret, 1954; Rose, 1954; Patey and Thackray, 1955; Thackray, 1955; Thonard, 1956; Ranger, 1956-57; Maxwell, 1960; Vanselow, Dodson, Angell and Duff, 1963; Lathrop, 1964; Calman and Reifman, 1966; Cook and Pollack, 1966; and Malkin, 1968). Moreover the combined topics of sialography and Sjøgren's syndrome figure prominently in a number of major publications on sialography (Rubin, Blatt, Holt and Maxwell, 1955; Blatt, Rubin, French, Maxwell and Holt, 1956; Garusi, 1964), Sjøgren's syndrome (Blatt, 1964; Bloch, Buchanan, Wohl and Bunim, 1965) and

Xerostomia (Bertram, 1967), although only Ericson (1967 and 1968) and Ericson and Sundmark (1970) have discussed sialography in relation to rheumatoid arthritis alone. Disappointingly perhaps the largest group of patients with Sjøgren's syndrome so studied numbered only thirty-seven (Bloch, Buchanan, Wohl and Bunim, 1965).

Surprisingly in view of the large amount of dental epidemiological research which has followed what is regarded as the first notable work in that field, namely the study of McKay and Black (1916), and of the frequent reports which indicate that xerostomia leads to increased dental decay (Morgan and Rowen, 1952-53; Ehrlich and Greenberg, 1954; Bunim, Buchanan, Wertlake, Sokoloff, Bloch, Beck and Alepa, 1964; Bloch, Buchanan, Wohl and Bunim, 1965; Jacobson, 1966; Bertram, 1967; Cawson, 1968; Ericson and Jacobbson, 1968) no detailed study of the dental health of a group of patients suffering from Sjøgren's syndrome has been completed. Even more surprisingly no attempt has been made to determine the different dental requirements which might be needed by a house-bound, for example a rheumatoid arthritic, section of our population although in recent years H.M.S.O. reports on fluoridation (Shaw, 1969) and the dental health of a cross section of the adult population in England and Wales (Gray, Todd, Slack and Bulman, 1970) have been published in addition to articles describing the dental status of industrial populations (Sheiham, 1969; Sheiham, Hobdell and Cowell, 1969; Sheiham and Hobdell, 1969; Hobdell, Sheiham and Cowell, 1970) and of adolescent school-children living in an industrial region (Stephen and Sutherland, 1970). The closest approaches to such a study appear to be those of Ericson and Jacobsson (1968) previously mentioned, and of Martinello and Leake (1971) and Leake and Martinello (1972) who studied the oral health of different groups of elderly people in Canada.

Involvement of the temporomandibular joint by rheumatoid arthritis is another subject that has received relatively little attention in both the rheumatological and the dental literature. It is barely mentioned in the major rheumatology textbooks. One of these dismisses temporomandibular joint involvement as "rather uncommon" (Hollander, 1966) while others regard it as not uncommon (Copeman, 1964; Boyle and Buchanan, 1971). Monographs on the temporomandibular joint (Schwartz, 1959; Sarnat, 1964; Schwartz and Chayes, 1968) devote sections or chapters to the rheumatic diseases but have little, in effect, to say about how these diseases affect this particular joint. This neglect is the more surprising in view of the emphasis placed on temporomandibular joint involvement by physicians of the last century. Sir Archibald Garrod, who introduced the term "rheumatoid arthritis"

(Garrod, 1859), described limitation of movement of the jaw and occasionally ankylosis in patients with this disease and believed that rheumatoid arthritis had a "peculiar tendency to select the temporo-maxillary articulation" (Garrod, 1876). His son, A. E. Garrod (1890) found temporomandibular joint involvement in one-quarter of a large series of five hundred cases and Bannatyne (1898) who described an incidence of 68 percent in his series of two hundred and ninety-three patients believed that temporomandibular joint involvement was almost pathognomonic of rheumatoid arthritis.

During the first four decades of the present century rheumatoid arthritis of the temporomandibular joint appears to have been almost completely neglected apart from occasional anecdotal accounts (Riesner, 1936; Kazanjian, 1938; Buchman, 1939; Bellinger, 1940) and the next major survey was that of Russell and Bayles (1941). They reported an incidence of 51 percent in a clinical study of one hundred consecutive patients with rheumatoid arthritis. After the Second World War reports appeared in which very low prevalences of temporomandibular joint involvement were recorded. Ragan (1949) gives a figure of 4.7 percent while those given by Markowitz and Gerry (1950) and Lewis-Faning (1950) are 8.7 percent and 15 percent respectively. In the later nineteen fifties somewhat higher figures were quoted. Caldwell (1957) estimated that about 20 percent of patients with rheumatoid arthritis developed the disease in the temporomandibular joint and French authors, writing at approximately the same time, found the incidence of temporomandibular joint involvement in their patients to be very much greater, ranging from 56 percent (Blanc, 1959) to 80 percent (Cadenat and Blanc, 1958). During the past twelve years higher figures have tended to predominate although some have been relatively low. Hankey (1963) gives a prevalence of 10 percent, Kuhns and Potter (1960) 22 percent, Einaudi and Viara (1964) 29.3 percent, Uotila (1964) 41 percent, Mériel, Ruffié, Cadenat, Fournié and Blanc (1960) 48 percent, Franks (1966) 53 percent, Ericson and Lundberg (1967) 55 percent and Hatch (1967) 58 percent.

Although relatively little has been written on the clinical aspects of temporomandibular joint involvement by rheumatoid arthritis it appears that even less has been written about the radiological aspects. Zimmer (1941) and De Lorimier (1949) described changes which they had seen in patients with rheumatoid arthritis but the first formal survey appears to be that of Cadenat and Blanc (1958) in which fifteen patients were studied (fourteen with rheumatoid arthritis and one with ankylosing spondylitis). They found ten cases (71 percent) in which changes resembling rheumatoid arthritis elsewhere in the body were seen in the temporomandibular joint. Their patient with ankylosing spondylitis also had changes in this joint. Subsequent studies have included larger numbers of patients. Mériel, Ruffié, Cadenat, Fournié and Blanc (1960) found radiological changes in 31 percent of thirty-five patients. Uotila (1964) gives a figure of 19 percent of two hundred and fifty-one patients. Ericson and Lundberg (1967), studying sixty-five patients, observed that structural alterations were present in 78 percent of the joints and 86 percent of the patients. The figure given by Franks (1969) is 56 percent of ohe hundred patients. Hatch (1967) carried out a radiological study on forty patients with definite clinical symptoms or signs of temporomandibular disease and found that twenty-two (55 percent) showed radiological abnormalities.

In addition to a number of case reports (Brussell, 1949; Oshrain and Sackler, 1955; Van De Mark, 1955; Forsslund, Bjurwill and Orrling, 1961; Goodwill and Stiggles, 1966; Marbach and Spiera, 1967; and Cacioppi, Morrissey and Bacon, 1968) some of which discuss the superimposed problem of ankylosis (Thomas, Smith, Bosco, Blumenthal and Goldman, 1946; Blackwood, 1957; Cook, 1958) two further studies are of interest. Crum and Loiselle (1970) using restricted criteria found evidence of temporomandibular joint involvement in twenty-three (43 percent) of fifty-three male patients and Blackwood (1963) reported that histopathological examination of the temporomandibular joints of ten cadavers who had widespread changes of rheumatoid arthritis revealed evidence of involvement in seven (70 percent) of these by the rheumatoid arthritis.

Although there is no doubt that degenerative changes occur in the temporomandibular joint, these having been admirably demonstrated in morbid anatomical studies (Bauer, 1941; Coleman and Weisengreen, 1955; and Blackwood, 1963) as far as I am aware there have been no controlled studies on the incidence of temporomandibular joint disease among patients with primary osteoarthrosis although Markowitz and Gerry (1950) and Mayne and Hatch (1969) did comment on the rarity of subjective primary osteoarthrosis among those of their patients with temporomandibular joint degeneration. Degenerative temporomandibular joint disease is, however, often described in the literature under the heading of "Osteoarthrosis" or "Osteoarthritis" and coupled with a description of the primary disease involving other parts of the skeleton, thus implying that temporomandibular joint involvement is part of the syndrome of primary osteoarthrosis, (Weinstein and Ward, 1949; Caldwell, 1957; Grokoest and Schwartz, 1959; Lamont-Havers, 1966).

I am certain that it is very obvious that further studies on the effects of rheumatoid arthritis on the various structures in and around the mouth are indicated. Some of those already completed are inadequate and others reveal considerable discrepancies in their estimates of both the clinical and the radiological involvement of these structures by this disease. My intention is to present the results of such a study. In order to prevent any personal bias a wide selection of patients was referred to me for the various oral and dental examinations without any particular medical information. This information was supplied only when I had completed all these examinations. As a result various small groups of patients with a number of different conditions were seen in addition to larger groups with rheumatoid arthritis, osteoarthrosis and Sjøgren's syndrome. Interestingly the next largest group, albeit a very much smaller one, consisted of patients with psoriatic arthritis. This condition which affects men more frequently than women is defined on the triad of (i) psoriasis, (ii) radiological erosive polyarthritis and (iii) a negative serological test for rheumatoid factor (Boyle and Buchanan, 1971) and is an entity quite distinct from rheumatoid arthritis. The first reports that this condition affected any of the oral structures were published in 1965 (Franks, 1965; Lundberg, 1965). The largest study to date (Lundberg and Ericson, 1967) was also one related to the temporomandibular joint and consisted of eleven cases, three female, eight male ranging in age from seventeen years to sixty-four years with a mean age of thirty-nine years. Eighteen joints (82 percent) were shown to have deformative lesions, seventeen being erosive and one productive. In addition thirteen joints (59 percent) demonstrated reduced mobility. The authors concluded that the changes they discovered did not differ materially from those expected in a rheumatoid arthritic population. In view of this I feel that I must make a brief reference to those patients with psoriatic arthritis whom I saw although this is actually outside the intended scope of the study.

SECTION II

ASSOCIATED INVESTIGATIONS

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CHAPTER 4

THE MEDICAL AND SPECIAL OPHTHALMOLOGIC AND ORAL EXAMINATIONS

This chapter is included although I did not perform these examinations personally because I feel that the nature of the various clinical, radiological and laboratory examinations should be explained. The results of these examinations will be referred to in relation to the oral and dental studies which I did perform. A full understanding of the significance of the results which I am to detail would be impossible, therefore, without this background information.

The results of these examinations were recorded on an individual blue card (Figure 33) (T. & I. 33), the results of the other examinations being similarly recorded on white cards (salivary gland and dental health) (Figures 34 and 35) (T. & I. 34 & 35) and pink cards (temporomandibular joint) (Figure 36) (T. & I. 36). These different colours were used because by so doing it was found to be simple thereafter to sort the various aspects of each patient's history. On every card the patient's surname, christian or fore names, sex, date of birth and age, marital status, occupation and address were entered in addition to the date of the particular examination and the Centre for Rheumatic Diseases and Glasgow Dental Hospital and School case record reference numbers, thus providing a fool-proof cross reference system when all the information about each patient was pooled.

Rheumatoid arthritis was diagnosed using the criteria of the American Rheumatism Association (Ropes, Bennett, Cobb, Jacox and Jesser, 1959) and was, therefore, classified as classical, definitely probable or possible dependant upon how many of the eleven established criteria were satisfied. Each diagnosis was reached, accordingly, following clinical examination taking subjective symptoms into account, radiological examination and laboratory investigations (for example agglutination tests and histology). The duration of the disease was also noted as was the patient's age at its time of onset.

A number of investigations were used to further assess the severity of the disease. The Articular Index (Ritchie, Boyle, McInnes, Jasani, Dalakos, Grieveson and Buchanan, 1968) is determined by ascertaining the patient response to the application of firm pressure to a number of joints and the passive movement of four. A score of 0 to 3, representing 0 - not tender, 1 - tender, 2 - tender and winced, and 3 - tender, winced and withdrew, was given as a result of each examination and the various scores summed to produce the articular index, the range of which is 0 to 78. It, therefore, afforded a subjective assessment of the patient's condition whereas the Functional Class and X-ray Stage are objective assessments. Steinbrocker, Traeger and Batterman (1949) defined the Functional Classes as follows:-

I No disability; II Pain but able to perform normal activities;

III Unable to perform normal activities but still mobile; and IV Bed or chair bound; and the various X-ray Stages:- I No change; II Juxta-articular osteoporosis and loss of joint space; III Erosions; and IV Bony ankylosis. The presence of subcutaneous nodules, often found around the elbows when present, is an indication that a destructive form of the disease is likely to develop. Splenomegaly occurs in 3 to 5 percent of patients with rheumatoid arthritis and when also associated with neutropenia, superficial lymphadenopathy and, perhaps, anaemia is referred to as Felty's syndrome (Felty, 1924), one of the dangers of which is a susceptibility to infection. A mononuclear inflammatory cell infiltration of the adventitia and outer portion of the media, or of all the layers, of the walls of small arteries throughout the body with, occasionally, fibrinoid necrosis, provides histological evidence of arteritis (Sokoloff, Wilens and Bunim, 1951). This may be responsible, clinically, for the development of peripheral neuropathy, which may be painful sensory or mixed motor and sensory or mononeurotic in type, dermal infarction and ulceration, and perforation of the bowel. Arteritis is usually chronic or subacute (Cruikshank, 1954) but occasionally may be so severe and widespread as to be indistinguishable from polyarteritis nodosa (Ball, 1954).

Rheumatoid serum contains substances which act as antibodies to gamma globulin, even the subject's own gamma globulin; to these substances the name rheumatoid factor is given. It may be detected using latex fixation or sheep cell agglutination tests which have been described in detail by Singer (1961) and Ziff (1957) respectively. In the former human pooled immunoglobulin G is absorbed onto a particle of polystyrene latex. The patient's serum is added and agglutihation of the particles indicates a positive result. Various dilutions of the serum are added, the highest dilution which causes agglutination being termed the R.F. Titre. In some patients rheumatoid factor, which has an ability to react not only with human but also with mammalian gamma globulins, may be present. The latter test, sometimes alternatively termed the "Rose-Waaler" or "Waaler-Rose" test after those who first described it (Waaler, 1940; Rose, Ragan, Pearce and Lipman, 1948) is used to demonstrate this. The sheep cell agglutination test varies from the latex fixation test in that the polystyrene latex is replaced by a sheep red blood cell and the human immunoglobulin by rabbit gamma globulin. The formation of L.E. cells found in systemic lupus erythematosus and also, occasionally, chronic discoid lupus erythematosus, progressive systemic sclerosis, dermatomyositis and classical rheumatoid arthritis, among other conditions, depends on the presence of, among other things, antinuclear antibodies.

It has been stated that classical rheumatoid arthritis in which L.E. cells can be demonstrated is probably more severe than other forms of this disease (Keivits, Goslings, Schuit and Hijmans, 1956). It is more convenient to test for these antinuclear antibodies, and, thereby, determine the A.N.F. Titre, than to test for the L.E. cells themselves. An immunofluorescence test is used in which a slice of tissue, such as rat's liver, is treated with the patient's serum. An antibody to gamma globulin which has been labelled with a fluorescent dye is added and the section is then examined microscopically with ultra violet light to detect the presence of fluorescence (Beck, 1961).

During active stages of rheumatoid arthritis the erythrocyte sedimentation rate (E.S.R.) is usually raised, the serum globulin is elevated, at least relative to the value of serum albumin, and normocytic, hypochromic anaemia, refractory to iron, is commonly present (A.R.A. Primer on the Rheumatic Diseases, 1959).

The diagnosis of primary osteoarthrosis was based on the following criteria:- (i) typical radiological changes (joint space narrowing, sclerosis, osteophytes, subchondral cysts); (ii) involvement of typical joints (hips, knees, lumbar spine, distal interphalangeal joints); (iii) absence of predisposing congenital, traumatic, infectious or inflammatory joint conditions; and (iv) absence of evidence of active inflammatory joint disease (normal erythrocyte sedimentation rate, negative tests for rheumatoid and antinuclear factors) (Boyle and Buchanan, 1971). Psoriatic arthritis has already been discussed previously in Chapter 3.

Sialography and Xerostomia are also discussed widely elsewhere. It is appropriate, however, to describe the other investigations of Sjøgren's syndrome, which remain to be described, in this chapter. The objective tests for the presence of keratoconjunctivitis sicca (K.C.S.) are performed by an ophthalmologist. The patients I studied were examined by the technique of Williamson, Cant, Mason, Greig and Boyle (1967). A Schirmer I Tear Test (Schirmer, 1903) using standardised sterile paper strips as designed by Halberg and Berens* was performed in an atmosphere between 60 and 70 degrees fahrenheit and a relative humidity greater than 40 (Williamson and Allison, 1967). After five minutes the degree of wetting of the filter paper was measured and the mean of the two eyes was calculated. If this wetting was less than 15 millimetres a Schirmer II Tear Test was completed. This test differs from the Schirmer I Tear Test only in that tear secretion is stimulated by the presence of a 10 percent solution of ammonia held six inches from the nose for five minutes.

* Contactisol Inc., Lindenhurst, New York

Again wetting over 15 millimetres was regarded as normal but a lesser amount of secretion was followed by a Rose-Bengal Test. A one percent solution of this dye was instilled into each conjunctival sac which was then immediately irrigated with normal saline. The eye was then viewed through a Haag-Streit slit lamp for punctate and/or filamentary keratitis, any staining seen in the area previously in contact with the Schirmer filter paper being ignored. Definite keratoconjunctivitis sicca was diagnosed if the tear tests showed wetting of less than 15 millimetres and a punctate or filamentary keratitis was seen on slit lamp examination.

Scanning of the salivary glands following the intravenous injection of ^{99m}Tc - pertechnetate (Harden, Alexander, Shimmins and Russell, 1968) may develop into a useful investigative procedure but the detection of antibodies to salivary duct epithelium is not a reliable procedure as they are usually absent in the sicca syndrome (Whaley, Chisholm, Goudie, Downie, Dick, Boyle and Williamson, 1969) yet are found in 25 percent of patients with rheumatoid arthritis apparently not complicated by Sjøgren's syndrome (MacSween, Goudie, Anderson, Armstrong, Murray, Mason, Jasani, Boyle, Buchanan and Williamson, 1967). Bertram and Halberg (1964) who demonstrated an antibody to salivary duct epithelium, which was found in the sera of approximately 50 percent of patients with Sjϕgren's syndrome,pioneered this work in view of the strong autoimmune association of this condition in an attempt to detect salivary gland involvement in Sjϕgren's syndrome.

Parotid salivary flow studies, on the other hand, are both valuable and well regarded. The inner chamber of a modified Carlson Crittenden cup (Carlson and Crittenden, 1910) having an internal chamber diameter of 10 millimetres, an external chamber diameter of 20 millimetres and a depth of 4 millimeters is placed over the orifice of the parotid duct and maintained in position there by air suction applied through the outer chamber. Parotid saliva is collected under conditions of lemon juice stimulation and its volume measured accurately by weighing the collection bottles or tubes before and after collection. The maximum error involved, assuming the specific gravity of the salivary secretion to be 1.00, is 1 percent (Kerr, 1961). It will be appreciated that such accuracy is absolutely essential if I point out that the lower range of the normal lemon juice stimulated parotid salivary flow rate is 0.5 millilitres per minute, the amount produced by diseased glands often being considerably less.

I am deeply indebted to my colleagues Doctor Ian M. Chalmers, Doctor Derrick M. Chisholm and Doctor Keith

Whaley not only for concisely providing me with the results of the examinations described in this chapter for each patient I examined but also for their patience and perseverance in explaining fully to me their rationale and relevance.

SECTION III

THE SALIVARY GLAND STUDY

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CHAPTER 5

MATERIALS AND METHODS

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5.1) THE PATIENTS STUDIED

Two groups of patients were studied. The first consisted of three hundred and ninety-seven patients, three hundred and one being female and ninety-six male. The purpose of this study was to determine the sialographic appearances found in rheumatoid arthritis and Sjøgren's syndrome. This large group of three hundred and ninety-seven patients could be subdivided into thirteen smaller groups as follows:-

(1) 74 control patients (57 female, 17 male) mean age 61.7 years;

(2) 123 patients (93 female, 30 male) mean age 51.9 years, with rheumatoid arthritis;

(3) 46 patients (42 female, 4 male) mean age 55.3 years with Sjøgren's syndrome complicated by rheumatoid arthritis;

(4) 2 female patients, mean age 40.1 years with Sjøgren's syndrome complicated by systemic lupus erythematosus;

(5) 54 patients (49 female, 5 male) mean age 58.9 years with sicca syndrome (or Sjøgren's syndrome not complicated by a connective tissue disease).

These five groups were the ones primarily studied. However, as already stated they were referred with other groups of patients to prevent examiner bias. This was further aided by the fact that a number of the control group were osteoarthrotic and also referred randomly with the patients suffering from a connective tissue disease or sicca syndrome. The other eight groups were constituted so:-

(6) 29 patients (24 female, 5 male) mean age 43.8 years with psoriatic arthritis;

(7) 9 female patients, mean age 27.1 years with systemic lupus erythematosus;

(8) 7 female patients, mean age 46.5 years with progressive systemic sclerosis;

(9) 1 male aged 42 years suffering from polyarteritis nodosa;

(10) 18 patients (3 female, 15 male) mean age 44.8 years with ankylosing spondylitis;

(11) 24 patients (14 female, 10 male) mean age 48.3 years suffering from arthritis of unknown aetiology;

(12) 9 male patients, mean age 35.1 years, with Reiter's syndrome; and

(13) 1 female aged 32 with sarcoidosis.

The second group of patients were studied in order to evaluate hydrostatic sialography and lemon juice stimulated parotid salivary flow rates in patients with Sjøgren's syndrome with and without rheumatoid arthritis, and using these techniques to attempt to provide an index of salivary gland dysfunction. This group comprised one hundred and nine patients, twenty-one with sicca syndrome, forty-three with Sjøgren's syndrome complicated by rheumatoid arthritis and forty-five age and sex matched control subjects without evidence of Sjøgren's syndrome, connective tissue disease or other salivary gland disease. All but two patients in each of the diseased groups had both parotid glands examined with the result that two hundred and fourteen glands in total were included in this study. I performed all the sialographic examinations and collaborated in this study with my friend and colleague Dr. Derrick M. Chisholm who completed the salivary flow rate investigations.

5.ii) THE CLINICAL EXAMINATION

Each patient was first of all questioned about symptoms which might be associated with a diagnosis of Sjøgren's syndrome. An obvious example would be a history of salivary gland, usually parotid, enlargement often bilateral or symmetrical. This may have been a single instance, episodic and recurrent, or chronic, lasting perhaps for a few years or, even, persistent and progressive. A history of pain in the region of the major salivary glands especially during such glandular enlargements was also recorded. Histories of difficulty of swallowing due to dryness of the throat and inability to form boli especially with dry food because of dryness of the mouth which necessitated a large fluid intake with, and sometimes between, meals; soreness of the oral mucosa aggravated by "acid" and spicy foods; dryness, fissuring and ulceration of the lips and tongue; difficulty in keeping the mouth clean and any impairment of the sense of taste because of the lack of saliva; and an increase in the incidence of dental decay were considered indications of subjective xerostomia.

However, dryness of the mouth is a frequent complaint of mouth breathers and heavy smokers. Therefore an objective examination of the mouth is absolutely essential, although I did find that patients with xerostomia complained of a much more persistent dryness and also of much greater difficulty eating than those other patients. Rarely was evidence of salivary gland enlargement evident at the times of these examinations and when there was such evidence it was usually detected by palpation as in most instances it was not immediately obvious to the eye. Fissuring at the corner of the lips had to be differentiated from that due to other causes such as reduced vertical dimension or monilial infection, as had palatal lesions. The tongue often presented a characteristic dry fissured appearance (Bertram, 1967) in the more severe cases but often, even in such cases, where there was probably a sufficient secretion from the minor salivary glands to give the oral mucosa a moist appearance, little abnormal could be seen clinically. A strict assessment of oral hygeine, close examination of the salivary duct orifices, which were frequently found to be markedly atrophic, and of the saliva emanating from them assisted, if need be, by "milking the duct" or lemon juice stimulation, and the absence of the normal sublingual pool of saliva were in my opinion the most fruitful observations.

At the time of these examinations any history of salivary gland disease of a different nature was also sought to eradicate diagnostic confusion. In addition each patient was also asked about his or her general health and, particularly, any history of allergy, especially to iodine or iodine compounds. The reason for this was that all contrast media used in the sialographic examinations depended upon iodine compounds for their radiopacity.

5.iii) HYDROSTATIC SIALOGRAPHY

The barrel of a 20 millilitre syringe or other suitably calibrated reservoir is fixed to a stand so that it is approximately 72 centimetres above the orifice of the gland to be examined. This height was selected as it is sufficient to provide a very small positive pressure when a normal gland of a healthy subject is being subjected to sialographic examination by "hydrostatic sialography" (Mason, 1966). Fine polyethylene tubing PP 205* about 100 centimetres in length is fitted to the reservoir by means of a Connector with a Luer-Lok adapter and tap and an adapter cap ** designed to take this tubing. A fine polyethylene catheter PP 160* about 25 centimetres long is attached to the free end of this tubing by means of a Connector and two adapter caps**, one designed to accommodate the wider tubing, the other to accommodate the narrower catheter. The reservoir is filled with Conray 280***. The tap is opened to permit complete filling of the entire length of the tubing and catheter with this water soluble contrast medium and is then closed. The various components of the apparatus are illustrated in Figure 37 (T. & I. 37) and the assembled apparatus in Figure 38 (T. & I. 38).

* Portland Ltd.

** H. A. West, Edinburgh 11.

*** May and Baker Ltd.

The patient being examined lies on a skull table. The orifice of the main duct of the gland to be radiographed is located (Figures 39 and 40) (T. & I. 39 & 40) and dilated with lacrimal duct dilators to permit the entry of the very fine atraumatic tip of the catheter (Figures 41 and 42) (T. & I. 41 & 42). This is formed by drawing out a suitable length of the narrower polyethylene tubing over a spirit lamp flame (Figure 43) (T. & I. 43). The catheter is retained in position by a sphincter-like action of the salivary duct assisted by the presence of a small bubble on the catheter formed during the drawing out of its fine tip, by gentle lip pressure on the part of the patient, and by the taping of the lower Connector-adapter mechanism to the patient's forehead. I have never found local anaesthesia to be necessary for the completion of this examination and although the submandibular duct is more difficult to control I have never considered its control with forceps (Garusi, 1964) to be necessary far less its incision (Kimm, Spies and Wolfe, 1935; Castigliano, 1962). Similarly, neither sutures nor clamps have ever been used to maintain the correct relative positions of the soft tissues and the catheter.

The patient is positioned for an off centre antero-posterior film with the central ray passing through the ascending ramus of the mandible of the side being radiographed (or for a true lateral view in the case of the submandibular gland). Contrast medium is allowed to run freely into the parotid gland until the patient indicates pain or discomfort by raising a hand. The film is exposed before the tap is closed. The procedure is then repeated, a 15 degree lateral oblique jaw view being taken on this occasion. I consider that at least two films taken at different angles must be available if a reliable radiological report is to be provided. The catheter is now removed from the mouth and the patient encouraged to suck the juice from a slice of fresh lemon in order to stimulate salivary flow before the five minute secretory film is taken. I have found the whole procedure to cause no more discomfort than an infiltration local anaesthetic.

The parotid gland was radiographed solely throughout this study not only because it is technically easier to examine it sialographically and in the various ways described in Chapter 4 than either of the other major salivary glands but also because it appears that it is the first to be affected (Morgan, 1954), the most frequently affected (Morgan and Raven, 1952-53; Bloch, Buchanan, Wohl and Bunim, 1965; Bertram, 1967) and symmetrically affected (Garusi, 1964; Ericson, 1968) by rheumatoid arthritis and associated conditions. Technical details of each exposure for which an Elema-Schonander Skull Unit (Lysholm Precision

Apparatus for Skull Radiography) with a Helios 4 Control Unit* was used were:- KV 58 (for the antero-posterior projection) and 62 (for the lateral oblique jaw view); m As 20 (250 m A for 0.08 seconds); Diaphragm - number 13; Kodak R.P. films 8 inches x 6 inches (20 cm. x 15 cm.) in a Phillips casette with Ilford Fast Tungstate Screens were used, the anode-film distance being 36 inches (92 cm.). The exposed films were processed automatically in the Kodak X-OMAT.

* Siemens

5.iv) ASSESSMENT OF HYDROSTATIC SIALOGRAPHY

I have assessed this technique over a period of five years during which seven hundred and forty-six patients, including those of the present study, were referred to me for sialography. Only eight (1.1 percent) of those examinations did not succeed and five of these failures were due to stenoses of the orifices of one or other Wharton's duct. The results of the successful examinations are summarised in Tables I to V (T. & I. 44-48). It can immediately be stated, therefore, that this technique holds a valuable place in the field of present day oral diagnosis, which value can be considered to have been enhanced by the five failures described because it may fairly be claimed that the likelihood is that a more traumatic technique would more probably have forced contrast medium into the sublingual soft tissues than into the ducts being examined. Catheters recently introduced by Hettwer (1969) and Rabinov and Joffe (1969) which do away with the need for prior dilation could prove to be a further safeguard in such cases. Poor catheter control was the cause of my other three failures. Simple modifications of my technique incorporating ideas of Damascelli (1967) or McCallum (1965) for example, might have ensured success. Movement of the patients between the stages of these examinations could be considered a disadvantage. However, despite the chronic joint disability of many of the patients I examined, diagnostically satisfactory radiographs were invariably produced. I did consider the use of the orthopantomograph (Uotila and Westerholm, 1965) for some such cases especially as more than one gland could be portrayed on the same radiograph. However, the problem of the second view remained and a further one was added. Any technique which is basically a form of linear tomography may only provide the radiologist with a view of a section of the gland being examined, the plane of this section having been pre-determined.

During the course of this study the new Glasgow Dental Hospital and School was opened and I was privileged by being asked to perform sialographic examinations there. I use exactly the same technique (Figure 44) (T. & I. 49) and have already completed over one hundred examinations. I can discern no noticeable difference between the two series of films.

The timing of radiography is determined by a signal from the patient. Without doubt it would be much better if such patient participation could successfully be discontinued. It could well be that further development of image-intensifi--cation (Feldman, 1965) may allow this ideal to be achieved. I never, however, had any preconceived notions of how much contrast medium to use in any particular case. Table VI

(T. & I. 50) illustrates the wide differences in the recommended volumes of contrast media used by a variety of operators. Ericson (1968) has demonstrated that good results are obtained if the radiographs are exposed when the patient being examined experiences moderate pain and has suggested that only moderate injection-pressure and injection volumes are required for adequate reproductions of complete salivary duct systems. The advantage of hydrostatic sialography over other techniques, in this respect, is the great control any operator has over the volume of contrast medium injected into any gland and the pressure at which it is injected. Different people, no matter how practised, use different pressures when carrying out an injection procedure but all can turn a tap with equal facility. This controlled introduction of the contrast medium eliminates the likelihood of rupture of the ductal system (Koumrouyan, 1948; Patey and Thackray, 1955; Thackray, 1955; Rubin and Holt, 1957) and even the gland capsule (Ranger, 1957; Cook and Pollack, 1966) that can result from uncontrolled pressure and overfilling. Such an accident is particularly liable to occur in Sjøgren's syndrome, where in the later stages of the disease the gland may show marked acinar atrophy with fatty infiltration.

A contrast medium of low viscosity and surface tension is a prerequisite if the principles of "secretory sialography"

(Rubin, Blatt, Holt and Maxwell, 1955) are to be followed. The water soluble contrast media have these properties. Moreover, their use is recommended in the light of the reports of adverse effects of the oil-based dyes which have already been described (Chapter 2, Section ii). I have discovered no adverse reactions to the contrast media used in this study. In the majority of cases Conray 280 (Meglumine Iothalamate with an iodine content of 280 mg. per ml.) was used but Triosil 45* (Sodium metrizoate; iodine content 260 mg. per ml.) and Hypaque 45 ** (Sodium diatrizoate; iodine content 270 mg. per ml.) were also used with equal success. Sufficient radiopacity, proper viscosity, capability of rapid absorption and excretion, and no injurious effects on the tissues were defined by Neustaedter, Ehrlich, Du Bois and Blalock (1933) as the desirable properties for contrast media almost forty years ago. Although all three contrast media which I used satisfied those requirements well and also those added by Nitsche and Valyi (1962) of low surface tension, miscibility with saliva and hypertonicity I considered it prudent to be guided in the use of the safest solution available. It is in fact probable that both the cation and anion of Conray are the safest in present day use (Grainger, 1970).

*   Glaxo Laboratories Ltd.

** The Bayer Products Company.

Subjective assessment is more difficult than objective assessment. It is, however, relevant to note that thirty-four patients made no complaint when referred for further hydrostatic sialography and eleven, who had been examined before the original description of the technique under review, were unanimous, as was another group examined by Park and Bahn (1968), in stating that they found hydrostatic sialography preferable to the hand injection technique to which they had previously been subjected. Finally, six clinicians without experience of the technique were asked to carry out the procedure after having watched it being demonstrated during two consecutive cases. This they did safely and competently. After very few more cases they also completed the procedure with assurance.

5.v) RADIOLOGICAL INTERPRETATION

All the sialograms were more than adequate for comprehensive radiological interpretation. A recent modification using subtraction techniques (Liliequist and Welander, 1969; and Buchignani and Shimkin, 1971) may, it is claimed, facilitate this further by erasing any masking effects of the bones of the jaws. I consider that the greater benefit, if benefit there is, will be associated with submandibular sialography.

Blatt, Rubin, French, Maxwell and Holt (1956) recognised four types of sialectasis: punctate, globular, cavitary and destructive. Blatt (1964) graphically redefined and redescribed what are really examples of sialoangiectasis, as they apply only to the terminal intraglandular ducts, again eight years later. Sialodochiectasis is the corres--ponding term used for main duct disease. I shall use the term sialectasis as did Blatt and his colleagues and shall descriptively define the main duct changes I have observed. Blatt's criteria were modified by Bloch, Buchanan, Wohl and Bunim (1965) to punctate, punctate with intermediate duct involvement, globular, and cavitary or destructive. In addition to these findings, atrophy of the duct system has been mentioned but not defined by Ericson (1968). I recognise three grades of sialectasis: punctate, globular and cavitary where the diameter of the largest sialectatic defect seen on the radiograph under consideration is less than 1 mm., between 1 mm. and 2 mm., and more than 2 mm. respectively. A series of a normal sialogram is illustrated in Figures 45 to 47 (T. & I. 51-53) and representative examples of the three grades of sialectasis in Figures 48 to 53 (T. & I. 54-59). Atrophy is shown in Figures 55 and 56 (T. & I. 61 & 62), having been defined as sparsity, or diminution in number, of duct radicles with diminution in their calibre (or, radiographically, diameter). In this series the main parotid (Stensen's)duct was frequently seen to be dilated. This dilation was either diffuse and regular (Figure 57) (T. & I. 63) or intermittent and irregular (Figure 58) (T. & I. 64). I called these dilations smooth main duct dilatation and irregular main duct dilatation respectively. As is evident on Figure 57 (T. & I. 63) more than one of these features may be present on any one radiograph. The final abnormality sought was retention of any contrast medium within the duct system as seen on the five-minute secretory film. An example of this is shown in Figure 54 (T. & I. 60).

The accuracy of my radiological reporting was assessed in this way. Forty sets of radiographs, which I had reported, twenty as normal and twenty as abnormal, were randomly selected from the total series by a third party and presented to me one month later in order that I might report them again. In addition the same forty sets of radiographs were also reported by Dr. P. S. Low. The Intra-Observer Error was very small. Negative concordance was 100 percent and positive concordance 95 percent. This discordant reading was of a mildly atrophic case reported normal on the second occasion. The Inter-Observer Error was greater. Negative concordance was 95 percent, one normal radiograph being reported as punctate sialectasis. This is an error sometimes not easily avoided if the angulation of the gland and the film was such that many of the fine duct radicles are seen end-on on the resultant radiograph (Figure 59) (T. & I. 65). There was somewhat more discordance in reading the abnormal sialograms (3 of 20 discordant; 15 percent). One of these was the mildly atrophic case which I also reported incorrectly on one occasion and the other two were of cases of smooth main duct dilation which was not pronounced. In view of these results I, in co-operation with Mr. J. B. Davies, Senior Medical Photographer to the Glasgow Dental Hospital and School, designed a tem-plate (Figure 60) (T. & I. 66) which can be laid over the radiograph being reported. The exact size of any sialectatic spots, and any dilation or attenuation of the main or minor ducts, then becomes obvious. By the use of this tem-plate discordances in the interpretation of the sialographic changes described were completely excluded.

A word of warning is relevant here. The clinician must work in complete harmony with the radiographers and dark-room staff. The only possible reason for radiographs such as are shown in Figures 61 and 62 (T. & I. 67 & 68) was that the radiographer did not understand the principles of the examination, although another useless radiograph (Figures 63) (T. & I. 69) would have been avoided if the film had been more carefully handled, thus preventing the extra radiation incurred by repeating the procedure (Figure 64) (T. & I. 70). The value of the preceding plain films has been proved not only by indicating a non-salivary source of a patient's complaint in some cases but also by revealing the true nature of some conditions which could be misinterpreted on sialograms. Background calcifications (Figure 65) (T. & I. 71), such as lymph glands previously affected by disease, could simulate pools of contrast medium on a sialogram (Figure 66) (T. & I. 72). For reasons such as these plain or "scout" films are always taken and examined before sialography is envisaged. On the sialograms themselves air-bubbles and "radiolucent calculi" (which may constitute as many as 20 percent of all salivary calculi (Feuz, 1932) must be clearly differentiated if necessary, by repeating the procedure (Figures 67 to 70) (T. & I. 73-76). The "sialo-acinar" reflux of Samuel (1950) is a positive sign to look for on sialograms but gross overfilling (Figure 71) (T. & I. 77) completely ruins them (Rubin and

Blatt, 1955). Amazingly, and to the great credit of the technique, no retention of contrast medium was seen on this patient's clearance film (Figure 72) (T. & I. 78). This was all the more remarkable as the patient was ninety-two years of age. Carelessness on the part of the clinician can also mar the resultant radiographs from a radiological view point. Rubin and Holt (1957) describe back-flow of contrast medium into the mouth in this connection (Figure 73) (T. & I. 79). This is the result of poor positioning of the catheter. Spillage of minute drops of contrast medium onto the skull unit may also cause diagnostic confusion (Figure 74) (T. & I. 80).

5.vi) SUMMARY AND CONCLUSIONS

Oral examination does not necessarily confirm a diagnosis of Sjøgren's syndrome. In fact other clinical examinations such as sialography have been shown to be superior in this respect. The technique of hydrostatic sialography analysed is not perfect. However, it does have many advantages over most of the techniques described in the literature, even some in use at the present time. The accuracy of radio--logical reporting was also assessed and as a result improved. Technical errors which could give rise to false interpretation of sialograms have, as far as possible, been eliminated. I am confident therefore, that the modified technique of hydrostatic sialography now used produces, simply and comfortably, sialograms of the highest order of both major glands, healthy or diseased, in adults and children (Figures 75 to 79) (T. & I. 81-85) and that the tem-plate which has been introduced to assist their interpretation ensures accurate radiological reporting. I am also convinced of the facility of establishing the technique in any centre equipped for comprehensive skull radiography.

CHAPTER 6

RESULTS AND DISCUSSION

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6.i) SIALOGRAPHIC ABNORMALITIES IN RHEUMATOID ARTHRITIS AND SJØGREN'S SYNDROME

(a) <u>Results</u>: The results of this study are detailed in Tables VII and VIII (T. & I. 86 & 87). Five of the total of seventy-four control patients had abnormal sialograms, all showing main duct dilatation although one also demonstrated associated punctate sialectasis. A slightly higher percen--tage (9.8 compared with 6.8) of abnormal sialograms demon--strating a wider range of abnormalities, one globular sialectasis and two atrophy in addition to two punctate sialectasis and seven main duct dilatation, was discovered among rheumatoid arthritic patients. This difference although of interest is not statistically significant, 58.8 percent (60 of 102) of the combined Sjøgren's syndrome, sicca syndrome group demonstrated sialographic abnormalities. These findings reflect not only a highly significantly greater number of affected patients in this group when compared with both the control group (χ^2 = 49.9148, $p<0.0005$) and the rheumatoid arthritic group (χ^2 = 61.6950, $p<0.0005$) but also a complete and varied selection of all the sialographic abnormalities I have described. If the control group is compared with firstly the Sjøgren's syndrome complicated by rheumatoid arthritis group (χ^2 = 44.2594, $p<0.0005$) and secondly the sicca syndrome group (χ^2 = 35.2731,

$p<0.0005$) similar high levels of significance are found, as indeed they are if the control group is replaced by the rheumatoid arthritis group ($\chi^2 = 51.7373$, $p<0.0005$; $\chi^2 = 40.7211$, $p<0.0005$ respectively). Relatively more of those patients with Sjøgren's syndrome complicated with rheumatoid arthritis (63.0 percent) showed sialographic abnormalities if compared with those patients with sicca syndrome (53.7 percent) but more severe sialographic changes were seen in the latter group. For example, twelve of a grand total of sixteen cases of cavitary sialectasis and thirteen of twenty-one of retention of contrast medium in addition to a slightly greater incidence of main duct dilatation were discovered among the patients with sicca syndrome. Conversely the greatest number of glands showing punctate sialectasis was found in the Sjøgren's syndrome complicated by rheumatoid arthritis group as was the greatest percentage of atrophic glands. The only slightly statistically significant finding, however, determined from these results was the greater proportion of cases of cavitary sialectasis contained in the sicca syndrome group ($\chi^2 = 4.8025$, $p<0.05$). This finding becomes significant if the abnormal glands alone in both these groups are considered ($\chi^2 = 7.2837$, $p<0.01$). The two cases of Sjøgren's syndrome complicated by systemic lupus erythematosus could not be analysed independently. If they were added to the Sjøgren's syndrome plus rheumatoid arthritis group no material alterations in the findings already described resulted.

The incidental results of the other patients seen are shown in Figures IX and X (T. & I. 88 & 89). The overall percentage of abnormalities discovered in all these groups was only 10.2 (cf. rheumatoid arthritis 9.8) or ten of a total of ninety-eight patients. The smallest incidences of such abnormalities are apparently associated with ankylosing spondylitis and arthritis of unknown aetiology. Only one case each of polyarthritis nodosa and sarcoidosis were seen, both having normal sialograms.

Main duct dilatation was the sole sialographic abnormality seen in four control, seven rheumatoid arthritis, one sicca syndrome and one arthritis of unknown origin cases and combined with sialectasis in one control, nine Sjøgren's syndrome complicated with rheumatoid arthritis, one Sjøgren's syndrome with systemic lupus erythematosus, eleven sicca syndrome, two psoriatic arthritis and one progressive systemic sclerosis cases. As the definition indicates main duct dilatation and atrophy were never associated. Three hundred and twenty-three glands were completely normal or had duct dilatation as the only abnormal finding. Such a secondary finding was extremely uncommon (13 cases or 4.0 percent). On the other hand 45.5 percent of the glands demonstrating sialectasis also demonstrated main duct dilatation, this dilatation occurring with increasing frequency with increasing degrees of sialectasis. These results are tabulated in Table XI (T. & I. 90) from which it can be seen that main duct dilatation was present in 43.8 percent of the cases of globular sialectasis and 75.0 percent of the cavitary sialectasis cases but only in 26.1 percent of those showing punctate sialectasis.

An even more pronounced increase in the prevalence of retention of contrast medium within the gland five minutes after the completion of sialography, as detected on the secretory films, was noted with increasing severity of sialectasis, as can be seen in Table XII (T. & I. 91). Not one case of punctate sialectasis and only six, or 37.5 percent of globular sialectasis demonstrated this additional feature compared with thirteen or 81.3 percent of the patients with cavitary sialectasis. This feature was also seen twice with atrophy but never at all when duct dilatation was an isolated finding on the sialograms.

(b) Discussion : There is increasing evidence that subclinical forms of Sjøgren's syndrome occur in patients with rheumatoid arthritis. Thus many have focal lymphocytic sialadenitis in the major (Waterhouse and Doniach, 1966) and minor (Bertram, 1967; Chisholm and Mason, 1968) salivary glands and approximately 25 percent have salivary duct antibody in their serum (MacSween, Goudie, Anderson, Armstrong, Murray, Mason, Jasani, Boyle, Buchanan and Williamson, 1967). In this study 9.8 percent of one hundred and twenty-three rheumatoid arthritic patients had sialographic abnormalities in the parotid glands and five of these twelve abnormal cases had sialographic pictures frequently associated with Sjøgren's syndrome. The prevalence of sialographic abnormalities, especially these particular abnormalities, is higher among these patients than the control patients. There is little or no evidence that sialectasis is due to a congenital abnormality such as occurs in the bronchi in certain cases of bronchiectasis (White, 1965) and it seems likely that these sialographic abnormalities represent the focal Sjøgren's lesions described by Waterhouse and Doniach (1966). Although my evidence is slight it would be wrong, therefore, to consider Sjøgren's syndrome as anything other than an almost integral part of rheumatoid arthritis.

It could well be that this study is, in fact, the first systematic sialographic study of the parotid gland in a group of patients with rheumatoid arthritis. The only studies which might possibly be compared with it are those of Ericson (1967), Ericson (1968) and Ericson and Sundmark (1970). However, a close scrutiny of these has led me to the conclusion that a proportion of the patients studied in each instance may have actually been patients with Sjøgren's syndrome. In the first paper (Ericson, 1967) fifty-four patients with definite or classical rheumatoid arthritis had bilateral parotid sialography. Six patients proved to have bilateral sialectasis, one atrophy and two main duct dilatation alone. However, four of these patients had signs and symptoms of xerostomia and another had swollen parotid glands. Thus only four patients (7.4 percent) who definitely did not suffer from Sjøgren's syndrome, had evidence of sialographic abnormalities. These findings would closely resemble those of my control group although Ericson's control group was healthier. I stated earlier (Chapter 5, Section III) that I radiographed only the parotid gland in this study. Moreover, in almost every case, I radiographed one gland only because a small study of ten patients with Sjøgren's syndrome showed that eight had similar bilateral changes and only two, with slight punctate sialectasis, had one side alone affected. However, if even two of my rheumatoid arthritic patients, with abnormal sialograms, had unilateral changes only, my percentage of abnormal glands would fall from the figure of 9.8 percent stated above to one more closely related to that of 7.4 percent which I have calculated from the details included in Ericson's paper. In the second study

(Ericson, 1968) ninety-one patients and one hundred and seventy-eight glands were studied and thirty-four (19.1 percent) of these glands were found to be abnormal. Five of these abnormalities were due to the presence of salivary calculi leaving a total of twenty-nine glands (16.3 percent) in nineteen patients with changes consistent with abnormalities found in the connective tissue diseases. These were:- 17 punctate, 8 globular and 2 cavitary sialectasis (17 patients), one atrophy and one main duct dilatation. No clinical details are given to indicate whether, in fact, any of these patients may have had symptoms or signs of Sjogren's syndrome other than rheumatoid arthritis. However, apparently, a parallel study of the parotid salivary secretion of ninety-two patients (Ericson and Jacobbson, 1968) included the ninety-one patients studied sialographically. Evidence is produced that eleven of these ninety-two had swollen parotid glands, fourteen changes of the oral mucosa typical of Sjøgren's syndrome and thirteen subjective xerostomia. Thus all nineteen patients with sialographic abnormalities may, in actual fact, have had Sjøgren's syndrome. It is, however, more likely that only some of them had this condition. This statemeht is re-inforced in the third paper by Ericson himself, working with Sundmark (1970) when it was discovered that fifteen (31.3 percent) of a group of forty-eight patients with rheumatoid arthritis actually fulfilled the criteria for Sjøgren's syndrome.

The largest group of patients with Sjøgren's syndrome so far studied by means of sialography was one of thirty-seven (Bloch, Buchanan, Wohl and Bunim, 1965). A hand injection technique was used and thirty-six of the patients were found to have sialectasis, seven having the punctate variety, fourteen punctate with intermediary duct involve--ment, eight globular and seven cavitary or destructive. The classification used is very similar to mine with the exception that I distinguish sialectasis and duct involve--ment in my primary classification. This series of patients represented a very severe and extreme form of Sjogren's syndrome having been referred from throughout the United States of America to the National Institute of Health, whereas my study of one hundred and two patients includes very mild to extremely severe cases. Nevertheless my study shows highly significantly more sialographic abnormalities in this group than in either the control or rheumatoid arthritic group.

Changes were seen in 58.8 percent of the one hundred and two cases. Forty-seven of the sixty abnormal cases demonstrated one or other of the sialectatic patterns. A number of different conclusions concerning the nature of these patterns have been reached. Conceivably they may be the result of rupture of the terminal intralobular ducts with "puddling" of the contrast medium in the surrounding glandular tissue as has been suggested by Patey and Thackray (1955), Thackray (1955) and Patey (1965), a suggestion supported by Maynard (1965) and Wilson (1966). Bloch, Buchanan, Wohl and Bunim (1965) differ somewhat from this opinion stating that sialectasis is probably due to "distortion or ectasia of the ducts or 'weakness' of the duct walls, which permits 'puddling', or periductal extravasation of injected radiopaque dye". In contrast Prowler, Bjork and Armstrong (1965) have suggested that the sialographic appearances are due to gross enlargement of the secretory acini at the proximal ends of the terminal ducts, or, possibly, represent small intra-glandular abscesses, a view proposed also by Aubert and Guerin (1949). However, water soluble contrast media, such as have been used in this study, would not be expected to form well defined globules, typical of liposoluble contrast media, following extravasation (Garusi, 1964). I have no histological proof that such extravasation did not occur but studies by Blatt, Rubin, French, Maxwell and Holt (1956), Becker, Matzker and Ruckes (1960), Garusi (1963) and Ericson (1968) have shown that the radiographic appearances of sialectasis correspond closely to histological duct ectasia on subsequent biopsy specimens. Other workers (Seifert and Geiler, 1957; White, 1963; Seifert, 1965) have also shown definite ectatic changes in the parotid ducts. Furthermore, Einstein (1966) correlated the radiological and surgical findings in eleven advanced cases of sialectasis, the radiological diagnosis being proved correct in them all, as a result of the further histopathological examinations. I am of the opinion, like these other workers, that sialectasis represents dilations of the terminal intralobular ducts and that this opinion is re-inforced by the fact that only nineteen (34.5 percent) of all the fifty-five glands which demonstrated sialectasis in the complete study also demonstrated retention of contrast medium, most of these cases being associated with the most severe grades of sialectasis and a correspondingly greater reduction in the secretory potential of these glands. If the contrast medium had actually been present in the surrounding glandular tissue I would have expected a much higher incidence of retention of contrast medium in glands which demonstrated sialectatic changes. Atrophy was detected in twelve cases, main duct dilatation in twenty-two and retention of contrast medium on the five minute secretory film in twenty. Both main duct dilatation and, especially, retention of contrast medium were more commonly associated with the severer grades of sialectasis. This is not unexpected as both are, probably, measures of decreased secretory capacity.

Cavitary sialectasis was markedly more common in patients with the sicca syndrome. Conversely atrophy, shown to be a relatively common sialographic abnormality, and the total frequency of all such abnormalities were discovered to predominate in the Sjøgren's syndrome complicated with rheumatoid arthritis group. It may be that the salivary glands are either less severely or much more severely involved in the sicca syndrome as further instanced by the more frequent findings of main duct dilatation and retention of contrast medium in that group also. On the other hand these additional findings may only verify that this sicca syndrome group contained a biased majority of severely affected cases. Further study is needed to determine the true relevance of these findings.

Although Sjogren's syndrome has been associated with the other connective tissue diseases no investigations of sialographic abnormalities have been carried out in any large series of patients with these diseases. I, incidently, found sialographic abnormalities in two of the total of nine patients with systemic lupus erythematosus and one of seven with progressive systemic sclerosis in the absence of other evidence of Sjøgren's syndrome. In addition three abnormal sialograms were found in the group of patients with psoriatic arthritis, two in a group with Reiter's syndrome and one in a group with ankylosing spondylitis. This may be further evidence that there are mild or subclinical forms of Sjøgren's syndrome, as I suggested when discussing rheumatoid arthritis, and that any of these conditions may predispose to them. Clearly there is a need for further investigations of these aspects of these diseases. The main duct dilatation found in the arthritis of unknown aetiology group is probably of no significance at all, such a finding being made relatively more frequently in the control group.

6.ii) AN EVALUATION OF HYDROSTATIC SIALOGRAPHY AS AN INDEX OF SALIVARY GLAND INVOLVEMENT IN SJØGREN'S SYNDROME

(a) <u>Results</u> : The results of this study are detailed in Table XIII (T. & I. 92). Forty-five (36.3 percent) of the sialograms proved to be normal, and seventy-nine abnormal. The primary abnormalities reported were twenty-nine punctate sialectasis, fifteen globular sialectasis, fifteen cavitary sialectasis, fourteen atrophy and six main duct dilatation. Proportionately fewer abnormal glands were reported as a result of sialography in the Sjøgren's syndrome complicated with rheumatoid arthritis (47 of a total of 84, or 56.0 percent) than in the sicca syndrome group (32 or a total of 40, or 80.0 percent) among which by far the most cases of cavitary sialectasis were found but also a small minority of atrophic glands. The sialographic abnormalities discovered in the Sjøgren's syndrome complicated with rheumatoid arthritis group were nineteen punctate sialectasis, ten globular sialectasis, four cavitary sialectasis, ten atrophy and four main duct dilatation with no evidence of any other sialographic abnormality. The corresponding figures for the sicca syndrome group were ten punctate, five globular and eleven cavitary sialectasis, four atrophy and two main duct dilatation alone. The mean lemon juice stimulated parotid salivary flow rate of those glands with normal sialograms was 0.85 (S.E.M. ± 0.068) millilitres per minute. The comparable figure for an age and sex-matched control group, not having evidence of connective tissue disease, Sjøgren's syndrome or other salivary gland disease was 1.29 (S.E.M. ± 0.12) millilitres per minute which is significantly higher ($t = 3.1429$, $p<0.005$). However, the mean flow rate of those glands with punctate sialectasis was 0.38 (S.E.M. ± 0.041) millilitres per minute which is highly significantly lower ($t = 6.2851$, $p<0.0005$) than the value obtained for those diseased patients whose sialograms were normal. The mean flow rate for those glands showing globular sialectasis was slightly but not significantly lower than this figure being 0.34 (S.E.M. ± 0.063) millilitres per minute, whereas it was highly significantly higher ($t = 2.7815$, $p<0.0005$) than the value obtained for glands exhibiting cavitary sialectasis of 0.13 (S.E.M. ± 0.004) millilitres per minute. The fourteen salivary glands showing the changes of atrophy on sialographic examination had a mean parotid flow rate of 0.25 millilitres per minute (S.E.M. 0.052 millilitres per minute). When compared to the mean parotid flow rates of those patients with Sjogren's syndrome who had normal sialograms the sifference was again noted to be highly significant ($t = 7.1207$, $p<0.0005$). It was also almost significantly lower than the value obtained from those glands with punctate sialectasis ($t = 1.9825$, $p<0.05$). However, no significant difference was noted between the mean flow rates of those glands showing atrophy and globular sialectasis although the value for cavitary sialectatic glands was only slightly significantly lower ($t = 1.8741$, $p<0.05$) than the value for atrophic glands. It is interesting to note that the mean parotid flow rate of those patients whose sialograms show main duct dilatation alone was 0.32 (S.E.M. $\pm$ 0.067) millilitres per minute which is lower than the mean flow rates of those patients manifesting punctate and globular sialectasia although not significantly so. This value is significantly lower ($t = 6.7317$, $p<0.005$) than that obtained for patients with Sjøgren's syndrome with normal sialograms and significantly higher ($t = 2.7424$, $p<0.01$) than that obtained for those with cavitary sialectasis.

In addition, I examined the groups showing sialectasis to try to ascertain whether duct dilatation or retention of contrast medium on the five minute secretory film was associated with a greater reduction in salivary flow rate than those glands not showing these changes. However, the numbers were small and could not be subjected to statistical analysis. There was, nevertheless, a tendency for flow rates to be slightly lower where duct dilatation or retention was noted in addition to the predominant sialographic abnormality. Six of fifty-one glands (11.8 percent) demonstrated main duct dilatation alone whereas this feature was coupled with punctate sialectasis twice, globular sialectasis five times and cavitary sialectasis eight times (Table XIV) (T. & I. 93). With the exception of the group of patients with punctate sialectasis the incidence of main duct dilatation increased with more severe grades of sialectasis. Statistical analysis using the chi-squared test, with a Yates' correction for small numbers, showed that the prevalence of main duct dilation with cavitary sialectasis was highly significantly higher than main duct dilatation alone ($\chi^2 = 11.9841$, $p<0.001$). The prevalence of main duct dilatation with globular sialectasis was not, however, signifi--cantly different from either main duct dilatation alone or main duct dilatation with cavitary sialectasis.

(b) <u>Discussion</u> : The purpose of this study was to assess whether or not the apparent degree of parotid gland abnormality recorded as a result of sialographic examination correlated with diminution of parotid gland function as assessed by the capacity of the gland to secrete saliva in response to lemon juice stimulation. I have shown that patients with Sjøgren's syndrome who have normal sialograms have higher parotid flow rates than patients demonstrating sialographic abnormalities. The mean parotid flow rate decreases with increasing degrees of sialectasis and extremely low flow rates were recorded in those patients with cavitary sialectasis. However, it is interesting that patients with globular sialectasis do not have a significantly lower parotid flow rate than those with punctate sialectasis although the mean value is slightly lower. This suggests that the degree of parotid involvement is probably of similar severity in patients demonstrating punctate and globular sialectasis. Atrophy of the duct system, as shown by sialography, is associated with considerable gland dysfunction. The reduced mean flow rate is almost significantly lower than that observed in the presence of punctate sialectasis. This finding is not altogether unexpected as Ericson (1968) showed that patients with duct atrophy had severe histological changes on parotid gland biopsy. Only six glands demonstrated main duct dilatation as the only abnormality on sialograms. If only those glands with a normal sialographic appearance or main duct dilatation as an isolated feature are considered, this represents 11.8 percent of the glands in the Sjøgren's syndrome group or 4.3 percent of all such glands examined in this study. This figure, however, is not lower than I expected in the light of my first study when only one of the patients with Sjøgren's syndrome and 3.0 percent of all the patients with a similar sialographic appearance showed this feature (Tables XI and XV) (T. & I. 90 & 94). It is of considerable interest that the mean parotid flow rate in these six patients was significantly lower than the mean flow rate in those patients with Sjøgren's syndrome who had normal sialograms. This suggests that even in the absence of sialographic evidence of damage to that part of the salivary gland concerned with saliva formation a significant decrease in function may have occurred. This opinion is supported by the further evidence obtained from the control series whose mean flow rate was significantly higher than that of those of the Sjøgren's syndrome group who had normal sialograms.

Maynard (1965) attempted to correlate sialographic abnormality with salivary flow rates in seventy-three patients with recurrent parotid swelling of whom seven had Sjøgren's syndrome. He noted that sialectasis alone or sialectasis associated with minor duct changes was associated with normal flow rates, whilst sialectasis with main duct changes and main duct changes alone were associated with reduced flow rates. This would suggest that main duct changes are associated with considerable gland dysfunction. It is difficult to conceive how structural changes in the main duct other than obstructive changes could cause a reduction in salivary flow. Blatt, Rubin, French, Maxwell and Holt (1956) and Ericson (1968) have suggested that changes in the main duct are probably the result of infection secondary to diminished flow rate. It would, therefore, be logical to expect a higher incidence of main duct dilatation associated with salivary glands showing severe grades of sialectasis. This is certainly the case in this particular study, significantly so as far as cavitary sialectasis is concerned. However, the results detailed in the previous chapter (Table XI) (T. & I. 90) are even more convincing. They suggest, in fact, that the recording of only two cases with main duct dilatation in association with punctate sialectasis out of a total of twenty-nine cases of punctate sialectasis is unusually low and even that the incidence of this condition in association with globular and cavitary sialectasis reported in this study may also be low. It would also be realistic to expect a higher incidence of retention of contrast medium in association with a greater severity of sialectasis because of the very reduced flow rates associated with such conditions. The results obtained in the previous chapter (Table XII) (T. & I. 91) also emphatically support this supposition. It should be remembered when considering this set of results that retention of contrast medium was sought after a lapse of five minutes. Therefore, there could have been a longer clearance period that is normally the case in some of the other glands, which demonstrated sialectasis but not retention of contrast medium on the five minute secretory film. I have already mentioned that main duct dilatation alone appears to be a fairly constant finding, if anything slightly exaggerated, in this study of sixty-four patients with Sjøgren's syndrome.

It would thus appear that the severity of sialographic abnormalities is to a large extent paralleled by a decrease in parotid gland function as shown by lemon juice stimulated parotid salivary flow rates. However, this is by no means constant, as some patients with sialograms which are normal but for main duct changes have a mean parotid flow rate lower than that obtained for patients with punctate sialectasis or with globular sialectasis. It would also be reasonable to conclude that the amount of salivary gland destruction between patients having punctate or globular sialectasis is not very marked as there is little difference between the mean parotid flow rates of these two groups. This data supports the view that salivary flow rates provide a more sensitive index of salivary gland disease than sialography and this has been confirmed by the observation that patients with Sjøgren's syndrome whose sialograms are normal have a significantly lower mean parotid flow rate than age and sex matched control subjects. As a result of these findings the position of sialography in the diagnosis of Sjøgren's syndrome has been advanced.

It is evident from Table XIII (T. & I. 92) that some patients with either punctate or globular sialectasis must have had normal flow rate values. Sialography was, obviously of greater value in the diagnosis of these cases as it was in two suspected cases of Sjøgren's syndrome seen by myself recently. Both had normal salivary flow rate values but revealed widespread globular sialectasis on their sialograms. Similarly, Mason (1966) described twelve abnormal sialograms of patients with Sjøgren's syndrome and related the flow rate values of these glands to them. In three cases the flow rate values were normal. It is not, however, by detecting the exceptions that prove the rule that the technique of sialography has advanced but by more critical selection of which parotid gland should be radiographed. A small study of ten patients has largely substantiated the opinions of Garusi (1964) and Ericson (1968) that, because Sjøgren's syndrome affects both parotid glands, initially sialographic examinations need only be a unilateral procedure in its diagnosis. If salivary flow rates have been completed the gland with the lower flow rate value is the one selected.

6.iii) THE COMPARATIVE SEVERITY OF SALIVARY GLAND INVOLVEMENT IN SJØGREN'S SYNDROME, COMPLICATED WITH RHEUMATOID ARTHRITIS, AND SICCA SYNDROME, AS DETERMINED BY SIALOGRAPHY

I suggested in Chapter 6, Section i, b, that further study was needed in order to determine the relative severity of salivary gland involvement in Sjøgren's syndrome and sicca syndrome. I was uncertain whether a biased sample of sicca syndrome patients, showing evidence of a lower frequency of salivary involvement but also, contrarily, a higher incidence of glands with cavitary sialectasis, had been studied, or, in fact, sicca syndrome was associated with more severe salivary change as demonstrated by sialography. An opportunity for such a study arose as a result of my comparative investigations of sialography and parotid flow rates. The pertinent results from both studies are shown in Table XV (T. & I. 94).

It can be seen, from this table, that the percentage of abnormal sialograms may, in fact, be greater among a group
with sicca syndrome than a corresponding group of patients
of patients/with Sjøgren's syndrome associated with rheumatoid arthritis. In fact, contrary to the results of my first study (designated study A in the table) where this percentage was considerably, but not significantly, lower in the sicca syndrome group, I found it to be significantly higher ($\chi^2 = 6.7774$, $p<0.01$) in the second study (designated study B in the table).

In addition, confirmation was provided of the markedly higher incidence of cavitary sialectasis among patients with sicca syndrome (Study A - $\chi^2 = 4.8025$, $p<0.05$: almost significant; Study B - $\chi^2 = 13.1750$, $p<0.0005$: highly significant). I remained concerned that the higher incidence of atrophy in both groups of patients with Sjøgren's syndrome associated with rheumatoid arthritis might in fact indicate a similar degree of salivary involvement in the two separate manifestations of this condition, as my salivary flow results had indicated that, next to cavitary sialectasis, atrophy was the most severe sialographic finding. However, I paired atrophy and cavitary sialectasis and discovered from study B that their combined frequency was almost significantly greater in the sicca syndrome group of patients ($\chi^2 = 6.538$, $p<0.02$). In addition, the increased prevalences of atrophy in the Sjøgren's syndrome associated with rheumatoid arthritis group never reached significant values. It would appear, therefore, that sicca syndrome is associated with more severe salivary abnormality, as demonstrated by sialography, than Sjøgren's syndrome associated with rheumatoid arthritis. This would be in accord with the findings of more symptoms of xerostomia and a much higher incidence of a history of, or the actual presence of, parotid gland enlargement in sicca syndrome described by Bloch, Buchanan, Wohl and Bunim (1965).

6.iv) SUMMARY AND CONCLUSIONS

Apparently, these are the first large studies to be described in which sialography was not performed by a hand-injection technique. Smaller studies have been described but these have been of a general nature in no way placing emphasis on any aspect of the connective tissue diseases. The control of pressure and consequent elimination of the possibility of ductal and capsular rupture, and of a considerable amount of patient apprehension, are two considerable advantages of the technique of hydrostatic sialography which I used. Another is the control of the volume of contrast medium used. It may be seen, from Tables VII and IX (T. & I. 86 & 88) that the mean volume of contrast medium needed to fill the parotid duct system varied considerably between clinical groups. The significance of this is somewhat obscure but does not appear to be abnormal in the presence of Sjøgren's syndrome, sicca syndrome or the connective tissue diseases associated with Sjøgren's syndrome. It does, however, show how relevant my comments in relation to Table VI (T. & I. 50) were. The use of water soluble contrast media as an integral part of this tecnnique of hydrostatic sialography may have helped to resolve the different interpretations of sialectasis especially if the full implications of the five minute secretory film are taken into account.

The incidence of salivary gland involvement in Sjøgren's syndrome was found to be highly significantly more common than in rheumatoid arthritis alone or in a group of patients without evidence of rheumatic disease. However, the study also revealed that there may, in fact, be sub-clinical forms of Sjøgren's syndrome in rheumatoid arthritis and other rheumatic disorders. In addition, the degree of involvement would appear to be more severe in patients with sicca syndrome alone than in those who have rheumatoid arthritis as one of the features of their disease.

The degree of salivary gland involvement shown by sialography related well with that demonstrated as a reault of salivary flow rate studies. In fact, punctate and globular sialectasis appear to be manifestations of a very similar degree of severity of the disease. The technique I used to examine the salivary glands was able to be further improved as a result of this particular investigation because it was shown that it was, generally, not so precise as the measurement of salivary flow rates. Therefore, an indication of these rates provides a useful indication as to which parotid gland would be the better to examine by sialography.

Main duct dilatation and/or retention of contrast medium on the secretory film in addition to a primary feature of sialectasis or atrophy appear to indicate a greater severity of salivary gland involvement than if the primary feature is present alone. It might, therefore be worthwhile considering expanding my classification of sialographic abnormalities in the event of any future large studies of a nature comparable to this one. The principal divisions would remain but they would be subdivided to give a more definite indication of the full degree of salivary gland involvement. For example, cavitary sialectasis would remain a principal division which would include the subdivisions cavitary sialectasis alone, cavitary sialectasis plus main duct dilatation, cavitary sialectasis plus retention and cavitary sialectasis plus main duct dilatation plus retention.

SECTION IV

THE TEMPOROMANDIBULAR JOINT STUDY

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CHAPTER 7

CIRCULAR TOMOGRAPHY

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7.i) INTRODUCTION

The incidence of temporomandibular joint involvement in various diseases has been the subject of much dispute over the last three decades. I described in Chapter 3, for example, estimates varying between 4.7 percent (Ragan, 1949) and 86 percent (Ericson and Lundberg, 1967) of such involvement by rheumatoid arthritis. The reason for these widely discrepant figures may have been the difficulty of radiographing this joint because of its close proximity to the dense petrous portion of the temporal bone. I indicated the gravity of this problem in Chapter 2, when I described eight accepted lateral and lateral-oblique projections and three linear tomographic techniques, all of which are used for this purpose. I considered it to be vitally important, therefore, before commencing my study of rheumatoid arthritis and the temporomandibular joint, for me to select a primary radiographic technique and two secondary techniques for examining the temporomandibular joint, to thoroughly evaluate the accuracy and reproducibility of my primary technique and to carefully compare it with my two secondary techniques. I was fortunate in being able to use Circular Tomography and Orthopantomography in addition to a number of conventional lateral skull techniques. After a full investigation I selected Circular Tomography as my primary technique and Orthopantomography and a method of lateral transcranio-oblique radiography as my secondary techniques. This chapter is devoted to an evaluation of Circular Tomography and a comparison of it and the other two selected methods because I feel that if my methods of examining the temporomandibular joint are not totally acceptable neither can the results of this study be totally acceptable.

7.ii) A CRITICAL EVALUATION OF THE ACCURACY AND REPRODUCIBILITY OF A TECHNIQUE

(a) Materials and Methods

(1) Subjects - Twenty-one subjects, eighteen female and three male, were examined. Seven of the females had rheumatoid arthritis, five osteoarthrosis, and six were completely free of any form of rheumatic disease, whereas two of the men had osteoarthrosis and one no evidence of any generalised joint disease. Thus there were seven patients in each of the clinical categories described. Eight patients, distributed between these three groups, had clinical evidence of temporomandibular joint disturbance. The mean age of all the patients was fifty-five years, the age range being twenty-three years to seventy-seven years. This varied cross section of patients was selected in order to ensure that the technique, if proven to be satisfactory, would be seen to be applicable to future studies of different diseases affecting the temporomandibular joint.

(2) Circular Tomography - The technique under review was, as stated in the Introduction, circular tomography. A CRT-7 unit* was the one I used. Technical details of each exposure were:- KV 80; mAs 160 (40 mA for 4 seconds); Diaphragms - 15:15, multileaf and 10 iris; Cone - 70 mm.,

* Elema-Schonander AB, Stockholm, Sweden.

field; Kodak fast films 5 inches x 7 inches (13 cm. x 18 cm.) in a Siemens cassette with Ruby screens (high definition) were used, the anode-film distance being 44 inches (112 cm.) and the temporomandibular joint film distance 12 inches (30.5 cm.). After exposure the films were processed automatically in the XR-Minor T*.

Each patient was radiographed on two separate occasions, the intervals between these examinations varying between half-an-hour and one week. The apparatus was reset prior to each examination. One joint only was examined in each case, its choice being made randomly at the first examination. As a result the left side was studied in nine patients and the right side in twelve patients. I instructed the radiographer which joint to examine on the second occasion to ensure that radiography of the same joint was completed each time.

The patient was seated with the head ereet so that the central ray passed through the temporomandibular joint being radiographed. The surface marking of the joint was taken as a point 7.5 mm. in front of the tragus of the ear, and it was by using this point that the joint was, in fact, aligned with the centre of the field. The cheek was flattened against the object table and the head held steady with adjustable head clamps (Figures 80 to 82) (T. & I. 95-97). In practice this meant that the zygomatic arch was parallel with the film. The depth of section was then adjusted so that it would fall on a

* Refrema, Denmark.

plane drawn through the outer canthus of the eye parallel with the object table. The average depth of cut was found to be approximately 1.7 cm. One of the advantages of the CRT-7 unit is the facility with which all these settings can be made. Two radiographs of the joint were taken on each occasion, the first with the teeth in normal occlusion and the second with the mouth maximally open. Edentulous patients wore their dentures throughout the initial part of the examination in order to achieve normal occlusion.

(3) Measurements made on radiographs - I used a modific--ation of the technique described by Madsen (1966). On every film the length (L) and depth (D) of the articular fossa were measured. The derivation of these parameters is illustrated in Figure 83 (T. & I. 98). In this figure X represents the edge of the squamotympanic fissure. From X a line was drawn to form a tangent with the articular eminence, the point of contact being marked Y in the diagram. The distance between X and Y represents L. A tangent to the articular fossa, parallel to L, was then drawn. The perpendicular distance between this tangent and L is D. The minimum distance between the head of the condyle of the mandible and the articular fossa was measured on those radiographs taken with the teeth in occlusion and designated A (Figure 84) (T. & I. 99). On the open-mouth films, the relationship of the mandibular condyle to the articular eminence was measured. This value, referred

to as P, was derived as follows:- through point Y a perpendi- -cular was drawn to line L (refer to Figure 83) (T. & I. 99). Another line was drawn parallel to this perpendicular through the midpoint of the condyle, the midpoint being taken as the centre of the circle which most neatly fitted within the condyle. The perpendicular distance between these two parallel lines is P. The value of P was accorded a plus sign if the condyle lay anterior to or a minus sign if it lay posterior to the articular eminence (Figures 85 and 86) (T. & I. 100 & 101).

Lines were laid on the films using a very narrow adhesive strip 0.4 mm. wide (Tape Pen)*. These could be removed between observations without damaging the emulsion, thus ensuring the independence of each observer's measurements, for which an eight-power Brinell measuring magnifier ** was used. The scale of this instrument is 1 cm. long and is subdivided into millimetres and tenths of a millimetre so the figures could be expressed with absolute accuracy to 0.1 mm. Representative examples of radiographs, examined in this study are shown in Figures 87 to 89 (T. & I. 102-104). I read the radiographs on two separate occasions one month apart and my colleagues Mr. Thomas G. Leggat and Dr. Ian M. Chalmers both read them on one occasion. In this way I was able to assess my own intra-observer error and also compare my results with those

* Chart-Pak Inc., Leeds.

** Leitz Wetzlar

of a dental colleague and of a specialist medical colleague, the latter having no particular knowledge of dental radiology, unlike the former.

(4) Reporting of radiographs - I reported each film on the same occasions as I read these measurements. In other words I reported two sets of films on two occasions one month apart. The position of the condylar head in the articular fossa with the teeth in occlusion was first noted and described as "normo-", "antero-" or "retro-" position. Its range of movement was described as "reduced, "normal" or "increased" according to its position relative to the articular eminence in the open-mouth films. The normal range was taken as -4 mm. to +4 mm., as described for P above. In each case, the presence of reduced inter-articular space, which was defined as a distance of less than 0.5 mm., subluxation and ankylosis was sought. The condition of the calcified structures was then considered and the presence of osteoporosis, sclerosis, surface or pocket erosions, subchondral cysts, flattening and marginal proliferations of the condylar head and abnormal calcification of the articular disc were recorded. The position of the condylar head was stated to be normal or abnormal, as was its condition. In common with Lundberg and Ericson (1967) I did not consider osteoporosis alone to be an abnormality. A joint was regarded as normal only if its various positions and the condition of the calcified structures had already been described as normal.

(b) Results and Discussion

(1) Results - The results of this study are summarised in Tables XVI to XXI (T. & I. 105-110), Table XVI (T. & I. 105) gives the mean values (± standard error of mean) of the measurements obtained from the radiographs of the twenty-one tempormandibular joints. The first set of radiographs is referred to as series I and the radiographs taken on the second occasion as series II. Table XVII (T. & I. 106) compares the figures for series I with those for series II and aims to quantitate the reproducibility of the technique. The first two columns give the means of the differences between the two sets of figures and their standard error. Values of t were calculated by the Student's t test for paired variables and the p values are those for the relevant t value, the degrees of freedom being twenty. Where the p value is more than 0.05 it is recorded as not significant (N.S.). Table XVIII (T. & I. 107) compares my two sets of measurements performed one month apart and Table XIX (T. & I. 108) compares the results of myself and my two colleagues using my first set of measurements together with those of Mr. Leggat and Dr. Chalmers. The figures in these two tables were derived similarly to those in Table XVII (T. & I. 106). Table XVII (T. & I. 106) thus assesses the reproducibility of the technique and Tables XVIII and XIX (T. & I. 107 & 108) provide an estimate of its accuracy, the former comparing myself on two separate occasions and the latter supplying the interobserver error. Tables XX

and XXI (T. & I. 109 & 110) compare my radiological reports. Table XX (T. & I. 109) shows the percentage concordance between these reports on the first and second sets of films and Table XXI (T. & I. 110) the percentage concordance between my initial reports and those I completed a month later. These two tables thus provide measures of reproducibility and of intra-observer accuracy in radiological reporting respectively.

(2) Discussion - I studied twenty-one joints, one from each of twenty-one patients some of whom had known joint disease using the CRT-7 unit in order to determine the accuracy and reproducibility of radiographs produced by circular tomography of the temporomandibular joint. Technical difficulties were experienced with some rheumatoid arthritic patients because of their generalised deformities, but they were included nonetheless as part of the trial of the technique. Two sets of radiographs were obtained of each joint in order to assess the reproducibility of the technique. Each set consisted of two views of the joint and on each radiograph measurements were made by three different observers, including myself, using a modification of the Madsen method (Madsen, 1966). This method was used because the anatomical points, between which the measurements are made, are easily identified by inexperienced observers, particularly so on radiographs of good quality. Other methods of measurement, including those of Andres (1939), Ricketts (1950) and Lindblom (1960), were considered but

appeared to be more complicated or less exact. I completed the measurements on every radiograph on two separate occasions and also qualitatively reported them on these occasions. Data obtained from the measurements and reports were compared in various combinations in order to obtain estimates of reprodu--cibility and intra- and inter-observer error.

There were no statistically significant differences between the two series of radiographs for most of the measurements, the exception being some of the values for the length of the articular fossa (L), where the difference was reported by myself three times and by Dr. Chalmers once to be statistically significant and by Mr. Leggat once to be almost significant (Table XVII) (T. & I. 106). I can think of no adequate explanation for this discrepancy especially as all the values for all the other parameters showed no significant difference. I feel, therefore, that I am justified in concluding that this technique has an acceptable degree of reproducibility.

Intra-observer error (Table XVIII) (T. & I. 107) was found to be negligible. By contrast, several of the inter-observer differences achieved statistical significance. There were fourteen such observations out of a total of thirty-six observations, six (two almost significant, two significant and two highly significant) when I was compared with Mr. Leggat, seven (one almost significant, three significant and three highly significant) when I was compared with Dr. Chalmers but only one (significant) when Mr. Leggat and Dr. Chalmers were compared. It may be noted from Table XIX (T. & I. 108) that I have not included comparisons between my second set of readings and those of my colleagues. The reason for this is that, not surprisingly in view of the foregoing, the results obtained were exactly comparable with those which are detailed. Interobserver error may thus be significant and care should thus be taken in comparing different observers' results.

I used the Student's t test for paired variables in making all the statistical comparisons described in this chapter. This is an extremely sensitive statistical tool and even where statistical differences were demonstrated, the actual values for the means of the differences were uniformly less than 1 mm. The widest range was that for some of the L values in the reproducibility study, these varying from 0.0 mm. to 5.6 mm. Despite the wide range, the majority of the differ--ences were of the order of 1 mm. In the interobserver study, the actual values of the means of the differences were very small, of the order of 0.1 to 0.5 mm., and the ranges likewise were small, being of the same order of magnitude, yet some of the differences achieved significant levels. I conclude that the reason for the achievement of these significances was that the interobserver differences, although very small, were consistent.

The magnitude of the differences between sets of radiographs and between different observers and the same observer must be compared with the values of the measurements themselves. When this is done, it becomes evident that the error is a small percentage of the total measurement. For example, in some instances where highly significant differences were obtained, the percentage error was of the order of 2.5. In terms of clinical radiological practice, this is sufficiently small to be negligible. The situation is analogous to that sometimes encountered in clinical therapeutic trials where statistically significant differences may be obtained but where the magnitude of the differences is insufficient to influence a change in therapeutic policy (Atkins, 1966). The present study indicates a high degree of reproducibility and a negligible observer error in interpreting circular tomograms of the temporomandibular joint.

The results of the study of the qualitative interpretation of the radiographs similarly show a high degree of reproducibi--lity and a small intra-observer error, which immediately lessens if, as I have stated, osteoporosis alone is not considered an abnormality. This aspect of my investigation could not be meaningfully quantitated because of the nature of the features being assessed. An attempt could be made, I suppose, to "quantitate" many of the features, for example, on the basis of the English adjectives of degree - slight +1, moderate +2, severe +3, very severe +4 - but this would merely ascribe a numerical value to a qualitative observation. Mainland (1967), discussing the estimation of inflammatory activity in rheumatoid arthritis, commented: "We forget that all numbers are abstractions and that a qualitative description may be nearer to reality".

7.iii) A COMPARISON OF THIS TECHNIQUE WITH ORTHOPANTOMOGRAPHY AND LATERAL TRANSCRANIO-OBLIQUE RADIOGRAPHY

(a) Materials and Methods

(1) Subjects - Twenty-seven patients were examined by both circular tomography and orthopantomography. One examination only was unilateral, the others being bilateral, with the result that fifty-three joints were studied. As in the previous study, radiographs were taken with the teeth in normal occlusion and with the mouth maximally open. In order to subject the techniques to as stringent a trial as possible, patients with joint disease were included again. Forty-six of the fifty-three joints radiographed were in patients with rheumatic disease. Nineteen of the patients were female and eight were male. Their mean age was fifty-six years the age range being twenty-two years to seventy-eight years. Each joint was examined by circular tomography and orthopantomography with the minimum or delay between the application of the two techniques.

A similar, if slightly smaller, group of patients was studied in the circular tomography, lateral transcranio-oblique radiography comparison. Forty-four temporomandibular joints were radiographed by these two methods, on the same occasion and with the minimum of delay, with the teeth in normal occlusion and with the mouth fully open. Nineteen of the total of twenty-two patients suffered from one or other rheumatic disease. The mean age of the group, which was composed of eighteen female and four male patients, was fifty-nine years, the age range being forty-three years to seventy-two years.

(2) Radiography - I have already described the technical details of circular tomography using the CRT-7 unit. Orthopantomography was performed with an Orthopantomograph unit* the principle of which was described in the explanation of tomography in Chapter 2, Section iii (Figures 26 to 29) (T. & I. 26-29). Technical details of each exposure are:- KV 76; mAs 225 (15 mA for 15 seconds); Diaphragm - 1 mm. x 30 mm. (Medium). Kodak Blue Brand films 6 inches x 12 inches (15 cm. x 30 cm.) in a Palomex metal curved cassette were used, the anode-film distance being 18 inches (46 cm.) and were processed in a Refrema XR-Minor-T automatic unit. The patient was positioned, standing or sitting, with the head erect and facing in a postero-anterior position (Figures 90 to 92) (T. & I. 111-113). The central ray was directed to pass through the temporomandibular joints, the depth of cut being 0.6 mm.

Lateral transcranio-oblique radiography was carried out using a Watson Mx II unit**. Details of each exposure are:-

* Palomex OY - Finland.

** Watson & Sons (Electromedical) Ltd., Edinburgh

KV 57 (Stud D); mAs 16 (20 mA for 0.8 second); Diaphragm - 60 mm. field Cone 12.5 cm. length; Filter - 1.5 mm. Al. Kodak Blue Brand (6 views per film) films $8\frac{1}{2}$ inches x $6\frac{1}{2}$ inches (22 .5 cm. x 16.5 cm.) in a Watson's Gold Star cassette with Sierex Saphir (fast) screens were used, the anode film distance being 15 inches (38 cm.). Four exposures were made on each film and processing was again completed automatically in the XR-Minor-T. Each patient was aligned, sitting, in the true lateral position with the head erect, the position being maintained with ear plugs (Figure 93) (T. & I. 114). The central ray was directed downwards at an angle of 12 degrees to the horizontal through the temporomandibular joint being examined (Figure 94) (T. & I. 115).

(3) Radiology - I reported every film taking into account the position of the condylar head in the open and closed positions and the condition of the calcified structures of the joint as described for circular tomograms (Chapter 7, section ii, 4). The films were arranged in random order so that I had no opportunity whatsoever of associating pairs of radio--graphs one with another. In addition I had no knowledge of the identities of the patients at this time. When all the reports were complete all the necessary information about each patient was made available and the various sets of radiographs were identified and paired. Some discordant results became

evident at this time and in these cases further studies, either of repeating the radiography or of rescrutinizing the original films, were made in an attempt to elucidate the reason for the discordance.

In addition tracings were made of a random sample of one-half of both series of radiographs in order to ascertain the degree of magnification of the temporomandibular joint by the different techniques, assuming the value for lateral transcranio-oblique radiography to be zero. Examples of such tracings are illustrated in Figure 95 (T. & I. 116).

(b) Results and Discussion

(1) Results - The comparison between circular tomography and orthopantomography is summarised in Tables XXII to XXIV (T. & I. 117-119) and that between circular tomography and lateral transcranio-oblique radiography in Tables XXV to XXVII (T. & I. 120-122) and the results of the magnification study in Table XXVIII (T. & I. 123).

It will be seen from Table XXII (T. & I. 117) that only thirty-six of the fifty-three sets of radiographs taken, using circular tomography and orthopantomography, when the teeth were occluded could be compared in the concordance study. The reason for this was that fifteen of the orthopantomographs and two of the circular tomographs were not sufficiently clear for definite observations to be made. All of the radiographs taken with the mouth fully open on the other hand, were of value in the concordance study. The concordance figures, for the radiographs that could be compared, show a high measure of agreement. It is clear, from Table XXIII (T. & I. 118) that all sets of radiographs produced by either circular tomo--graphy or orthopantomography, were suitable for studying the condition of the joint and that high concordance values were obtained. Only thirty-six of the fifty-three sets of radio--graphs could, for the reasons already mentioned, be subjected to an overall report, but, of these, only two sets were discordant, giving a high overall concordance of 94.4 percent.

When circular tomographs were compared with lateral transcranio-oblique radiographs it was found that two joints were unclear, in the occluded position, on both sets of films and a further five joints were uncleqr on the radiographs produced by the lateral transcranio-oblique method. Further--more, eight lateral transcranio-oblique radiographs, but no circular tomographs were indistinct in the fully open position. As a result, thirty-seven of the joints radiographed with the teeth in occlusion and thirty-six with the mouth maximally oepn could be compared in the concordance study. Concordance in this part of the examination was slightly more than 80 percent (Table XXV) (T. & I. 120). Five of the lateral transcranio-oblique radiographs were so unclear in both positions that no observations could be made regarding the condition of the condylar head. Thirty-nine joints, out of a possible total of forty-four, were thus included in the concordance study outlined in Table XXVI (T. & I. 121). Concordance in this part of the study was very high if the osteoporosis column was disregarded just as it was when the overall assessments of the various joints were compared (Table XVII)(T. & I. 122).

In order that my criteria of clear and unclear may be understood I selected one good and one bad example of each technique and have had them reproduced in Figures 96 to 101 (T. & I. 124-129).

It can be seen in Table XXVIII (T. & I. 123) that circular tomography produced a linear magnification when compared with both other techniques. This magnification is especially marked in relation to lateral transcranio-oblique radiography which indicates that orthopantomogfaphy also produces some linear magnification. The highest mean magnification was, however, less than 1.30.

(2) Discussion - I have, previously, shown that circular tomography is an accurate and reproducible technique when used in the examination of the temporomandibular joint. Now I have shown that it compares very favourably with two established and well regarded techniques in the demonstration of features of this joint. Concordance values, for individual

observations, of 74.4 percent to 100 percent were obtained while the overall value for the comparison of circular tomo--graphy and orthopantomography was 94.4 percent and for the comparison of circular tomography and lateral transcranio-oblique radiography 97.1 percent. It should be remembered when viewing these figures that any joint was reported as normal overall only if both its position and condition were reported to be normal, that for the purpose of the overall report osteoporosis was not considered to be abnormal if present as an isolated feature (Lundberg and Ericson, 1967), that increased mobility was never regarded as an abnormality unless there was concomitant evidence of subluxation (Nevakari, 1959; Wooten, 1966) and that antero- and retro- positions of the condylar head in the articular fossa, which are considered to be secondary manifestations of disease (Madsen, 1966), were disregarded if present as isolated features.

Discordant results in the studies of the position of the condylar head (Tables XXII and XXV) (T. & I. 117 & 120) were on all occasions found to have been the result of incomplete co-operation on the part of the patient. On eight occasions (one in the former study - Table XXII - and seven in the latter study - Table XXV) patients failed to occlude their teeth normally, and on eleven occasions (four and seven respectively) patients failed to open their mouths fully.

Repeat radiographs, with full patient co-operation, eliminated the differences. In this context it is proper for me to state that among the virtues of orthopantomography is an ease of checking that the subject was actually occluding when requested to do so and of confirming a lesser degree of movement of one condyle than of its partner of the opposite side.

The largest discordances, in the studies of joint condition (Tables XXIII and XXVI) (T. & I. 118 & 121), were those for osteoporosis. These can be explained by the subjective nature of the observation and in the case of lateral transcranio-oblique radiographs, by interference from underlying structures. Most of the remaining observations provided 100 percent concordances. The two instances of discordance for flattening of the condylar head, in the comparison of circular tomography and orthopantomogfaphy, were the results of missing minor degrees of this abnormality once on a circular tomograph and on another occasion on an ortho--pantomograph. Subsequent rechecking confirmed the presence of the abnormality both times. Superimposition of underlying structures on lateral transcranio-oblique radiographs resulted in the erroneous reporting of flattening of the condylar head and marginal proliferation once each. These observations were correctly omitted from the reports on the corresponding circular tomographs.

The concordance studies show that the three techniques are all similarly effective in demonstrating features of the temporomandibular joint, provided that the joint can be seen on the relevant radiograph. From this point of view, circular tomography has proved to be superior to the other two techniques. In each of the two studies there were only two circular tomographs, taken when the teeth were in occlusion, in which details of the position of the condylar head could not be discerned. The corresponding figures for orthopantomography and lateral transcranio-oblique radiography were fifteen and seven respectively. The position of the condylar head, with the mouth fully open, was obscured on eight films, all lateral transcranio-oblique radiographs. Likewise, there were five instances when the condition of the calcified structures of the joint could not be discerned on either lateral transcranio--oblique radiograph, whereas one or both of all the series of films produced by the other two techniques were suitable for study.

A measure of magnification was present on all films produced by one or other tomographic method if they were compared with lateral transcranio-oblique radiographs produced with a minimal object-film distance and so minimal magnification. This magnification was especially marked on some occasions when circular tomography was used but never reached those limits where the resultant films were rendered valueless because of distortion.

7.iv) SUMMARY AND CONCLUSIONS

Circular tomography was applied to the study of the temporomandibular joint. In order to assess the method, two sets of radiographs were obtained of twenty-one patients including some suffering from different joint disease. The results showed that the radiological technique was reproducible and that accurate measurements could be made from the radio- -graphs. Circular tomography was, then, compared with two established and well-regarded techniques, orthopantomography and lateral transcranio-oblique radiography. A high degree of concordance was demonstrated in the delineation of features of the joint, and circular tomography produced fewer radiographs on which these features were obscured, than did either of the other techniques. I conclude, therefore, that when details are required of the articular surfaces of the temporomandibular joint and of the range of movement of the mandibular condyle on the temporal bone, despite a degree of magnification inherent in the method, circular tomography is an acceptable technique. It is, in fact, probably the method of choice at the present time for the study of the temporomandibular joint in patients with articular diseases, providing that any unique properties of other techniques, such as an ease of checking both condyles and, perhaps, also the occlusion on a single orthopantomograph, are borne in mind.

CHAPTER 8

MATERIALS AND METHODS

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8.i) THE PATIENTS STUDIED

One hundred and sixty-three patients were referred to and examined by me in the course of this study. This number, I later learned, included one hundred patients with classical or definite rheumatoid arthritis, three with probable rheumatoid arthritis, three with possible rheumatoid arthritis, one with juvenile rheumatoid arthritis, one with rheumatoid arthritis plus osteoarthrosis, thirty-nine with osteoarthrosis, seven with psoriatic arthritis, one each with sicca syndrome, ulcerative colitis and Reiter's disease, four for whom a firm diagnosis had not been established and two without evidence of any sort of any form of rheumatic disease. In addition I examined fifty-six control subjects without any evidence of rheumatic disease selected on the basis of age and sex only. Therefore two hundred and nineteen patients were examined by me in total. However, only one hundred and ninety-five of these, the hundred with classical or definite rheumatoid arthritis, the thirty-nine with osteoarthrosis, and the fifty-six control patients, comprise this study. The primary reason for the inclusion of the other patients was, as I have already stated, to prevent me, albeit unwittingly, developing a bias during my examinations of the patients suffering from one or other of the rheumatic diseases.

The hundred rheumatoid arthritic patients had disease of sufficient severity to warrant their attendance on an in-patient or out-patient basis at a specialist rheumatology centre. This apart they were totally unselected. There were seventy-seven females and twenty-three males, representing the usual sex distribution in this disease. The ages of the patients ranged from eighteen years to seventy-seven years (mean fifty-three years), the duration of disease from two months to forty-seven years (mean eleven years) and the age of onset from sixteen years to seventy-three years (mean forty-two years). The mean articular index was 21 ± 16 (standard deviation) and the distribution of patients among the functional classes and X-ray stages was Class I sixteen patients, Class II thirty-seven patients, Class III thirty-nine patients, and Class IV eight patients, and Stage I seven patients, Stage II one patient, Stage III eighty-seven patients, and Stage IV five patients respectively. Subcutaneous nodules were present in thirty-two patients, two patients had clinical evidence of arteritis and seven had objective signs of Sjøgren's syndrome. Laboratory data showed many patients to be slightly anaemic (mean haemoglobin level 12.4 ± 1.7 grams per 100 millilitres), nearly all to have elevated erythrocyte sedimentation rates (mean 53 ± 31 mm. in one hour) and many to have altered serum protein ratios (mean albumin level 36 ± 5 grams per litre; mean globulin level 37 ± 7 grams per litre). Seventy-one patients were seropositive for rheumatoid factor and thirty-two had positive tests for antinuclear factor (homogeneous staining pattern).

The thirty-nine osteoarthrotic patients all had symptom--atic disease of sufficient severity for them to be attending a rheumatic diseases clinic or to be hospitalised for medical or surgical management. The group was composed of thirty-two females and seven males, the age range being forty-one years to seventy-seven years (mean sixty-years).

The fifty-six control patients were a sample of patients attending an out-patient dental clinic for general dental attention. They were selected only on the basis of age and sex and because of a complete absence of any signs or symptoms of rheumatoid arthritis, osteoarthrosis, or indeed, any other rheumatic disease. This group consisted of thirty-six females and twenty males, the age range being twenty-four years to eighty-three years (mean 52.8 years).

These patients were considered in several different ways as will be explained later. It is pertinent to explain now that the thirty-nine osteoarthrotic patients were compared with forty-four of the control patients to be called the "control group". The "control group" consisted of twenty-seven females and seventeen males, their age range being forty years to seventy-six years (mean fifty-eight years). In addition the hundred patients suffering from rheumatoid arthritis were compared with a "combined control group" of ninety-five patients made up of the thirty-nine osteoarthrotic patients and the fifty-six control patients. The ages of this "combined control group" ranged from twenty-four years to eighty-three years (mean fifty-six years) and it included sixty-eight females and twenty-seven males.

8.ii) THE CLINICAL EXAMINATION

I performed a detailed clinical examination of the temporomandibular joints of each patient. The presence or absence of the following abnormal features was recorded:-

(1) deviation of the mandible from the mid-line during opening and closing movements;

(2) limitation of opening;

(3) subjective stiffness of the joint;

(4) joint crepitus on palpation;

(5) audible or palpable clicking of the joint detected objectively during opening and closing movements;

(6) subjective clicking of the joint;

(7) history of pain in the temporomandibular joint itself, referred pain, or tenderness of the joint on biting;

(8) presence of tenderness of the joint, joint capsule or the muscles of mastication detected by palpation whilst the patient was performing the full range of mandibular movements;

(9) past history of, or presence of, soft tissue swelling external to the temporomandibular joint; and

(10) subluxation.

Only those signs and symptoms which were actually detected during the course of the examination were considered further as I felt that some of them might be considered to be open to misinterpretation by the patient. In this way all doubtful information was discarded and the clinical basis of this particular study was based on information verified at the time of the clinical examination.

At the same time I completed a dental examination for each patient the details of which are given in Chapter 10, Section ii. One purpose of this was to determine whether dental abnormalities could contribute to any differences between the findings for the temporomandibular joints in the various groups. Obviously an accurate assessment of occlusion was an extremely important part of this examination.

8.iii) RADIOGRAPHY AND RADIOLOGY

Seventy-five joints from the osteoarthrotic group, seventy-nine from the control group, one hundred and ninety-seven from the rheumatoid arthritic group and one hundred and seventy- seven from the combined control group were radiographed in the normally occluded and maximally open positions using circular tomography. If there was any doubt about the interpretation of a radiograph the examination was repeated using circular tomography or, alternatively, either orthopan--tomography or lateral transcranio-oblique radiography.

I, personally, examined all the radiographs "blind" and in random order. I drew up a proforma (Figure 102) (T. & I. 130) in order to ensure that I fully checked every feature on these radiographs and found that it assisted accurate reporting greatly. It will be seen that the position for the name and address of the patient was at the foot of each proforma. Names and addresses were filled in only when I had completed every report and it was found easier in these circumstances to use a proforma designed in the fashion illustrated. The position of the mandibular condyle and the condition of the calcified structures of the joint were systematically considered.

The position of the condylar head in the articular fossa, when the teeth were in normal occlusion, was designated "normo-", "antero-" or "retro-" (Figures 103 to 105) (T. & I. 131-133), and if the condylar head was not lying within the fossa, this situation was described as "subluxation in the closed position" (Figure 106) (T. & I. 134). An inter-articular space of less than 0.5 mm. was regarded as reduced (Madsen, 1966) (Figure 107) (T. & I. 135). With the mouth maximally open, the degree of mobility of the condyle was defined by its relationship to the articular eminence (Madsen, 1966). When it was seen to be 4 mm. or more posterior to the eminence, mobility was said to be "reduced" (Figure 108) (T. & I. 136). If the condylar head lies 4 mm. or more anterior to the articular eminence this may be said to represent "increased mobility" (Figure 109) (T. & I. 137), but this condition was not recorded as an abnormality in the present study unless there were concurrent clinical abnormalities, in which case it was described as "subluxation" in the open position" (Figure 110) (T. & I. 138). Ankylosis of the joint was also sought.

The condition of the calcified structures was evaluated according to the presence or absence of the following abnormal features:-

(1) sclerosis of the articular surfaces (Figure 111) (T. & I. 139);

(2) surface or pocket erosions (Figures 112 and 113) (T. & I. 140 & 141);

(3) flattening of the mandibular condyle (Figure 114) (T. & I. 142) or articular eminence (Figure 115) (T. & I. 143);

(4) marginal proliferations of the condylar head (Figure 116) (T. & I. 144);

(5) subchondral cysts (Figure 117) (T. & I. 145); and

(6) calcification of the articular disc (Figure 118) (T. & I. 146).

The presence of osteoporosis (Figure 119) (T. & I. 147) was recorded but it was not regarded as an abnormality (Lundberg and Ericson, 1967). As I stated in Chapter 7, Section iii, 2, orthopantomography was found to be of unique value in ascertaining the veracity of unilateral findings (Figure 120) (T. & I. 148), or, in fact, that a patient had maintained normal occlusion while the positions of the condyles in the closed position were being recorded (Figure 121) (T. & I. 149).

8.iv) THE PROBLEMS OF NORMAL OPENING AND SUBLUXATION

I have spent a considerable amount of time thinking how the terms "normal opening" and "subluxation" might be satis--factorily defined. Limitation of opening of the mouth and its measurement appear to have been important clinical considerations in the eyes of many students of the temporomandibular joint. Lindblom (1953) and Uotila (1964) regarded the symptoms of "difficulty in opening the mouth" and "stiffness" with respect. Madsen (1966) recorded reduced hinge and gliding movements, and a number of others including Uotila (1964), Ericson and Lundberg (1967), Hatch (1967), Franks (1969) and Crum and Loiselle (1970) measured the inter-incisal distance in the mid-line with the mouth maximally opened. Despite this no definition of the normal range of opening appears in any of these papers and, indeed, the various authors' own criteria appear to vary widely. Franks (1969) found that the measurements, between the groups he studied, varied little and so did not pursue the matter further. Crum and Loiselle (1970) stated that their patients demonstrated a range of opening of 30 mm. to 65 mm. with a mean value of 45.7 mm. Hatch (1967) attached great importance to this inter-incisal measurement and separated those patients who opened less than 25 mm. from those who opened more, although, by so doing he appears to have associated some patients, with a very slight limitation of movement, and his normal patients. Uotila (1964) classed any opening of less than 30 mm. and, also, those of less than 40 mm., in patients who subjectively demonstrated joint involvement, as abnormal whereas Ericson and Lundberg (1967) grouped their patients into categories who could open their mouths more than 45 mm. or were restricted to values of less than 45 mm. and, also, less than 40 mm. Obviously I had to establish my own criteria.

My first consideration was that the mid-line inter-incisal measurement was too crude as it took no account of overbite. I therefore amended the technique to take full account of this factor and thus recorded the full range of movement from the normally occluded to the fully open position. My method of examination is illustrated in Figures 122 and 123 (T. & I. 150 &151). I used a vernier guage of the type frequently used by orthodontists which give a reading which is accurate to one-tenth of a millimetre as shown in Figure 124 (T. & I. 152). Once I had established this method of measuring the amount of opening, I had to establish a figure below which clinical limitation of opening could be said to be present. I determined the mean opening value of thirty results obtained from patients who had absolutely normal joints both clinically and radiologically. A normal radiological joint, for this purpose, was one where the condyle was seen to be in normo-position in the articular fossa, in the closed position and immediately below the articular eminence in the fully open position (Figure 125)

(T. & I. 153) affording a value for P of 0.0 mm. ($\pm$ 0.4 mm.) as described in Chapter 7, Section ii, a, 4. A figure of 35 mm. was obtained by subtracting two standard deviations from this mean value and, thereafter, this figure was considered to be the lower limit of normal clinical opening as measured by the vernier guage.

I now turned my attention to the upper limit of normal opening and the related considerations of dislocation and subluxation. The term dislocation was fairly easily understood Shafer, Hine and Levy (1958) stating that it "occurs when the head of the condyle moves anteriorly over the articular eminence into such a position that it cannot be returned voluntarily to its normal position" adding that "the condyle is obviously outside the limits of normal in its position" before mentioning that rarely dislocation can be superior or posterior although normally occurring due to an abnormal forward position of the condylar head. Sarnat and Laskin (1964) produced this precise definition of dislocation:- "A derange--ment between the articulating components of a joint which is not self-reducing". However, as Brod (1968) declared, sublux--ation is difficult to define. He considered that the term implied a partial or incomplete dislocation. Bauerle and Archer (1951) considered subluxation to be a self reducing partial dislocation, Shafer, Hine and Levy (1958) thought of it as incomplete dislocation or hypermobility and Markowitz and Gerry (1950) described a condyle which had passed anterior to the articular eminence as subluxated. Hutchinson (1954) defined the condition more fully calling it "an undue mobility of the joint as a result of which partial dislocation may occur from trivial causes" and added that the head of the condyle was seen to be "located somewhat beyond the articular eminence when the jaws are widely separated" on radiographs. However, Nevakari (1959) and Wooten (1966) have shown that such mobility can be quite normal and so I believe that Sarnat and Laskin (1964), again, are responsible for the best definition available. They stated, and I accept, that a temporomandibular joint is subluxated if the condylar head passes in front of the articular eminence and the patient also complains of associated symptoms such as pain, temporary locking or cracking noises. My own definition is, therefore, hypermobility in the presence of associated signs or symptoms. It is interesting, although it may be co-incidental, that increased mobility and subluxation in the open position had slightly different appearances on the radiographs I examined. In the latter condition the condyle was seen to have moved forwards but also considerably upwards in relation to the articular eminence (compare Figures 109 and 110) (T. & I. 137 & 138).

As far as I am aware the question of subluxation of the condylar head in the closed position has never been discussed in the dental literature. I have shown conclusive examples (Figures 106, 115 and 121) (T. & I. 134, 143 & 149) of condyles failing to return normally into the articular fossa and feel that these must be considered instances of this form of subluxation. However, Schwartz (1968) may have been aware of this peculiarity because he considered clinical subluxation to be "a momentary slipping, jumping or locking of the mandible followed by a feeling that the teeth no longer mesh properly," an expression which conveys its meaning very well. I have tried to reduce this description to a definition. I have defined clinical subluxation to be a spontaneous, gradual and noticeable alteration of the dental occlusion. This definition is not solely objective because it covers the features seen on clinical examination very well (Figures 126 to 129) (T. & I. 154-157). It must be remembered, finally, that subluxation in the open position can only be determined by clinical and radiological examination whereas subluxation in the closed position can often be determined by one or other of these examinations alone.

8.v) SUMMARY AND CONCLUSIONS

This section is largely devoted to statements of fact. The medical diagnosis and the clinical and radiographical examinations must, certainly in view of the previous chapters, be so considered. However, the details of radiological reporting, including the introduction of a proforma which has been found to materially assist this, have also been discussed. The terms limitation of opening, range of normal movement and subluxation of the temporomandibular joint which are freely, and vaguely, used in the dental literature are considered in detail. As a result I have stipulated my criteria for normal range of movement by defining limitation of movement and subluxation. In fact I recognise two forms of subluxation of the temporomandibular joint, subluxation in the open position and subluxation in the closed position, and believe that I may be the first person to have done so.

CHAPTER 9

RESULTS AND DISCUSSION

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9.i) THE OSTEOARTHROSIS STUDY

(a) Results The results of this preliminary study, which compare the thirty-nine patients with osteo--arthrosis and forty-four normal patients comprising the "control group", are summarised in Tables XXIX to XXXI (T. & I. 158-160). Among the clinical features, only palpable click was significantly more common in the osteo--arthrosis group (12 cases; 30.8 percent) than in the "control group" (4 cases; 9.1 percent of cases) and even that could only be classed as slightly significant ($\chi^2 = 6.24$; $p<0.02$). No significant difference was found for any of the radiological features. It is evident, from Table XXXI (T. & I. 160) that clinical and radiological abnormalities do not necessarily coincide. This lack of correlation is closely similar in both groups. Dental examination revealed no features which might contribute to any differences between the findings for the temporomandibular joints in the two groups.

(b) Discussion I believe that this is the first controlled investigation into the incidence of temporomandi--bular joint involvement in primary osteo arthrosis. A group of patients suffering from primary osteoarthrosis was subjected to clinical and radiological examination of the temporomandibular joint and the results compared with those obtained from a matching "control group" without rheumatic disease.

Only one clinical sign, namely palpable click, was slightly significantly more common in the osteoarthrosis group than in the "control group". The origin of clicks in the jaw is a controversial subject and there is disagrement as to the structures involved in their production, (Weinstein and Ward, 1949; Markowitz and Gerry, 1950; Ireland, 1951; Schwartz, 1959; Thomson, 1971). I am unable, therefore, to offer any intelligent explanation for this on the basis of jaw mechanics. Dental status and age of the subjects can be discounted as possible factors, but the sex distribution of the two groups was unequal and could have been responsible. It is a well recognised fact that temporomandibular joint symptoms are more frequently found among women (Campbell, 1958; Thomson, 1959; Schwartz, 1968; Thomson, 1971) and 82 percent of the osteoarthrosis group were female compared with only 61 percent of the "control group". If only the female members of the two groups are considered, it emerges that nine of thirty-two in the osteoarthrosis group (28.1 percent) and four of twenty-seven in the "control group" (14.8 percent) exhibited a palpable click. This difference is not statistically significant ($\chi^2 = 1.51$) which does suggest that imperfect matching of the sexes may have been responsible for the difference in the incidence of palpable click between the two groups. At the same time, I am left with the problem that three of the seven men with osteoarthrosis had palpable clicks, whereas not one of the seventeen men in the "control group" had this sign. These numbers are, however, small and no statistical inference can be drawn from them. Moreover, not one of these three affected men had any radiological abnormality. Lack of correlation between clicking and radiological abnormality has also been reported by Hatch (1967). Clicking jaws are something of a mystery and my findings compound this, but a click does not seem to indicate the presence of serious joint disease.

No significant differences, apart from palpable click, could be detected for the clinical features and radiologically, the two groups appeared to be almost identical. It may, thus, be concluded that primary osteoarthrosis does not specifically affect the temporomandibular joint. Although clinical and radiological abnormalities are common in the temporomandibular joint in patients with this condition, they are equally common in normal middle-aged and elderly people. As has been previously observed (Nørgaard, 1947; Madsen, 1966) the correlation between clinical and radiological findings is poor, and this study has again shown this (Table XXXI) (T. & I. 160). The temporomandibular joint undoubtedly is the site of considerable trouble, but this cannot be attributed to primary osteoarthrosis. Osteoarthrosis of the temporomandibular joint would, actually, appear to be best classified as of the secondary variety, when present, in view of the considerable strains and trauma to which this joint is subjected.

9.ii) RHEUMATOID ARTHRITIS AND THE TEMPOROMANDIBULAR JOINT

(a) Results The results of the study are summarised in Tables XXXII to XL (T. & I. 161-169). The rheumatoid arthritic patients and the patients of the "combined control group" are compared in Tables XXXII and XXXIII (T. & I. 161 & 162). One or more clinical abnormalities were present in 71.0 percent of the rheumatoid patients and in 41.1 percent of the controls. This difference is highly significant ($\chi^2 = 17.76$; $p<0.0005$). Similarly, a highly significant difference was found on consideration of the radiological abnormalities ($\chi^2 = 76.50$; $p<0.0005$). These were present in 78.7 percent of the joints in the rheumatoid group but only 33.9 percent of the control joints. As is evident from Table XXXIV (T. & I. 163) overall clinical and radio--logical abnormalities show a better correlation in the rheumatoid patients than in the patients of the "combined control group". Individual clinical and radiological features that were found to be significantly more common among those patients affected by rheumatoid arthritis were:- limitation of opening, stiffness, crepitus, referred pain and tenderness on biting, and anteroposition, reduced mobility, surface and pocket erosions, flattening and marginal proliferations. Tables XXXV to XL (T. & I. 164-169) compare the various subdivisions of the rheumatoid group. Few individual features show significant differences, but some show trends which appear to correlate with more severe disease. No significant differences were found in the overall numbers of patients with one or more clinical abnormalities, whereas radiologically abnormal joints were found to be significantly more common among females, when the duration of the disease was more than ten years, among Functional Classes III and IV and in patients who were sero-positive for rheumatoid factor. Consideration of those dental factors, which might have had a bearing on these findings, showed that they were practically identical in the two groups.

It should be noted that comparison of patients in the different x-ray Stages was not possible because of the large preponderance in Stage III.

(b) Discussion I compared the temporomandibular joints of one hundred patients with definite or classical adult rheumatoid arthritis with those of a "combined control group" of ninety-five subjects without inflammatory joint disease, in this study. The "combined control group" consisted of thirty-nine patients with primary osteoarthrosis, which I have shown does not specifically affect the temporo--mandibular joint and fifty-six patients without any evidence of any form of rheumatic disease. No patients with juvenile rheumatoid arthritis were included because of the welldocumented high incidence of temporomandibular joint involvement in this disease (Bache, 1964; Sairanen and Helminen-Pakkala, 1966). The prevalences of both clinical and radiological changes were found to be high in the rheumatoid group. Clinical abnormalities were present in 71.0 percent of the patients and radiological abnormalities were present in 79.0 percent of the patients and 78.9 percent of their joints. The differences between these and the corresponding figures, of 41.1 percent, 34.7 percent and 33.9 percent, respectively, for the combined control group are statistically high significant.

These high figures are broadly in agreement with those of such recent workers as Ericson and Lundberg (1967), Hatch, (1967) and Franks (1969) but vastly exceed those given, by earlier authors including Ragan (1949), Lewis-Faning (1950), Markowitz and Gerry (1950) and Hankey (1963). Ragan gives no indication of the derivation of his figure of 4.7 percent and comment is, therefore, not possible. Markowitz and Gerry obtained their figure of 8.7 percent by comparing the number of patients with rheumatoid arthritis who had been referred because of significant disability to a special unit for temporomandibular joint disease with the total number of rheumatoid patients passing through their hospital. Their figure thus reflects only the most severe cases of temporo--mandibular arthritis. The patients studied by Lewis-Faning had rheumatoid arthritis of recent onset, in whom temporo--mandibular joint involvement is less likely to have developed (Russell and Bayles, 1941; Short, Bauer and Reynolds, 1957). Hankey's figure of 10 percent represents an estimate based on his clinical experience and is not the result of a formal study.

While it may be accepted that the prevalence of temporomandibular joint involvement in rheumatoid arthritis is higher than has been thought in the past, it may be felt that I have presented figures which are excessively high, particularly for clinical involvement. I looked for a large number of clinical abnormalities and, as discussed below, some of these are probably unrelated to rheumatoid disease. However, if consideration is given only to those features which may be regarded as specific for rheumatoid arthritis in this study, it is found that there is still a high proportion of patients - 59 percent - with clinical involve--ment. Observer bias is a possible factor but, again, it must be pointed out that I examined a total of two hundred and nineteen patients, one hundred and sixty-three of whom, including the one hundred patients with rheumatoid arthritis who are being studied, were referred, without any diagnostic information whatsoever, from a specialist rheumatology centre. To this should be added the fact that I completed these examinations in random order. Although all these patients were consecutive cases, they were attending this specialist rheumatology centre and were thus likely to have represented the more severe end of the disease spectrum. It may be because of the severity of their generalised disease that patients, such as those I studied, seldom volunteer complaints referable to the temporomandibular joints. Symptoms there are less likely to attract attention in a patient who is stiff and painful in many other parts of the body than in an otherwise fit person. Careful elicitation of signs and symptoms often reveals severe temporomandibular joint disease in the absence of spontaneous complaints by the patient.

Some clinical and radiological features appear to be specific for rheumatoid arthritis in the temporomandibular joint, at least by comparison with normal and osteoarthrotic controls. It may well be that similar features are present in other inflammatory joint diseases but that is beyond the scope of my present study. In any event, the changes that occur in rheumatoid arthritis appear to be qualitatively as well as quantitatively different from those that occur in temporomandibular joint degeneration, which was, presumably responsible for the abnormalities detected in the "combined control group". The following clinical features were found to be significantly more common among the patients suffering from rheumatoid arthritis:- limitation of opening, stiffness, crepitus, referred pain and tenderness on biting. One or more of these features was found, as I have mentioned, in 59 percent of the rheumatoid patients. Two other features, pain and tenderness on palpation, were present in more rheumatoid patients than controls, but the differences just failed to reach statistical significance. Antero-position, reduced mobility, surface and pocket erosions, flattening and marginal proliferations, of the radiological features, were all found significantly more frequently in the rheumatoid group. Circular tomography proved to be an eminently suitable method for examining the temporomandibular joint as it produced radiographs that were clear and easy to interpret. Radiation exposure of the patients was not great and the only real drawback could be said to be its capital cost. The concordance between the clinical and radiological findings for the rheumatoid patients was high (76 percent) (Table XXXIV) (T. & I. 163). Only 8 percent of patients had clinically abnormal findings in the presence of radio--logically normal joints and 16 percent radiological abnormalities without any clinical complaints.

Breakdown of the rheumatoid arthritis group into different categories did not show many striking differences between these categories (Tables XXXV to XL) (T. & I. 164-169). However, there was a tendency for some features to correlate with more severe disease. Limitation of opening was significantly more common in sero-positive patients and in those of Functional Classes III and IV, and showed a similar but non-significant trend in females and patients with a high articular index. The last mentioned group had significantly increased prevalences of stiffness, pain, tenderness on biting and tenderness on palpation. These features showed trends towards correlation with increased severity in other categories, but statistical significance was not attained. Referred pain occurred exclusively in female patients. A tendency for clicking in the joint to correlate with less severe categories of disease was evident. An audible click was found to be significantly more common in patients with a low articular index and a palpable click among those of Functional Classes I and II. This is all the more interesting if the results of the study of patients suffering from osteoarthrosis are recalled. Among the radiological features, antero-position seemed to be marginally more common in the severe categories, while the reverse appeared to be true for retro-position. Retro-position was significantly more common in disease of less than ten years' duration. By contrast, flattening, marginal proliferations and radiological abnormalities as a whole were significantly more common in disease of over ten years' duration. Patients in Functional Classes III and IV had significantly more reduced mobility, erosions, flattening and abnormal joints overall than those in the lower Functional

Classes. Marginal proliferations occurred exclusively where the onset of disease was after the age of forty years and subluxation occurred exclusively in females. The reasons for these findings are not clear. Female patients had significantly more abnormal joints than male patients. No individual radiological abnormality was significantly more common among the sero-positive patients, but the overall number of abnormal joints was significantly higher than in the sero-negative group.

Osteoporosis was not found significantly more commonly in the patients with rheumatoid arthritis than in the patients of the "combined control group", nor did it correlate with any of the categories within the rheumatoid arthritis group. This would appear to support the contention of Lundberg and Ericson (1967) that osteoporosis cannot be considered an abnormality in the context of studies such as the present one.

In conclusion, it may be stated that involvement of the temporomandibular joint by adult rheumatoid arthritis is common, probably much more common than has been thought in the past. Specific clinical and radiological features correlate with the presence of rheumatoid disease and, also tend to be more common in the more severely affected patients. These findings provide confirmation that the temporomandibular joint changes seen in patients with rheumatoid arthritis are the result of the disease and not merely of an accentuation of degenerative processes. Really severe disability is not common, but a careful search will often reveal quite marked clinical abnormalities.

9.iii) SUMMARY AND CONCLUSIONS

A comparison between thirty-nine patients with primary osteoarthrosis and forty-four control patients has, with the exception of one clinical feature, shown no significant clinical or radiological differences between the temporomandibular joints of the two groups. A palpable click was slightly significantly more common in the osteoarthrosis group, but this sign probably has no relationship to degenerative joint disease. I conclude, therefore, as a result of what appears to have been the first controlled study of the incidence of temporomandibular joint disease among patients with primary osteoarthrosis, that involvement of this joint does not appear to be a feature of this condition.

However, in a detailed study of one hundred consecutive cases of rheumatoid arthritis clinical abnormalities were present in the temporomandibular joints in 71.0 percent of patients compared with 41.1 percent of a group of matched controls. This difference is highly significant. Circular tomography was found to be an eminently suitable method for examining the temporomandibular joint radiologically. By this technique which does not appear to have been used previously in a study of this nature, 78.7 percent of the rheumatoid patients' joints showed abnormalities compared with 33.9 percent of the control joints. This difference is also highly significant. Certain clinical and radiological features appeared to be almost specific for rheumatoid arthritis and to correlate with increasing severity of the disease. In conclusion, I can fairly make the observation that rheumatoid arthritis, apparently, affects the temporo--mandibular joint more commonly than was at one time thought.

Dentists, as well as rheumatologists, have a responsibi--lity in the care and management of these patients. For example, one patient with temporomandibular joints severely damaged by rheumatoid arthritis (Figures 121 and 130) (T. & I. 149 & 170) was considerably comforted by the provision of well made dentures and another, referred to Glasgow Dental Hospital and School because of pain in the temporomandibular joints was found to have changes typical of rheumatoid arthritis in these joints (Figure 131) (T. & I. 171) and so was afforded both proper medical and dental attention.

SECTION V

THE DENTAL STUDY

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CHAPTER 10

MATERIALS AND METHODS

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10.i) THE PATIENTS STUDIED

One hundred and ninety-seven patients were studied. They fell into four groups:- ninety-three patients with rheumatoid arthritis, seven with Sjøgren's syndrome complicated by rheumatoid arthritis and two with sicca syndrome, thirty-nine with primary osteoarthrosis and fifty-six control subjects without evidence of rheumatic disease. The one hundred and thirty-nine patients with joint disease and the two with sicca syndrome were randomly selected from in-patients and out-patients attending a specialist rheumatology centre. The fifty-six control subjects were selected only on the basis of age and sex. The rheumatoid arthritis group consisted of seventy-one females and twenty-two males, which reflects the normal sex distribution seen in this disease. The Sjøgren's syndrome group consisted of six females and one male, the diagnosis being reached on the objective recording of xerostomia twice and of keratoconjunctivitis sicca in six cases. All one hundred cases with rheumatoid arthritis had "definite" or "classical disease". The ages of these patients ranged from eighteen to seventy-seven years (mean fifty-three years). The severity of their disease is reflected by their high mean articular index of 21 $\pm$ 16 (standard deviation), the fact that eighty-four of them fell into functional classes II, III and IV and ninety-two into x-ray stages III and IV, and their mean erythrocyte sedimentation rate of 53 $\pm$ 31 mm. in one hour. The sicca syndrome patients were both female, one aged thirty-four years, the other fifty-five years. The age range of the nine patients with Sjøgren's syndrome/sicca syndrome was twenty-three to sixty years (mean forty-eight years) and of the ninety-three uncomplicated rheumatoid arthritics eighteen to seventy-seven years (mean 53,6 years). The osteoarthrosis group consisted of thirty-two females and seven males, their age range being forty-one to seventy-seven years (mean 59.6 years) and the control group of thirty-six females and twenty males, whose ages ranged from twenty-four to eighty-three years (mean 52.8 years). Most of the osteoarthrotic patients were attending the specialist rheumatology centre for reconstructive surgery because of the severity of their disease.

10.ii) EXAMINATION OF THE MOUTH

Every patient was examined by myself in the same dental clinic. The relationship of the upper dental arch to the lower was classified as defined by Angle (1899). All natural teeth present were charted and all dental restorations and carious cavities present in these teeth recorded. The omission of any teeth, which had been lost following trauma or as part of the treatment of malocclusion or which were congenitally absent, from these recordings permitted the completion of D.M.F. indices as advocated by Klein, Palmer and Knutson (1938). Similarly a D.M.F.S. index was completed for each patient. These indices provide a numerical record of the number of decayed, missing and filled teeth and the number of decayed, missing and filled tooth surfaces respectively. The degree of periodontal involvement was assessed using Russell's Index (1956), a value of 0 to 8 being assigned to the tissues surrounding each standing tooth, the final index being the mean of these figures. A value of 0 indicated no periodontal involvement, 1 mild gingivitis, 2 circumscribed gingivitis, 6 gingivitis and pocket formation, and 8 advanced destruction with loss of masticatory function. When in doubt, the lower value was assigned. A score of 0 to 3, 0 for no debris, 1 for interproximal debris only, 2 for debris covering less than one-third of the tooth surface being examined and 3 for more debris than that, was given to the lingual or palatal tooth surface and the labial or buccal tooth surface most covered by debris in the upper and lower anterior regions and the upper and lower right and left posterior regions of the mouth. If the total obtained by adding these scores was divided by a figure corresponding to one quarter of the number of tooth surfaces examined a resultant figure of 0 to 12 was obtained. This is the modified Greene and Vermillion (1960) Index of McHugh, McEwan and Hitchin (1964). If calculus was detected on these tooth surfaces - $\underline{1|}$ and $\overline{|1}$ labially, $\underline{6|6}$ bucally and $\overline{6|6}$ lingually - it was scored and thereby a final score determined for each mouth using the method described by Greene and Vermillion (1964), the possible range for any one mouth being 0 to 3. Greene and Vermillion allotted the following values:- 0 = no calculus; 1 = supragingival calculus covering not more than one-third of the exposed tooth surface; 2 = supragingival calculus covering one-third to two-thirds of the exposed tooth surface or small flecks of sub-gingival calculus; and 3 = supragingival calculus covering over two-thirds of the exposed tooth surface or a continuous heavy band of subgingival calculus. If any of the stated teeth were missing and an adjacent tooth of similar morphology was present it was scored. The soft tissues of the entire oral cavity were closely examined and any abnormal finding noted.

The presence or absence of dentures was confirmed in every mouth where one or more teeth had been lost. Dentures were classified as first class, needing to be replaced or satisfactory (i.e. not immediately needing to be replaced but of limited future use) by assessing the vertical dimension, the material of which they were made, their cleanliness, their general condition (i.e. cracks, teeth or flanges broken off etc.), their age and their stability within the mouth during full functional activity. Finally, the occlusion was examined, with dentures in position if the patient had them, and was described as excellent, good, fair, poor or very poor. An excellent occlusion was one which was very well balanced and without spacing in either arch due to tooth loss; a good occlusion was well balanced with limited equal and opposite tooth loss; a fair occlusion was also well balanced with the additional feature of spacing not necessarily equal or opposite; unilateral loss of posterior support with, at least, a fair occlusion on the opposite side was classified as a poor occlusion and bilateral loss of posterior support often accompanied by some loss of anterior teeth in addition as a very poor occlusion.

10.iii) PERIAPICAL RADIOGRAPHY

Periapical intra-oral radiographs were taken of the lower anterior teeth, using a Ritter Modulex unit (Figure 132) (T. & I. 172), in those mouths which were not completely edentulous. Technical details of each exposure were:- KV 70, mAs 6 (15 mA, 0.4 second), Diaphragm 3.5 cm., Cone 8 inch (20 cm.) length; Kodak DF 51 Size 0 films were used and were automatically processed in a XR-Minor-T. The patients head was positioned with the alar-tragus line parallel to the floor and the central ray was directed at right angles to the teeth being radiographed using the Paralleling Technique with an anode-film distance of 16 inches (41 cm.). Four radiographs were needed in each case (Figure 133) (T. & I. 173).

10.iv) DENTAL RADIOLOGY

I examined all the periapical radiographs in the good light afforded by a viewing-box using a magnifying glass for clarification when necessary. The presence or absence of teeth was recorded, special care being taken not to miss any unerupted or impacted tooth which might not have been visible clinically. The condition of each tooth was then ascertained taking into account radiographic indications of caries and fillings and of pulpal pathology, such as widening of the periodontal membrane periapically or more extensive areas of periapical radiolucency indicative of dental granulomata or cysts. Radiographic evidence of periodontal disease and pocketing with horizontal or vertical alveolar bone loss and of subgingival calculus was verified. General widening of the periodontal membrane was sought in vain. Finally, the general condition of all the mandibular bone apparent on the radiographs was examined.

10.v) DISCUSSION

The clinical epidemiological methods I used are generally accepted. It has been shown that, if a large group of patients is being studied, the degree of gingivitis and periodontal involvement present can be fealistically assessed by studying a few representative areas of the mouth rather than all of it (King, 1940; Schour and Massler, 1947; Ramfjord, 1959). For example McHugh, McEwan and Hitchin (1964) examined $\underline{21|}$, $\underline{|56}$, $\overline{1|1}$ and $\overline{65|}$ labially (bucally) and lingually (palatally). However, the number of patients seen in this study was limited so the whole mouth was examined as described by Russell (1956). Moreover, it would be disappointing if the results obtained in this study could not be used again as part of a larger study involving more than one dental examiner. This difficulty, I hope, has been overcome because the Russell Index appears to produce an effective correlation between examiners after only a short calibration time (Russell, 1967). McHugh, McEwan and Hitchin (1964) claimed that it was notoriously difficult to assess oral hygeine. However, their modification of Greene and Vermillion's (1960) Index was found to be satisfactory in practice and superior to the earlier "good", "fair" and "neglected" classification sometimes described (Schei, Waerhaug, Løvdal and Arnø, 1959; Mansbridge, 1960;

Finlayson, 1961). Similarly the modified Calculus Index of Greene and Vermillion (1964) was preferred to the one they described four years earlier. Classification of dentures and occlusion was found to be more difficult. However, if all features of a denture were considered an assessment was found to be readily derived. I consider that the descriptive terms I used, in this regard, are more appropriate than alternative, less colourful, expressions. Similarly I determined what appears to be a satisfactory method of grading occlusion.

As radiography of many joints is carried out to help determine the diagnosis of rheumatoid arthritis I decided that dental radiography should be limited. Some was, however, essential not only to confirm the clinical findings but also to ascertain whether or not any unusual periodontal or periapical conditions were evident. I, therefore, completed an unrelated survey of the dentition of three hundred and sixty consecutive patients, one hundred and forty-two females, two hundred and eighteen males, aged between twenty years and seventy-four years who attended Glasgow Dental Hospital and School. Thirty-one (8.6 percent) were edentulous. This apparently low figure may be accounted for by the fact that the majority of these patients were under forty years of age. This fortunate weighting suited my purpose admirably as the prime aim of this particular survey was to ascertain the pattern of tooth loss in a West of Scotland population. The results are shown graphically in Figures 134 and 135 (T. & I. 174 & 175). Three hundred and nine of the remaining three hundred and twenty-nine patients had all their lower anterior teeth and three hundred and twenty-four had four or more. The corresponding figures for the upper anterior region were two hundred and thirty and two hundred and ninety-six respectively and for the best maintained posterior region, the upper right, forty-eight and two hundred and twelve. The lower anterior region was, therefore, selected for radiographic examination. My decision was fully justified because all the subjects in the present study who had natural teeth had lower anterior teeth. The Paralleling technique was used for the reasons detailed in Chapter 2, Section iv, the anode-film distance of 16 inches having been shown to be satisfactory for the examination of this region of the mouth by this technique (Fitzgerald, 1947).

10.vi) SUMMARY AND CONCLUSIONS

Methods of examining the mouth so that dental health may be assessed have been developed since the turn of the century and, especially, during the past twenty years. I was able to make use of many of these accepted methods in this study but had to contrive my own criteria for the condition of dentures and standard of occlusion. I have explained why I chose the methods I used and how I devised my two new classifications. In addition the necessity for limited dental radiography has been explained and how, as a result of this requirement, I decided which part of the mouth should be radiographed, has been described. The success of this independent survey has been proved in the present study. My reasons for selecting the Paralleling technique for intra-oral periapical radiography are more tenuous but are generally accepted by, and acceptable to, dental radiologists today. I feel certain, accordingly, that the comparisons between the dental health of patients afflicted by rheumatic diseases and control patients, which I am to make in the next chapter, are totally valid.

CHAPTER 11

RESULTS AND DISCUSSION

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11.i) RESULTS

The thirty-nine patients suffering from primary osteoarthrosis were compared with forty-four control patients, twenty-seven female, seventeen male, with a mean age of fifty-eight years (range forty years to seventy-six years). Thirty-nine of these patients demonstrated an Angle's Class I arch relationship, one a Class II division 1, none a Class II division 2 and four a Class III. The corresponding figures for the osteoarthrosis group were thirty, none, three and six respectively. The general condition of the oral soft tissues was good, one case each of denture sore mouth, acute ulcera--tive gingivitis and denture induced hyperplasia being evident among the control patients and only one example of denture sore mouth among those afflicted by osteoarthrosis. The mean number of teeth present in the non-edentulous patients was 14.8 in the control group and 15.1 in the osteoarthrotic group, the respective ranges being four to twenty-six and six to twenty-eight. Interestingly none of these patients had edentulous mandibles although nine had edentulous maxillae, four of these being in patients with joint disease. The results of the detailed oral and dental examinations are shown in Tables XLI to XLV (T. & I. 176-180).

As will be explained in the discussion it was found that it was possible to compare the ninety-three rheumatoid arthritic patients with a combination of these two groups plus twelve further control patients. The combined control group so constituted thus consisted of ninety-five patients, sixty-eight females and twenty-seven males, with a mean age of 55.5 years (range twenty-four years to eighty-three years). The arch relationships showed a good similarity there being seventy-eight Class I, two Class II division 1, three Class II division 2 and twelve Class III relationships in the control group compared with seventy-one Class I, four Class II division 1, three Class II division 2 and fifteen Class III cases among those patients suffering from rheumatoid arthritis. The general condition of the soft tissues of the mouth appeared to be slightly better in this latter group among whom two cases of denture sore mouth were discovered compared with the two cases of denture sore mouth, one of acute ulcerative gingivitis and one of denture induced hyperplasia evident in the mouths of those patients who were completely free from rheumatoid arthritis. The mean number of teeth present in the combined control group was 6.0 (range 0 to 31) and in the rheumatoid arthritic group 6.5 (range 0 to 30) the corresponding figures for those patients who still had natural teeth present being 15.8 (range 4 to 31) and 17.6 (range 5 to 30). All patients with natural teeth present had a proportion of these in the mandible whereas twenty of the seventy dentate patients had edentulous maxillae, eleven of these being patients of the combined control group. Detailed comparisons of the oral and dental findings in these two groups of patients are shown in Tables XLVI to L (T. & I. 181-185).

Such a comparison was impossible for the patients suffering from Sjøgren's syndrome because of the small number of patients making up this group. However, one twenty-three year old girl with an Angle's Class I occlusion was examined periodically over a period of twelve months. The deterioration in her mouth was compared with two female control subjects, who were selected because they had a scholastic and social background plus a keen interest in the dental health of their mouths similar to this patient, and is graphically illustrated in Table LI (T. & I. 186) and also pictorially in Figure 136 (T. & I. 187). One of these was slightly younger (nineteen years), the other slightly older (twenty-eight years) at the time of their first examinations than this girl who demonstrated the complete triad described by Sjøgren and who was the only one of these three patients who had to have teeth extracted (a total of five) during the period of the study. One other female, aged fifty years, had natural teeth standing. Her D.M.F. and D.M.F.S. indices were 25 and 84, and her Oral Hygeine, Russell and Calculus Indices 6.3, 1.2 and 0.7 respectively.

She wore a partial upper denture which was classified as still being of some use but her Class I occlusion was described as poor due to the lack of both natural lower posterior teeth and a lower partial denture. The remaining five patients with Sjøgren's syndrome, four females aged fifty, fifty-one, fifty-four and sixty years and one fifty-nine year old male, were all edentulous, two of the complete upper and lower dentures being classed as "still some use", the remaining three as "need to be replaced". These patients had been edentulous since they were forty-six, twenty-four, fifty, thirty-five and twenty-eight years of age respectively, their present dentures being two, twenty, four, fifteen and thirty years old. Four arch relationships were Angle's Class I and one class III, and two occlusions were considered good, one poor and two very poor. Thus both patients with natural teeth and three of the edentulous patients required immediate dental treatment at the time of the examination. Both patients with sicca syndrome had natural teeth present in their mouths and also Angle Class I arch relationships. The younger, a thirty-four year old female, stated that most of her nine missing teeth had been lost due to a fairly rapid onset of decay shortly after she had first noticed her mouth to be dry seven years previously. Her D.M.F. and D.M.F.S. indices were 19 and 60, and her Oral Hygeine, Russell and Calculus Indices 8.0, 1.2 and 0.0 respectively. I considered that her fair occlusion would be improved by the provision of a partial lower denture, there being no need for any prosthetic replacement in her upper jaw. The older patient a fifty-five year old female was found to have a very dry mouth, her tongue showing evidence of the characteristic dry fissured appearance found in the more severe cases of Sjøgren's syndrome (Figure 137) (T. & I. 188), and bilateral swelling of her parotid glands (Figure 138) (T. & I. 189). The results of her dental examination were:- D.M.F. 28, D.M.F.S. 108, Oral Hygeine index 4.3, Russell index 1.6, and Calculus index 0.0. Her occlusion was classified as good when it was examined with both her upper and lower partial dentures, found to be of "still some use", in position.

However, she like the younger patient with sicca syndrome was found to be in need of immediate dental treatment at the time of examination.

The radiographs taken during the course of this study confirmed, but did not elaborate, the clinical findings.

11.ii) DISCUSSION

The dental status of one hundred and ninety-five patients was assessed using, by and large, standard dental epidemiological methods in order to ascertain if, and how, the dental needs of the chronically disabled varied from those of the normal population. The patient has to visit the dentist for treatment. This statement is certainly true for all but the simplest techniques some of which may be performed fairly adequately in the patient's own home or at the bed-side. The necessity of expensive immobile equipment if any other techniques are to be properly executed certainly makes the desirable aim of routine regular dental treatment more difficult to attain for those unfortunate persons who are largely or totally restricted in movement because of disease.

Two major groups were included in this study. The smaller suffered from osteoarthrosis which, although severe enough to warrant surgery in the majority of cases, was less crippling than the rheumatoid arthritis which affected the larger number of patients. This can be readily understood when it is remembered that all had definite or classical rheumatoid arthritis, the mean value for the articular index was high and the number of patients with a high functional class and x-ray stage was large. In addition to these two groups, seven patients with Sjøgren's syndrome and two with sicca syndrome, and fifty-six with no evidence of any form of rheumatic disease were also examined.

The osteoarthrosis group and the control group with which it was compared were found to be very similar in all respects. Four edentulous control patients were without one or both dentures but no permutation of the assessment of complete dentures revealed any difference of significance. The osteoarthrotic patients with natural teeth had a few more affected tooth surfaces but their mouths were slightly cleaner and healthier than those of the comparable division of the control group. The mean age of dentures belonging to the former group was less than that of the latter and the other information which I derived from this study showed a striking resemblance between these two groups. Everything taken into consideration the dental status of the osteoarthrosis group was found to be so similar to that of the control group that I considered myself fully justified in including it in the "combined control group" which was compared with the rheumatoid arthritic group of patients.

The striking resemblance between the temporomandibular joint study and the dental study to this stage should not have passed unnoticed. The osteoarthrosis patients and the control patients were the same in both studies. The rheumatoid arthritis group, in the former, included seven patients with Sjøgren's syndrome associated with rheumatoid arthritis, who were excluded from the rheumatoid arthritis group in the dental study, to which, however, was added the additional group of seven patients with Sjøgren's syndrome and two with sicca syndrome.

Differences were discovered, however, when the rheumatoid arthritic group was compared with this combined control group. Twenty-four of the edentulous patients with rheumatoid arthritis had lost all their natural teeth before the age of thirty compared with ten of the "combined control group". This was found to be slightly significant (χ^2 = 6.17, $p<0.02$). Corresponding figures for this type of patient who retained natural teeth until they were over fifty years of age were three and sixteen, respectively, a difference found to be significant (χ^2 = 10.60, $p<0.01$). The mean age when these two groups of patients lost their natural teeth differed by more than nine years. Further statistical analysis using the t test for unpaired variables revealed that this difference was highly significant ($t = 4.40$, $p<0.001$). Although fewer control patients needed urgent provision of complete upper and lower dentures the difference between the two groups was not found to be significant.

The natural teeth of the control patients were found to be cleaner than those of the rheumatoid arthritic patients.

If the subdivisions with the best oral hygeine (or lowest oral hygeine indices) were specifically considered this difference was found to be slightly significant ($\chi^2 = 5.09$, $p<0.05$). It was, therefore, perhaps not surprising to find that, although on average 1.8 more teeth were present in the mouths of the latter group, their mean D.M.F. and D.M.F.S. indices were higher. This factor, however, does not seem to have had any effect on the gingival condition or the formation of calculus.

Many of the dentures, complete and partial, were considered to have been worn for an over-long period of time. Both groups of subjects were discovered to have been comparably guilty in this respect. Although variations were discovered in the treatment requirements the results of the other examinations disclosed close similarities between the two groups.

The number of patients with Sjøgren's syndrome was too small for me to complete any detailed analyses. The continued examination of one young woman and the evidence of another did, however, suggest that previous statements relating this condition and a high incidence of dental caries could be correct (Morgan and Raven, 1952-53; Ehrlich and Greenberg, 1954; Bunim, Buchanan, Wertlake, Sokoloff, Bloch, Beck and Alepa, 1964; Bloch, Buchanan, Wohl and Bunim, 1965;

Jacobson, 1966; Bertram, 1967; Cawson, 1968; Ericson and Jacobbson, 1968) and warrants the controlled study of as large a number as possible of such patients who still have natural teeth. This is especially important because, despite one further case presenting with a characteristic lingual appearance and swollen parotid glands, no abnormal trend was in fact seen when these nine patients were considered together and compared with other groups of patients.

The differences found in the oral hygeine of the patients studied is probably explained directly by the disability of rheumatoid arthritis (Figure 139) (T. & I. 190). The reason for the earlier loss of teeth by patients with this disease is less easily understood. It might have been convenient for these patients to request dental clearances in order that their future number of visits to the dentist could be reduced. On the other hand "focal sepsis" and rheumatoid arthritis have been closely linked in the past. This relationship has been discussed as recently as 1959 by Weinstein and Ling and 1960 by Payer and could in fact have contributed to this finding.

Finally the clinical and radiographical evidence of this study substantiates the findings of Ayer, Kusek and Steubner (1968) who were unable to confirm histological changes in the teeth of two subjects, who had been treated with long term steroid therapy, which had been reported by earlier observers as a result of experimental animal researches. A considerable proportion of the patients I saw had been treated with cortisone drugs but not once did I detect any of the changes expected in the light of the reports of the animal studies. In fact, apart from the exceptions described, all groups appeared to have a similar dental status, this similarity being closest when the groups with the least physical disability were compared.

The high treatment requirements of the patients examined substantiate the findings of previous dental health studies (Bulman, Richards, Slack and Willocks, 1968; Stephen, 1969). The final phrase of Halsbury's statement, in what some will consider to be one of the most important publications of 1972, that "although the general standard of dental health in this country has improved dramatically since the inception of the N.H.S. .... there is still room for much improvement" is convincingly supported by this study. The major question left unanswered is whether a chronically disabled section of our population takes so much interest in its personal dental health that it compares with other sections or whether the general dental health remains so poor that, in most respects, it can be equated with the dental health of those who, through no fault of their own, have difficulty in obtaining regular, comprehensive, dental treatment.

11.iii) SUMMARY AND CONCLUSIONS

A dental epidemiological study of one hundred and forty-one patients suffering from rheumatic disease, ninety-three of whom had severe rheumatoid arthritis, nine Sjøgren's syndrome, seven of which cases were associated with rheumatoid arthritis, and thirty-nine primary osteoarthrosis, was completed. The high treatment requirements of all the groups studied including a control one with no evidence of any form of rheumatic disease, is fully discussed. Special attention is paid to the two outstanding features of this study - the high oral hygeine indices of the rheumatoid arthritic patients and their relative youth when they became totally edentulous. It is concluded that a considerable improvement in the standard of dental health in this country is highly desirable.

SECTION VI

SUPPLEMENT

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CHAPTER 12

PSORIATIC ARTHRITIS

As I stated in Chapter 3, I had no intention of mentioning far less discussing, psoriatic arthritis. However, in view of the fact that there is a dearth of information about the oral and dental manifestations of this condition in not only the medical but also the dental literature, and because I saw groups of patients with this disease as an incidental part of my present study, I finally became convinced that to omit it entirely would be wrong. The results of the salivary gland and temporomandibular joint examinations are shown together on Table LII (T. & I. 191).

Twenty-four females and five males had sialography performed on one or other of their parotid glands. This sample is rather unrepresentative because, unlike rheumatoid arthritis, psoriatic arthritis is more prevalent among men. Three (10.3 percent) of the sialograms were found to be abnormal, two showing punctate sialectasis associated with main duct dilatation and one atrophy. None of these patients had signs of Sjøgren's syndrome. Conversely one patient who had psoriatic arthritis and Sjøgren's syndrome had a normal sialogram. Psoriatic arthritis has many clinical, radiological and serological differences from rheumatoid arthritis although the histological features of the synovitis may be indistingui--shable from those found in rheumatoid arthritis (Leczinsky, 1948; Reed, 1961; Baker, 1966; Boyle and Buchanan, 1971). Sjøgren's syndrome is not usually considered to be a complica--tion of psoriatic arthritis, and it is therefore of interest that these three patients had abnormal sialograms. Further studies of larger numbers of patients with psoriatic arthritis may well reveal an increased predisposition to mild or sub-clinical Sjøgren's syndrome as occurs in rheumatoid arthritis.

Support for this point of view was provided by the results of the dental examinations. Generally the findings of the dental examinations of seven patients, five of whom were edentulous, were closely similar to those of the various other groups I have examined and so I do not propose to detail them. However, one of the two edentulous males, only one male and one female had natural teeth present at the time of these examinations, had objective signs of xerostomia and one edent--ulous female had a subjective history of a dry mouth.

Five of a total of seven patients with psoriatic arthritis had clinical evidence of temporomandibular joint disturbance , but only five of fourteen joints showed radio--logical abnormalities. One patient had limited opening and another referred pain, two of the clinical features which I described as being of major importance in connection with rheumatoid arthritis, but there was no clinical evidence of stiffness, crepitus or tenderness on biting, although one patient did complain of tenderness on palpation. This patient also displayed deviation and a palpable click. In fact, on no occasion was a click, either palpable or audible, found as an isolated feature. The only significantly commonly found radiological feature of rheumatoid arthritis, which was absent from this small group of patients, was marginal proliferations, there being six instances of antero-position and one of reduced mobility in addition to evidence of surface erosions and flattening of two and three condyles respectively. Two condyles were also seen to be in retro-position, two subluxated and five osteoporotic. One articular disc was calcified. One of the three patients with radiological evidence of temporo-mandibular joint involvement was quite normal on clinical examination.

A comparison of those clinical features which appear to be important in relation to rheumatoid arthritis showed that the incidence of referred pain was similar in psoriatic patients and rheumatoid arthritics, and of limitation of opening and of tenderness on palpation was most frequent among patients with rheumatoid arthritis but also markedly more common in patients with psoriatic arthritis than control patients. Deviation was found most frequently and a palpable click least often, by comparison with the various groups already studied, in psoriatic arthritis. A similar analysis of the radiological abnormalities indicated a very high frequency of antero-position, a frequency of surface erosions equal to that found in rheumatoid arthritis and less frequent occurrences of erosions as a whole, flattening and reduced mobility in psoriatic arthritis than in rheumatoid arthritis although only the last-mentioned descended to anything approaching the level found in the control groups. In addition retro-position, quite the opposite of antero-position, appeared to be a rare feature of psoriatic arthritis.

Such changes are not unexpected, Wright (1959) described three patterns of psoriatic arthritis, the third of which closely resembled rheumatoid arthritis clinically although tending to be less disabling and to involve fewer joints. This would largely accord with my present findings. Lundberg and Ericson (1967) found the incidence of radiological abnormalities to be much higher, however, and concluded that the temporomandibular joint was involved as often by psoriatic arthritis as by rheumatoid arthritis. More of their patients may have fallen into Wright's second pattern of psoriatic arthritis which is deforming, may involve any joint and occurs in a younger age group. Indeed, the mean age of their patients was thirty-nine years and of mine 52.3 years.

However, apart from agreeing that psoriatic arthritis does involve the temporomandibular joint, on occasion severely, further conjecture on my part about these differences would be presumptions. After all they could form the basis of another study, in fact it appears that they should do so, and, perhaps, again show just how inter-related the fields of the dentist and the physician actually are.

CHAPTER 13

THE METHOD OF LOGISTIC DISCRIMINATION

In view of the very definite findings I have made in the course of this study, I have decided that it should be continued. I do not intend to study only rheumatic diseases other than adult rheumatoid arthritis, such as psoriatic arthritis and osteoarthrosis, which have proved to be interesting, as well as unique, if largely incidental aspects of my main topic. Adult rheumatoid arthritis is equally important. I have had the extreme good fortune to obtain the willing advice and assistance, already, with the promise of future help, if, and when, it is required, of Dr. John Anderson, of the University of Oxford's Department of Biomathematics.

The first series of results with which Dr. Anderson has helped provides very substantial support for the conclusions I reached in Chapter 9 and, also, concrete evidence of the value of continuing the work on which my present study was based. Therefore, I propose to mention it briefly.

The results of one hundred and eighty-two bilateral temporomandibular joint radiographic examinations were studied. The thirteen radiological abnormalities, which I recorded as a result of reporting the radiographs of all the patients whose temporomandibular joints I studied, were the thirteen considered (Table LIII) (T. & I. 192). Each was considered in turn and was said to be present, if detected in one or both joints of any particular patient, or absent. In other words, the temporomandibular joints were considered to be a unit and not two distinct joints in this particular statistical analysis. Thus thirteen observations were made on each of ninety-nine patients with rheumatoid arthritis, thirty-six with osteoarthrosis and forty-seven with no evidence of any form of rheumatic disease. By inspection of the table it can be seen that the normal patients and those with osteoarthrosis were closely similar and this was confirmed by a logistic analysis. Thus the data from these normal and osteoarthrotic patients were combined and tests were carried out for the differences between the patients with rheumatoid arthritis and of this combined control group on each observation, separately. There were significant differences on eight of these observat--ions (1, 4, 5, 7, 8, 9, 10 and 12 in Table LIII) (T. & I. 192) so it is clear that there were differences in the incidence of temporomandibular joint involvement between these two groups of patients. I determined similar differences when I compared antero-position, reduced mobility, surface and pocket erosions, flattening and marginal proliferations but my numbers were too small for me to derive any results for subluxation or sclerosis by the statistical methods I used. The more refined methods used in this analysis, therefore, more than substantiate those findings I have previously described.

The logistic discrimination procedure was carried out, using only these eight significant observations, to differentiate between the two populations. Technical difficulties arise in the standard logistic discrimination when sample splits occur, which involve either none of or all of the total number of patients under consideration, as was the case with observations 7, 8 and 9 in the combined control group. However, by slightly modifying the approach to take account of this problem, this logistic scoring function was established:-

$$S = 1.385 - 0.665_{x1} - 0.426_{x4} - 0.473_{x6} - 3.472_{x8}$$
$$- 2.329_{x9} - 1.824_{x10} - 2.336_{x12}$$

where x stands for the observations under consideration, and the number following x denotes the particular observation. Observation 7 was omitted from this scoring method because only three patients, all suffering from rheumatoid arthritis, displayed sclerosis. Positive values of S are associated with "normality" and negative values with rheumatoid arthritis. The scores (S) of all subjects in this study were then calculated and plotted as depicted in Figure 140 (T. & I. 193). It can be seen that, although only one combined control group patient had a score much below -1.5, there were a number of patients with rheumatoid arthritis who had scores in the region 0 to +1.4. This is a reasonable picture of the possible discrimination since twelve rheumatoid arthritic patients had no abnormalities on their radiographs and several had only one. It would appear that anyone from these groups with a score of -2 or less was likely to have rheumatoid arthritis.

Therefore, this preliminary further study confirms the similarity of the involvement of the temporomandibular joint among patients with osteoarthrosis and with no evidence at all of rheumatic disease and, also, that there are differences in some but not all of the observations, taken one at a time, between the combined control group and the rheumatoid arthritic group. It has shown, in addition, that the method of logistic discrimination may be used to separate these two groups solely on the basis of abnormalities detected on their temporomandibular joint radiographs.

SUMMARY

SUMMARY

Four considerations provide the basis for this thesis, namely the necessity for this study, the aptness of the methods used, the oral and dental manifestations of adult rheumatoid arthritis, and the wisdom of undertaking further, similar, research.

The necessity for the study is considered, initially, by a description of anatomy and physiology, from which the damaging effects of disease of the structures studied on the affected subjects can be understood. Secondly, the very large number of different radiographic techniques used to examine, especially, the temporomandibular joint but, also, the salivary glands and teeth is described in greater detail than originally intended because no comprehensive record of these could be found in the dental or medical literature. The third consideration is the evidence gained by a thorough review of the literature. No large scale study of a major salivary gland has been reported. The results produced by the various students of the temporomandibular joint, some of which are fairly extensive, at best can be described as confusing. Apparently, no serious consideration has been given to the effect of the general, systemic manifestations of adult rheumatoid arthritis on the dental health of a section of our population suffering from this disabling disease. The need for my investigation is conclusive and emphatic.

The methods used to diagnose adult rheumatoid arthritis and Sjøgren's syndrome are summarised but not analysed. However the methods I used to investigate the salivary glands, the temporomandibular joint and the teeth are examined in detail. Hydrostatic sialography, although deficient in certain minor respects, is considered to be at least the equal of any other sialographic method in use at the present time. Circular tomography, which has not been used before in any large study of the temporomandibular joint, is an accurate and reproducible technique, superior to others recently advocated because a higher proportion of radiologically clear radiographs are produced by it. Periapical dental radiography is, probably, a less controversial subject but justification is provided for selecting the lower anterior teeth in a large radiological survey if, for any reason, this form of radiography has to be limited. All radiological reporting has been standardised. Clinical examinations have depended to a much greater extent on established methods, the selection of which has been justified. However, the method of measuring the extent of opening of the mouth and clinical and radiological interpre-tations of "normal opening" and "subluxation" have been strictly defined. In addition, schemes for classifying the state of occlusion and the condition of individual dentures have been suggested.

Sialographic abnormalities of the parotid gland in adult rheumatoid arthritis are defined and described. Their incidence in a group of patients with Sjøgren's syndrome has been shown to be highly significantly more common than in patients with adult rheumatoid arthritis alone and in control patients. Subjects with Sjøgren's syndrome complicated by rheumatoid arthritis appear to have less severe salivary gland involvement than subjects with sicca syndrome. It is proposed, additionally, that there may be a sub-clinical form of Sjøgren's syndrome whose detection is assisted by sialography. The technique of hydrostatic sialography has been modified by taking into consideration the more critical assessment of salivary gland involvement in these conditions, obtained by measuring salivary flow rates.

The first recorded investigation into the effect of primary osteoarthrosis on the temporomandibular joint is included. It appears that a diagnosis of primary osteoarthrosis of one or more peripheral joints is no indication that the temporomandibular joint is likely, also, to be involved by this condition. On the other hand, adult rheumatoid arthritis has been shown, both clinically and radiologically, to affect the large majority of subjects suffering from this disease. Certain clinical and radiological features described appear to be almost specific for adult rheumatoid arthritis and to correlate with increasing severity of this disease.

The oral hygeine of those patients examined, who were suffering from adult rheumatoid arthritis, was poorer than that of control patients and they were much more likely to have lost all their natural teeth at an earlier age than patients not afflicted by this disease. This is, possibly, due to the processes of the disease itself but the latter finding could, also, be a result of the theory of "focal infection" which was in vogue until fairly recently. The results of the dental investigations, in addition substantiate the findings of other dental health surveys that there is great room for improvement in the general standard of dental fitness in the United Kingdom. No evidence was discovered, however, that dental abnormalities, such as have been described as the result of animal studies, may be produced as a consequence of steroid therapy.

Psoriatic arthritis appears to involve the temporo-mandibular joints in a fashion similar to adult rheumatoid arthritis and to be associated, also, perhaps, with a sub-clinical form of Sjøgren's syndrome. These findings are of interest because they provide support for, and add to, the scant information available in the literature concerning the oral and dental manifestations of psoriatic arthritis. However, the sample of patients seen suffering from this disease was too small for comprehensive observations to be made. Substan--tial support for the results enumerated in the section on the temporomandibular joint is provided by a detailed statistical method, and a simple logistic scoring function has been devised, using the procedure of logistic discrimination, to differentiate, radiologically, adult rheumatoid arthritis from other abnormalities of the temporomandibular joint. It is, therefore, suggested that studies of the oral and dental manifestations of other rheumatic diseases, and the continued study of adult rheumatoid arthritis, would be valuable, and of benefit, not only to rheumatologists but also to the dental profession.

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DEGREE OF M.D.S.

"ORAL AND DENTAL MANIFESTATIONS

OF

ADULT RHEUMATOID ARTHRITIS"

by

GEORGE STEWART BLAIR

SUMMARY

Four considerations provide the basis for this thesis, namely the necessity for this study, the aptness of the methods used, the oral and dental manifestations of adult rheumatoid arthritis, and the wisdom of undertaking further, similar, research.

The necessity for the study is considered, initially, by a description of anatomy and physiology, from which the damaging effects of disease of the structures studied on the affected subjects can be understood. Secondly, the very large number of different radiographic techniques used to examine, especially, the temporomandibular joint but, also, the salivary glands and teeth is described in greater detail than originally intended because no comprehensive record of these could be found in the dental or medical literature. The third consideration is the evidence gained by a thorough review of the literature. No large scale study of a major salivary gland has been reported. The results produced by the various students of the temporomandibular joint, some of which are fairly extensive, at best can be described as confusing. Apparently, no serious consideration has been given to the effect of the general, systemic manifestations of adult rheumatoid arthritis on the dental health of a section of our population suffering from this disabling disease. The need for my investigation is conclusive and emphatic.

The methods used to diagnose adult rheumatoid arthritis and Sjøgren's syndrome are summarised but not analysed. However the methods I used to investigate the salivary glands, the temporomandibular joint and the teeth are examined in detail. Hydrostatic sialography, although deficient in certain minor respects, is considered to be at least the equal of any other sialographic method in use at the present time. Circular tomography, which has not been used before in any large study of the temporomandibular joint, is an accurate and reproducible technique, superior to others recently advocated because a higher proportion of radiologically clear radiographs are produced by it. Periapical dental radiography is, probably, a less controversial subject but justification is provided for selecting the lower anterior teeth in a large radiological survey if, for any reason, this form of radiography has to be limited. All radiological reporting has been standardised. Clinical examinations have depended to a much greater extent on established methods, the selection of which has been justified. However, the method of measuring the extent of opening of the mouth and clinical and radiological interpreta--tions of "normal opening" and "subluxation" have been strictly defined. In addition, schemes for classifying the state of occlusion and the condition of individual dentures have been suggested.

Sialographic abnormalities of the parotid gland in adult rheumatoid arthritis are defined and described. Their incidence in a group of patients with Sjøgren's syndrome has been shown to be highly significantly more common than in patients with adult rheumatoid arthritis alone and in control patients. Subjects with Sjøgren's syndrome complicated by rheumatoid arthritis appear to have less severe salivary gland involvement than subjects with sicca syndrome. It is proposed, additionally, that there may be a sub-clinical form of Sjøgren's syndrome whose detection is assisted by sialography. The technique of hydrostatic sialography has been modified by taking into consideration the more critical assessment of salivary gland involvement in these conditions, obtained by measuring salivary flow rates.

The first recorded investigation into the effect of primary osteoarthrosis on the temporomandibular joint is included. It appears that a diagnosis of primary osteoarthrosis of one or more peripheral joints is no indication that the temporomandibular joint is likely, also, to be involved by this condition. On the other hand, adult rheumatoid arthritis has been shown, both clinically and radiologically, to affect the large majority of subjects suffering from this disease. Certain clinical and radiological features described appear to be almost specific for adult rheumatoid arthritis and to correlate with increasing severity of this disease.

The oral hygeine of those patients examined, who were suffering from adult rheumatoid arthritis, was poorer than that of control patients and they were much more likely to have lost all their natural teeth at an earlier age than patients not afflicted by this disease. This is, possibly, due to the processes of the disease itself but the latter finding could, also, be a result of the theory of "focal infection" which was in vogue until fairly recently. The results of the dental investigations, in addition, substantiate the findings of other dental health surveys that there is great room for improvement in the general standard of dental fitness in the United Kingdom. No evidence was discovered, however, that dental abnormalities, such as have been described as the results of animal studies, may be produced as a consequence of steroid therapy.

Psoriatic arthritis appears to involve the temporomandibular joints in a fashion similar to adult rheumatoid arthritis and to be associated, also, perhaps, with a subclinical form of Sjøgren's syndrome. These findings are of interest because they provide support for, and add to, the scant information available in the literature concerning the oral and dental manifestations of psoriatic arthritis. However, the sample of patients seen suffering from this disease was too small for comprehensive observations to be made. Substantial support for the results enumerated in the section on the temporomandibular joint is provided by a detailed statistical method, and a simple logistic scoring function has been devised, using the procedure of logistic discrimination, to differentiate, radiologically, adult rheumatoid arthritis from other abnormalities of the temporomandibular joint. It is, therefore, suggested that studies of the oral and dental manifestations of other rheumatic diseases, and the continued study of adult rheumatoid arthritis, would be valuable, and of benefit, not only to rheumatologists but also to the dental profession.

ORAL AND DENTAL MANIFESTATIONS

OF

ADULT RHEUMATOID ARTHRITIS

A Clinical and Radiological Study

by

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THESIS

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TABLES AND ILLUSTRATIONS

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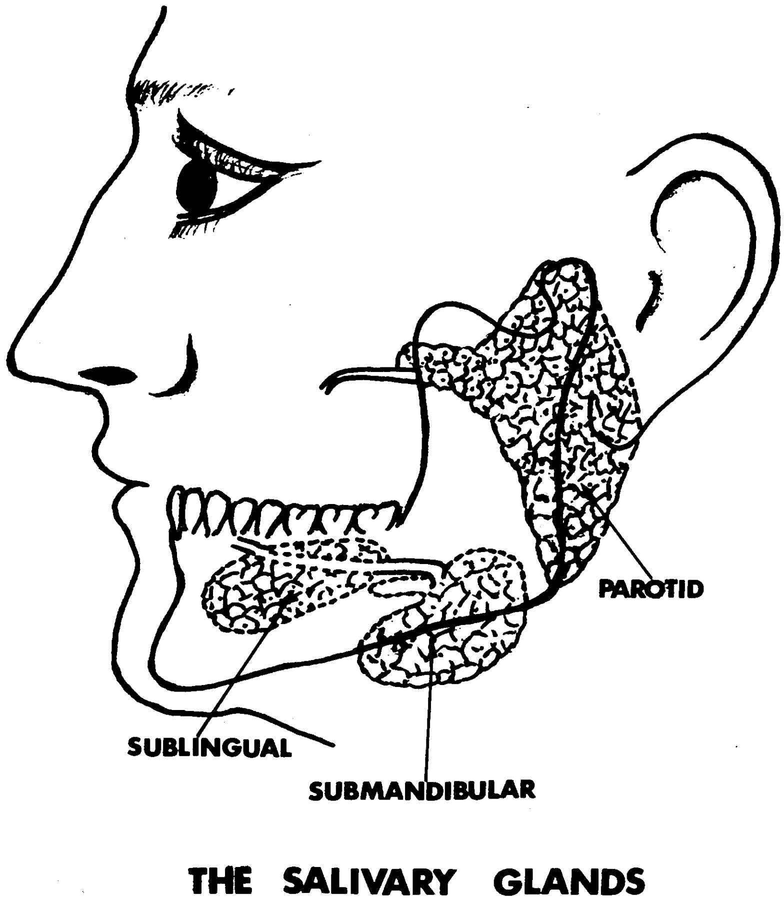
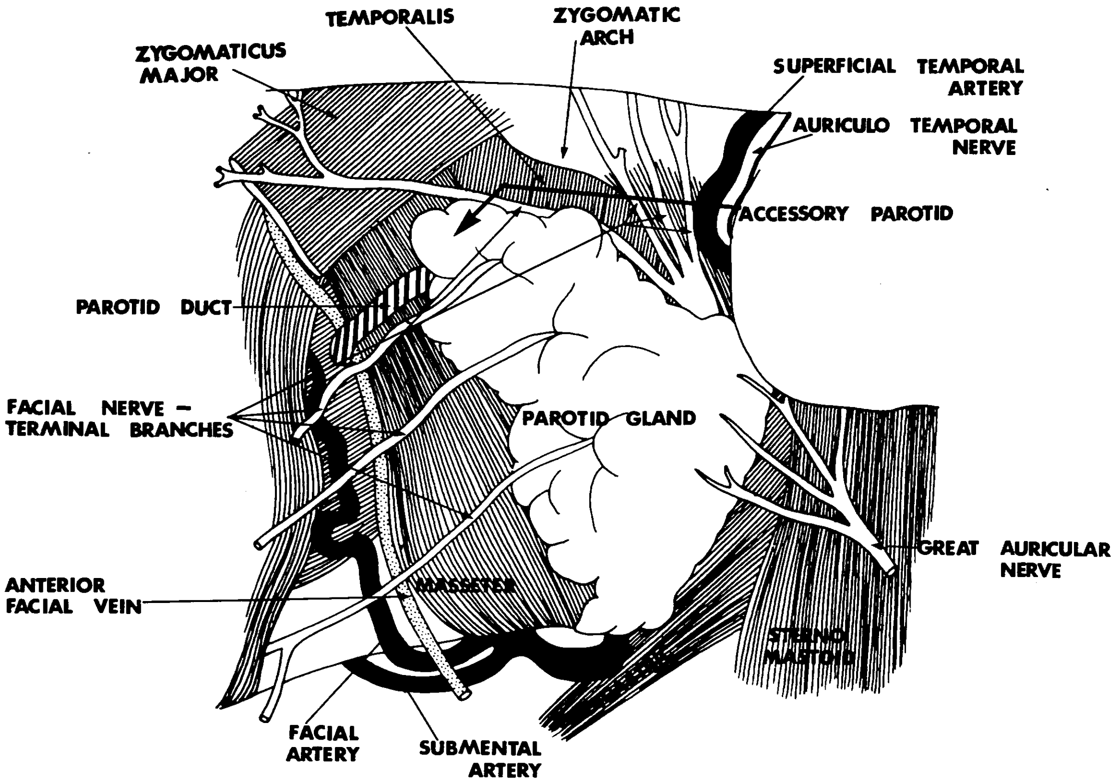
FIGURE 1



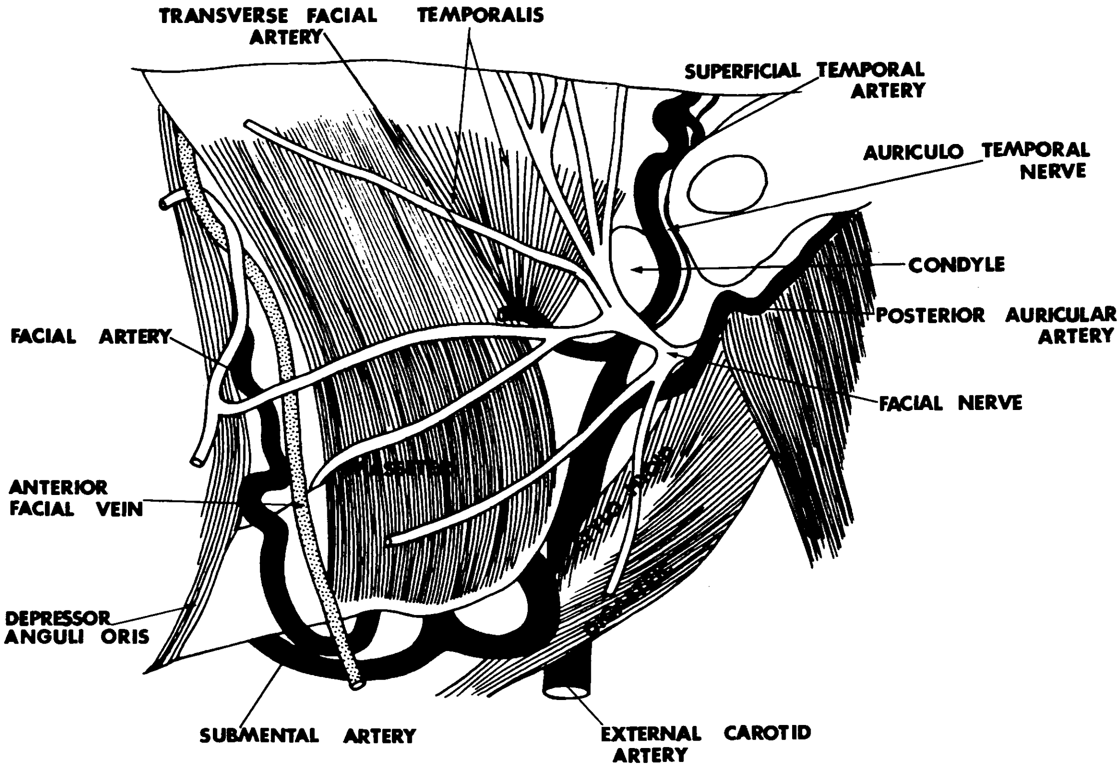
Location of the major salivary glands and the temporomandibular joint

FIGURE 2



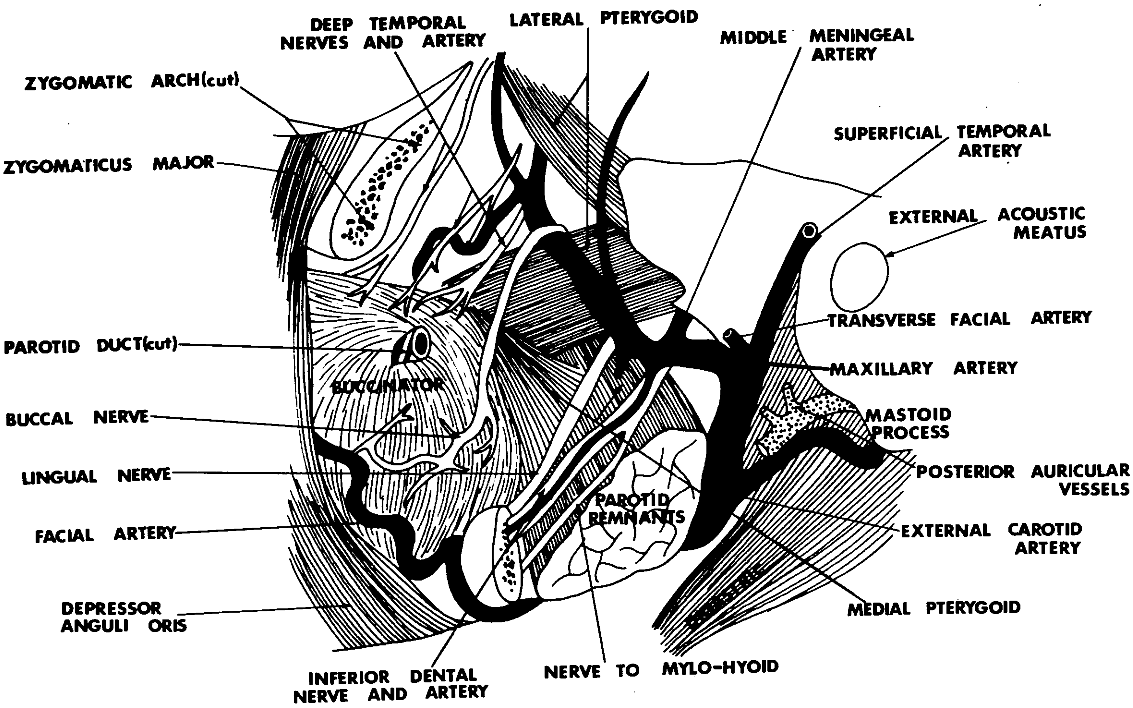
Superficial relations of the parotid gland

FIGURE 3



<u>**Structures intimately associated with the parotid gland**</u>

FIGURE 4



Deep relations of the parotid gland

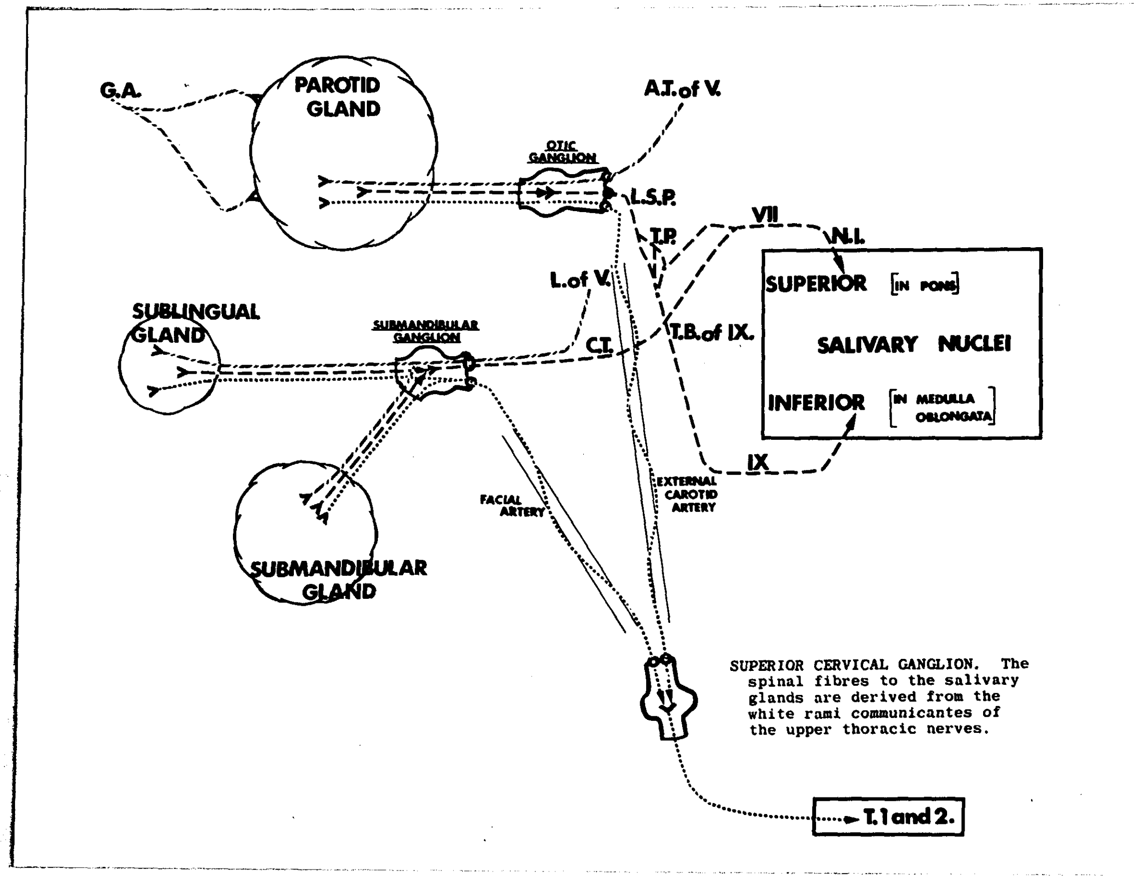
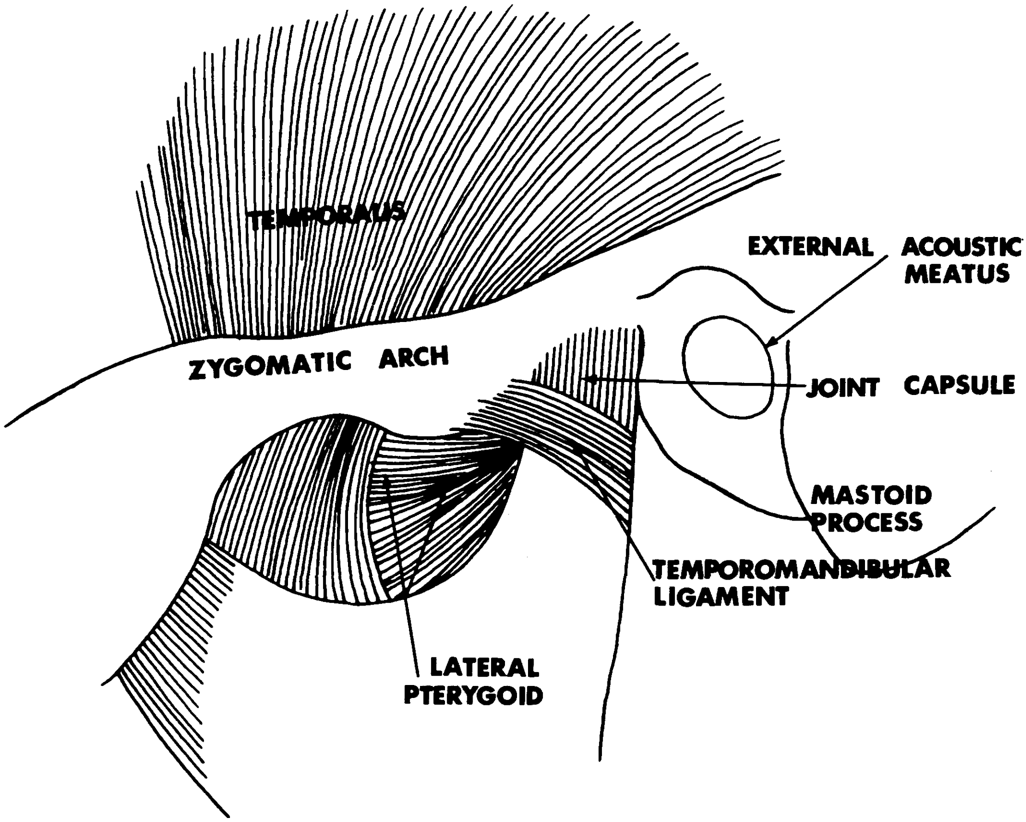

G.A.
PAROTID GLAND
OTIC GANGLION
A.T. of V.
L.S.P.
T.P.
VII
N.I.
SUPERIOR [IN PONS]
SALIVARY NUCLEI
INFERIOR [IN MEDULLA OBLONGATA]
SUBLINGUAL GLAND
SUBMANDIBULAR GANGLION
L. of V.
C.T.
T.B. of IX.
IX
EXTERNAL CAROTID ARTERY
FACIAL ARTERY
SUBMANDIBULAR GLAND
SUPERIOR CERVICAL GANGLION. The spinal fibres to the salivary glands are derived from the white rami communicantes of the upper thoracic nerves.
T.1 and 2.

FIGURE 5

NERVE SUPPLY OF THE MAJOR SALIVARY GLANDS

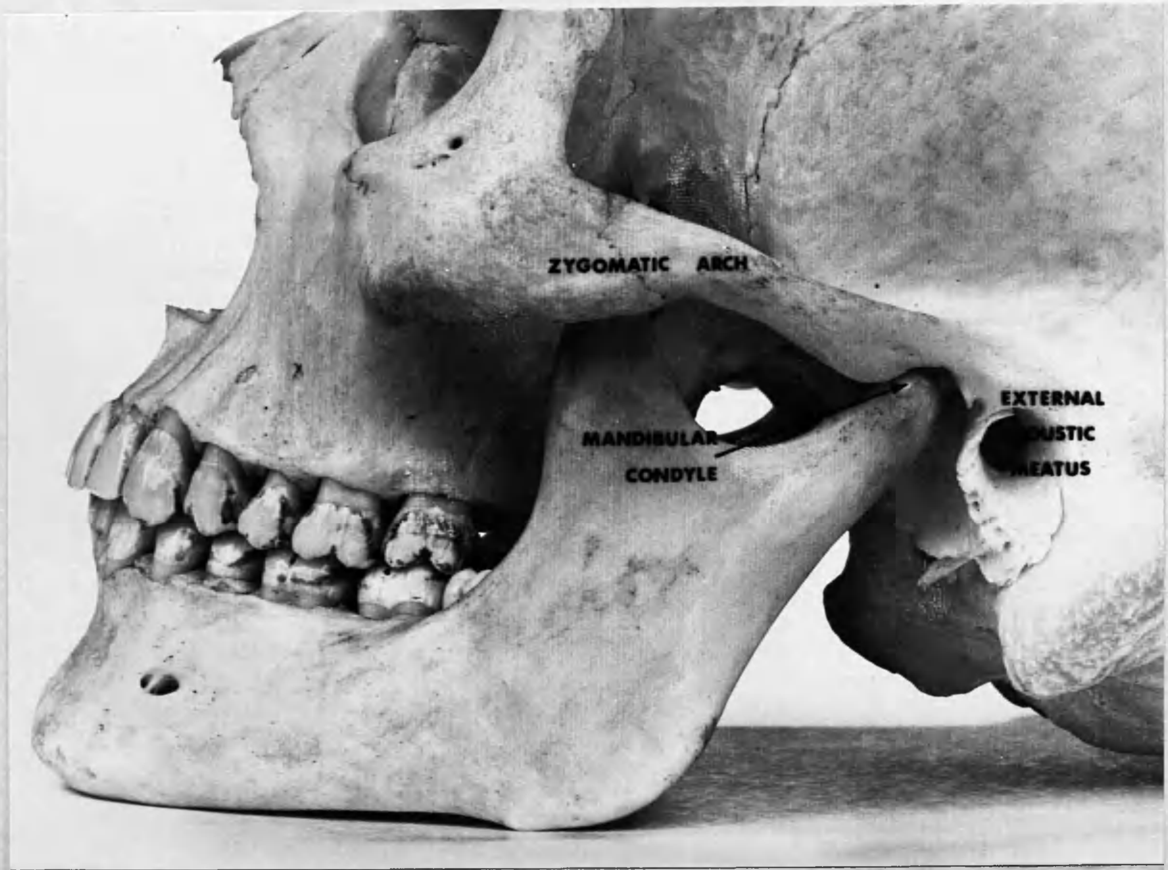
Parotid Gland	Auriculo-temporal nerve	Sensory	(1) to gland Auriculo-Temporal nerve (A.T. of V.) (2) to capsule Great Auricular nerve (G.A.)
		Para-sympathetic	Glossopharyngeal nerve (IX). Arises in Medulla and fibres pass via the Tympanic branch (T.B. of IX), Tympanic plexus (T.P.) and Lesser Superficial Petrosal Nerve (L.S.P.) to the Otic Ganglion where they are relayed. Fibres from the Nervus Intermedius (N.I.) joint these fibres in the Tympanic plexus.
		Sympathetic	Plexus around the External Carotid artery from the Superior Cervical Ganglion.
Submandibular and Sublingual Glands	Lingual Nerve	Sensory	Lingual Nerve (L. of V.)
		Para-sympathetic	Nervus Intermedius (N.I.) root of Facial nerve (VII). Arises in Pons and travels via the Chorda Tympani branch (C.T.) to join the Lingual nerve and reach the Submandibular Ganglion where its fibres are relayed.
		Sympathetic	Plexus around the Facial artery from the Superior Cervical Ganglion.

FIGURE 6



Superficial features of the temporomandibular joint

FIGURE 7



Lateral dry skull view of the permanent teeth, jaws, and temporomandibular joint

FIGURE 8

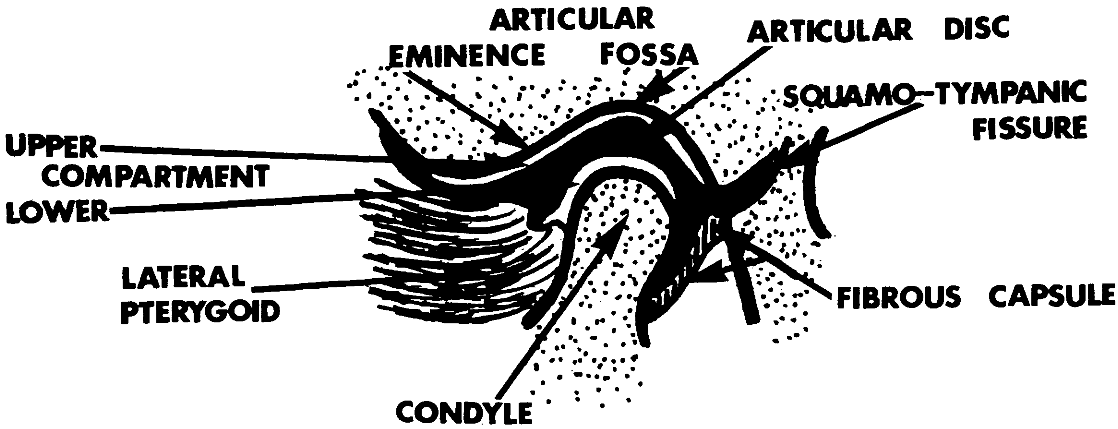
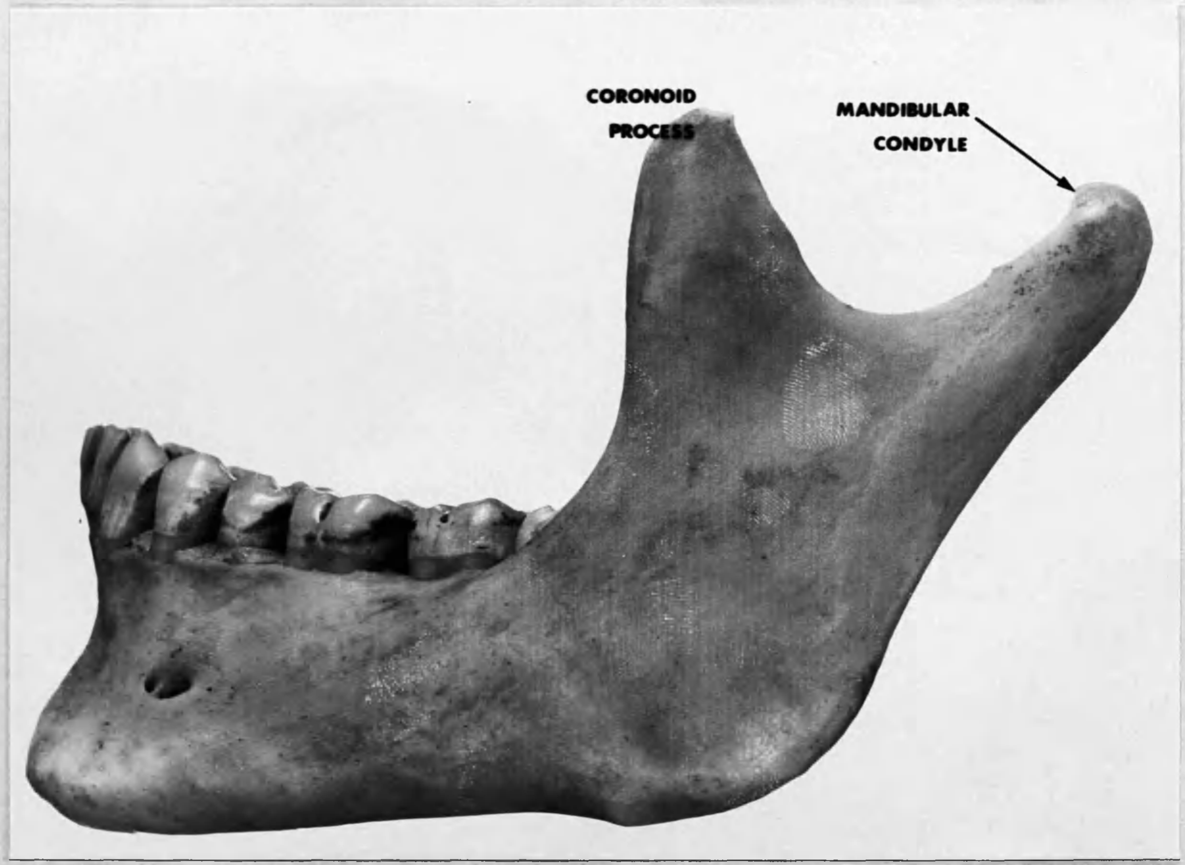


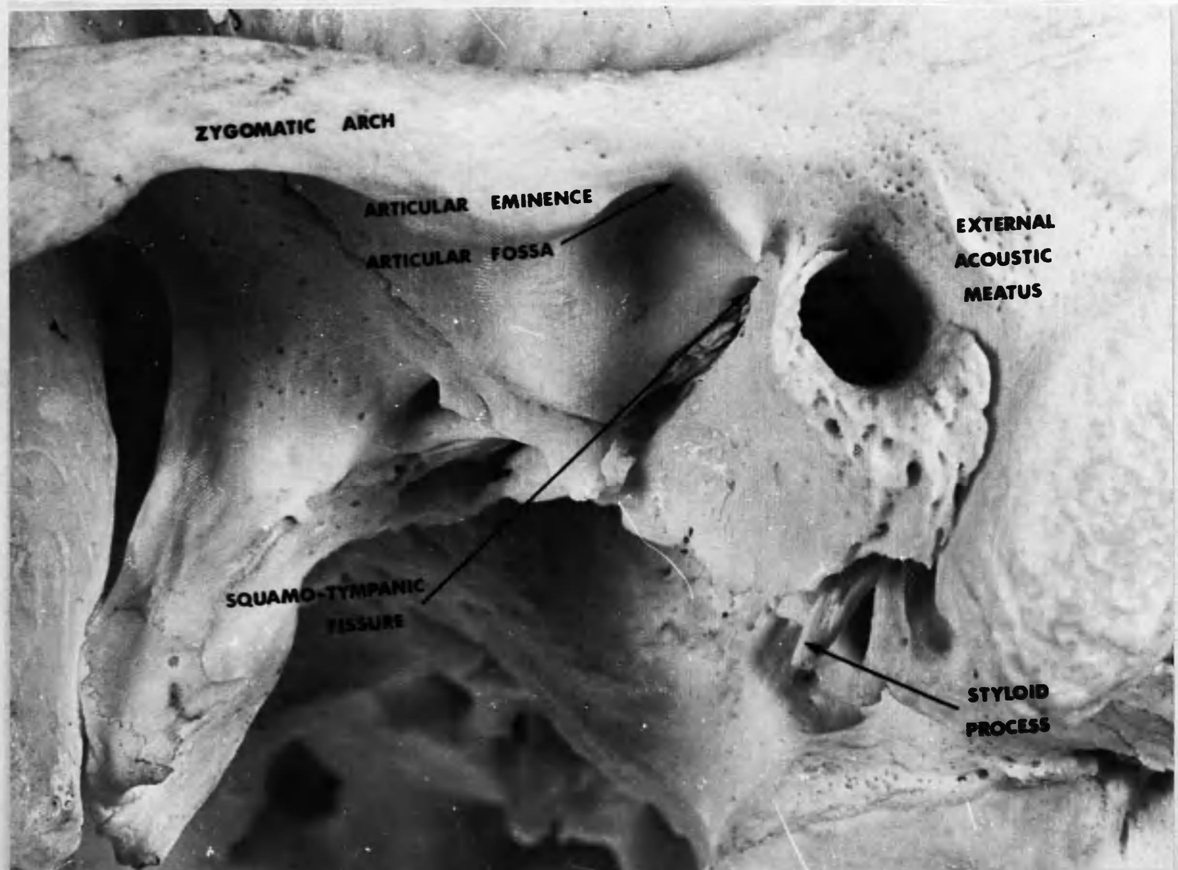
__Diagram of the articular surfaces, the articular disc and the squamo-tympanic fissure__

FIGURE 9



Lateral dry skull appearance of the mandible, the coronoid process and the mandibular condyle

FIGURE 10

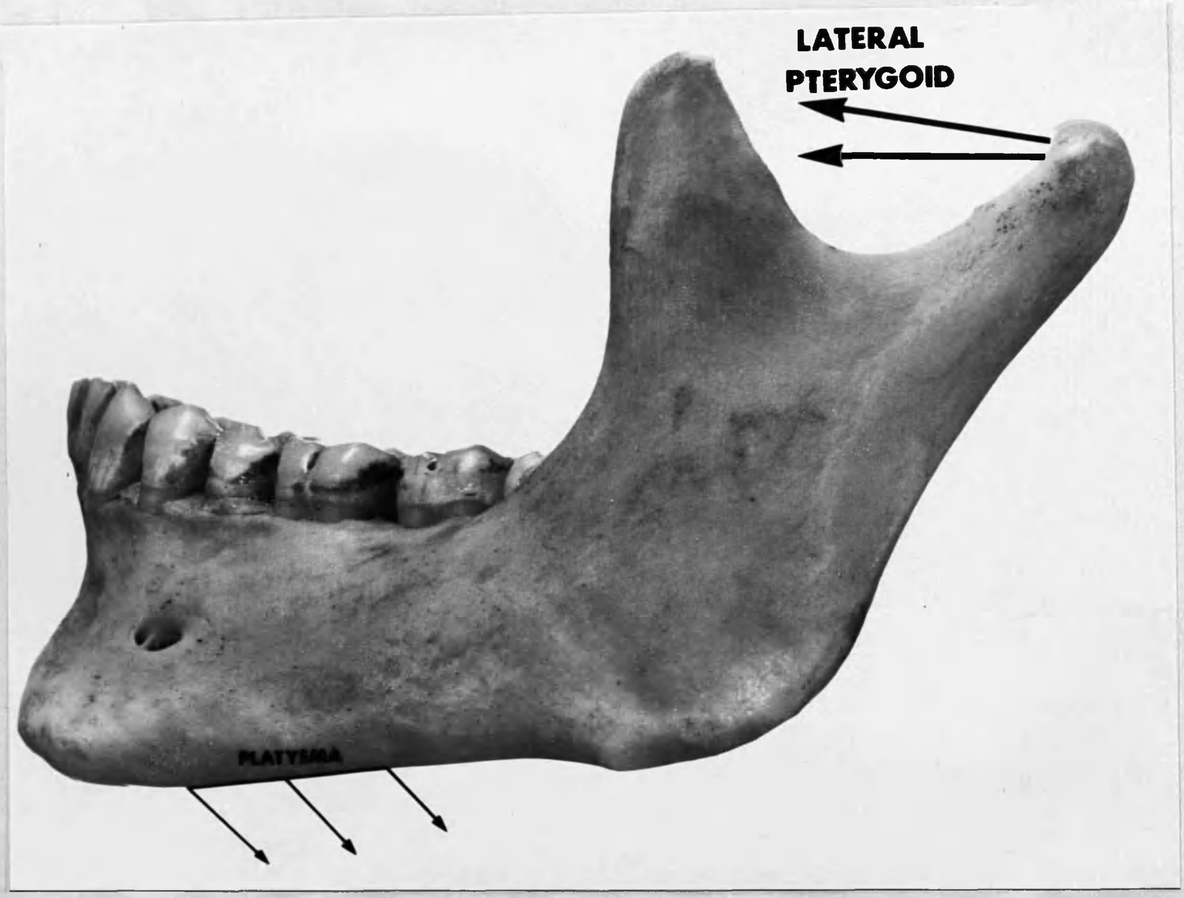


The articular eminence, the articular fossa and the squamo-tympanic fissure

FIGURE 11

The bi-convexity of the mandibular condyle

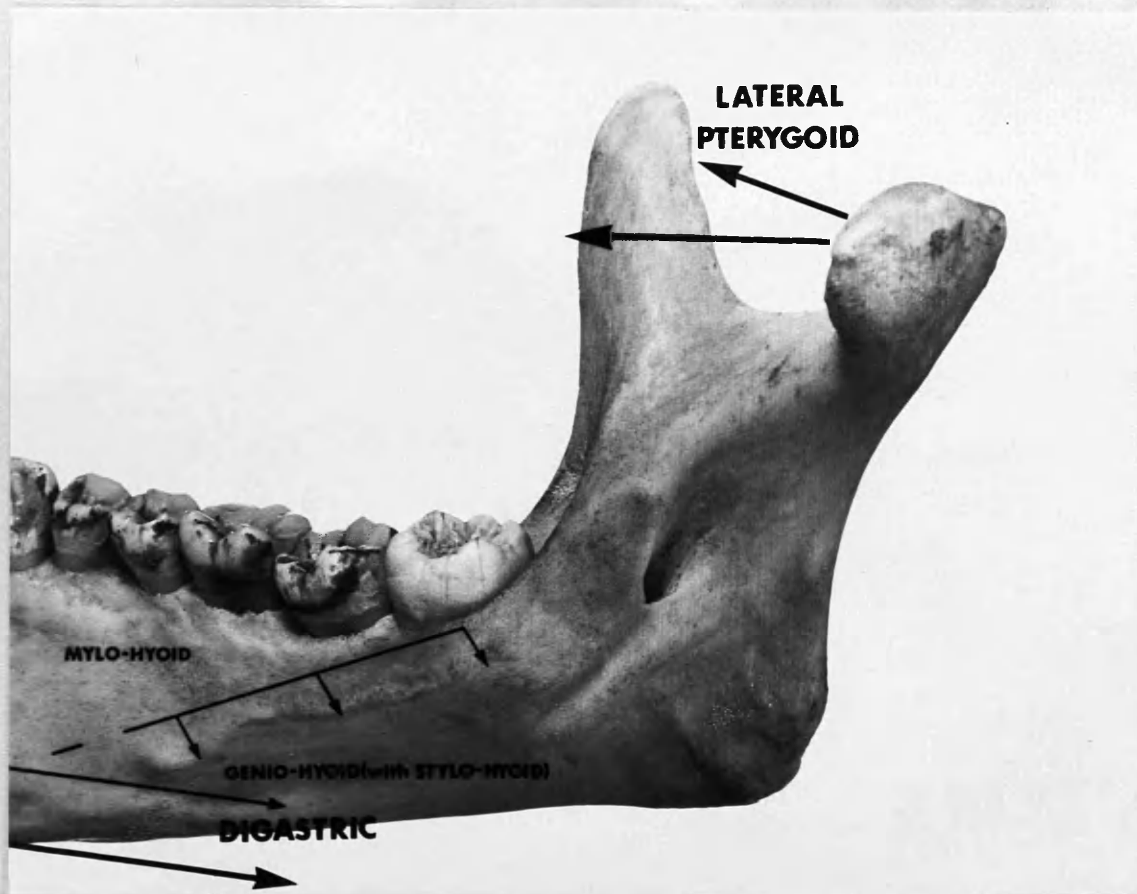
FIGURE 12



The depressors of the mandible

A diagrammatic representation viewed from the lateral aspect of the mandible

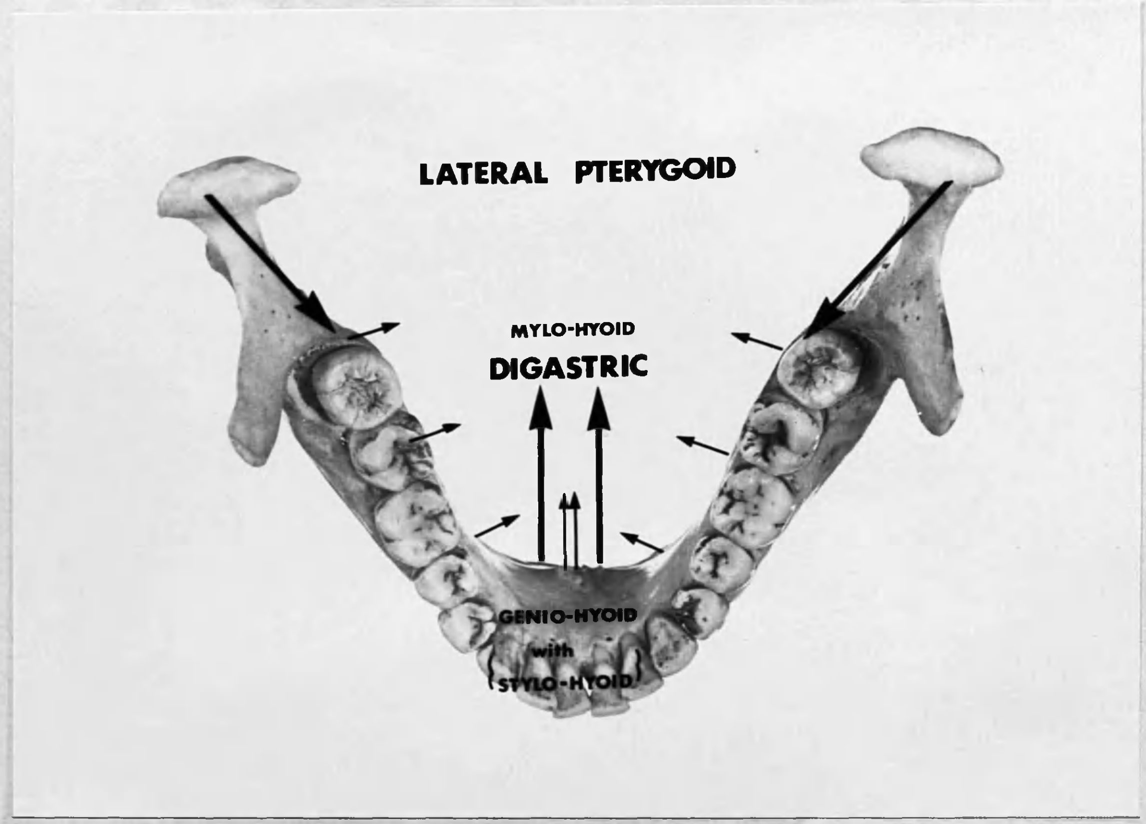
FIGURE 13



The depressors of the mandible

A diagrammatic representation viewed from the medial aspect of the mandible

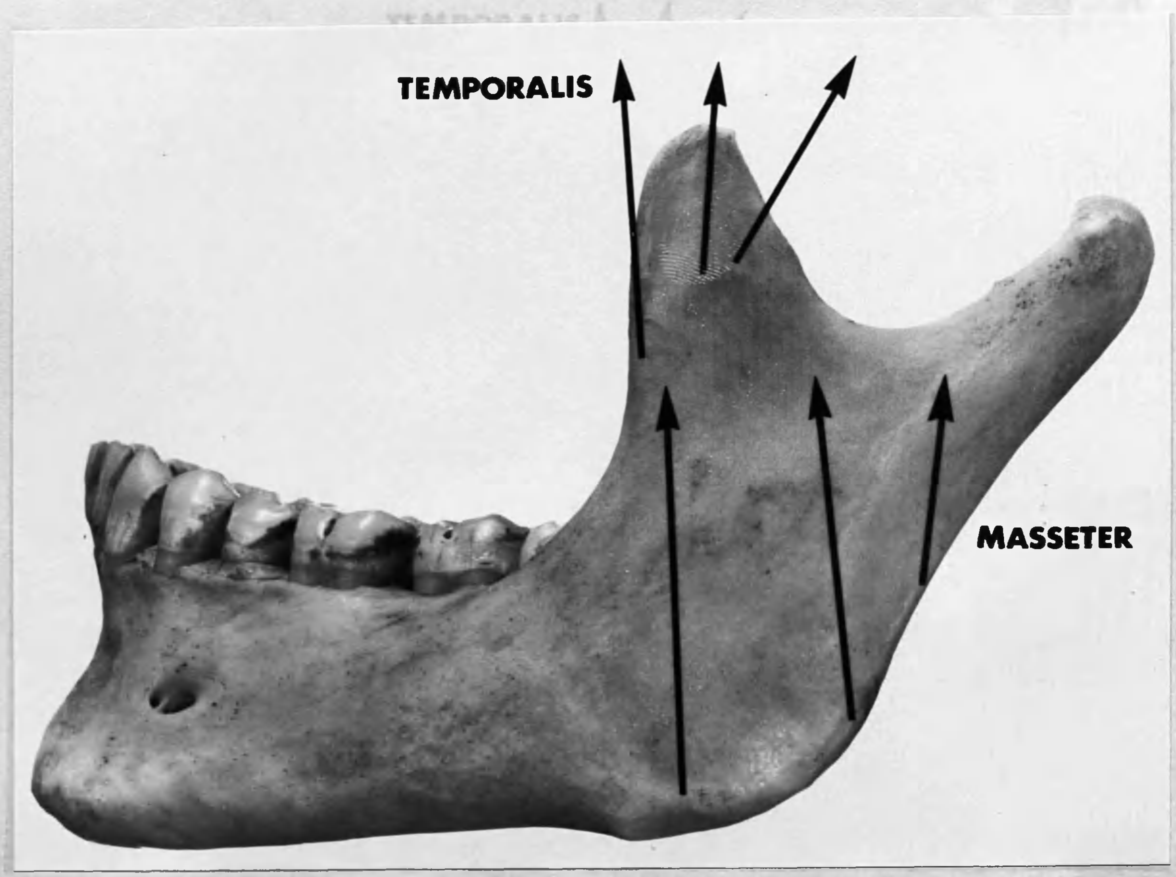
FIGURE 14



The depressors of the mandible viewed from above

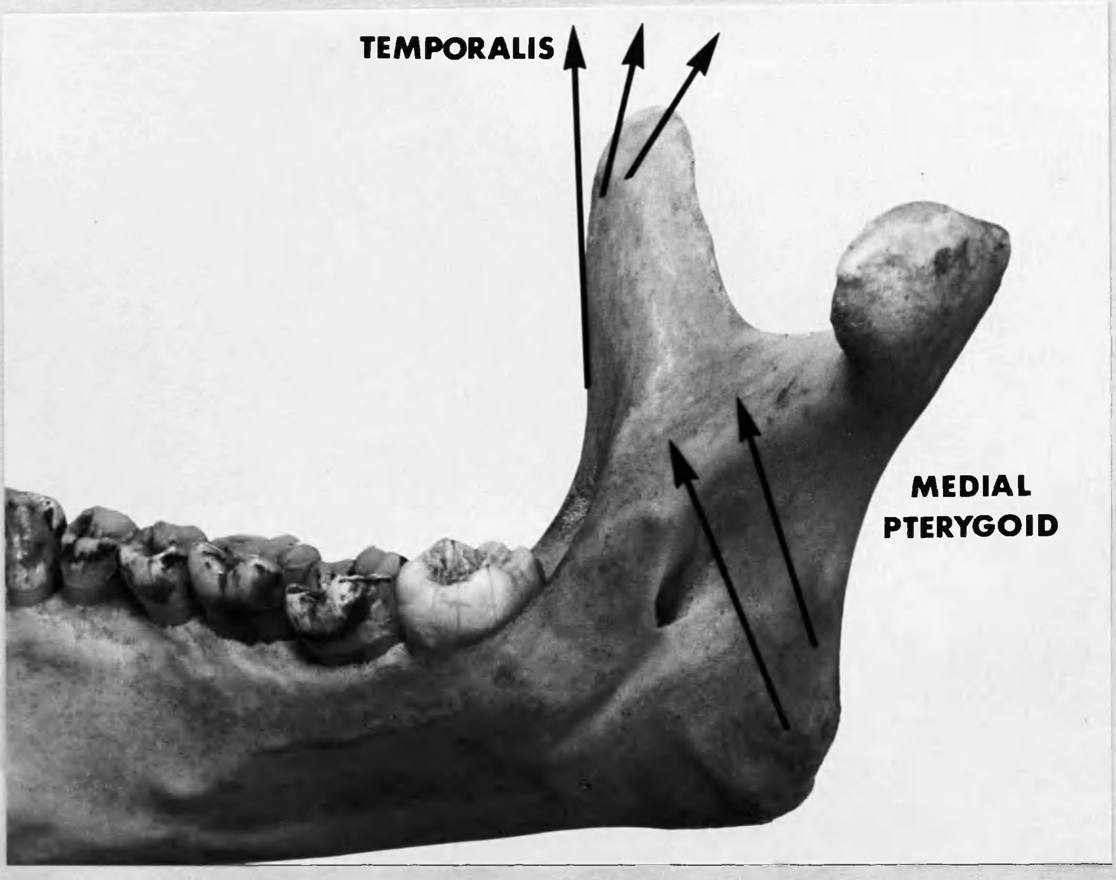
A diagrammatic representation

FIGURE 15



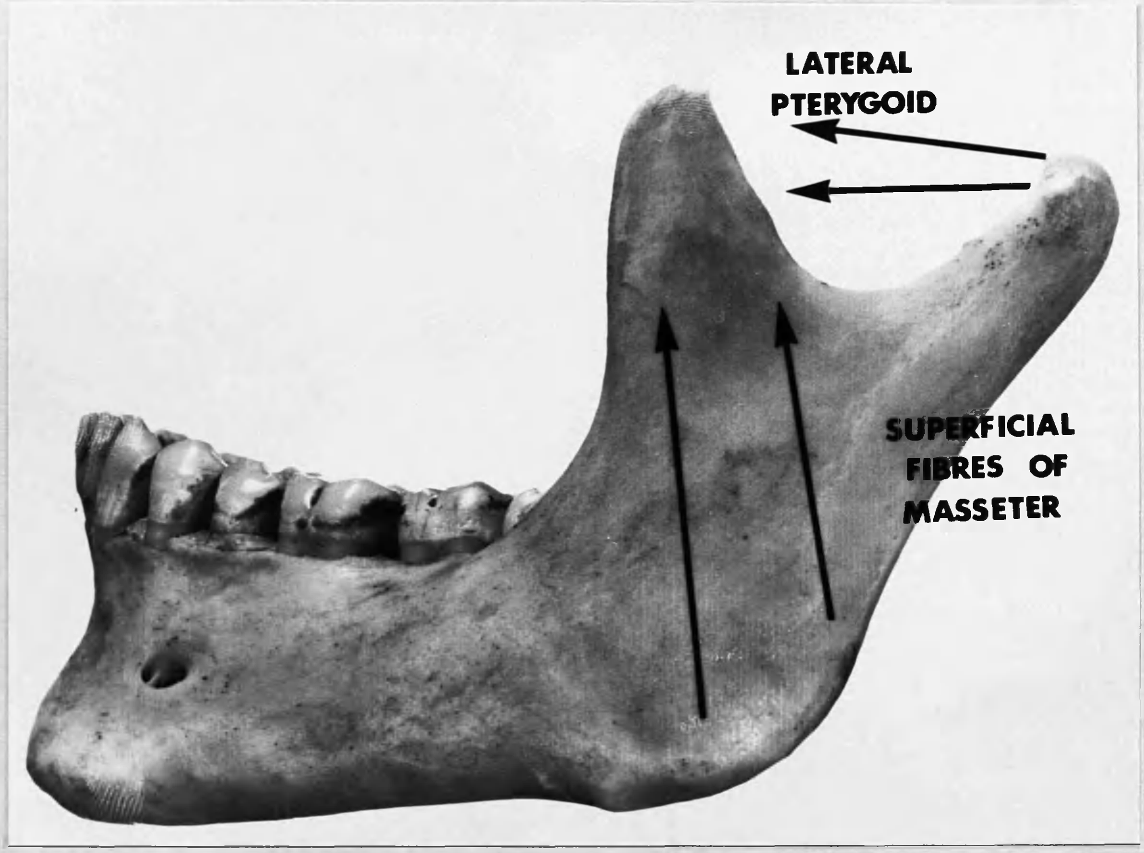
A lateral view of the elevators of the mandible presented in diagrammatic form

FIGURE 16



A medial view of the elevators of the mandible presented in diagrammatic form

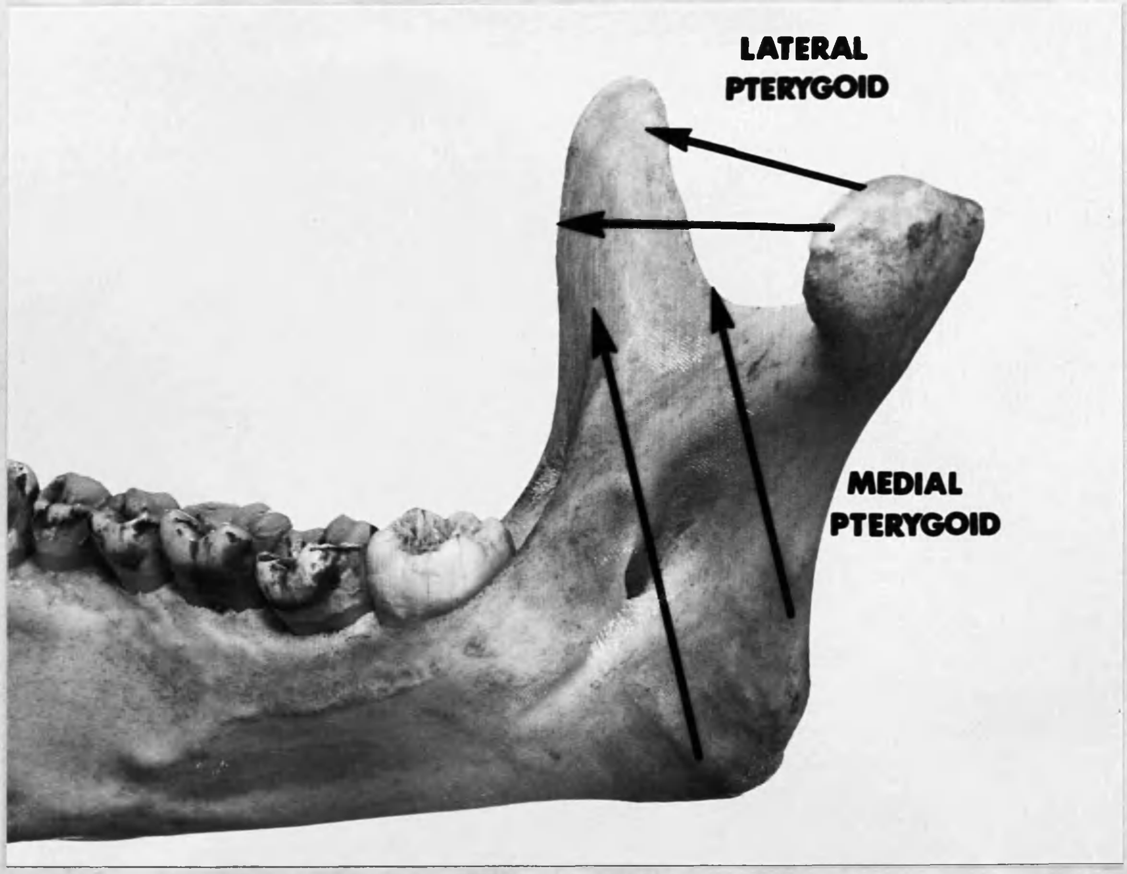
FIGURE 17



Protrusion of the mandible

A lateral view of the mandible with the resulted actions of those muscles responsible superimposed

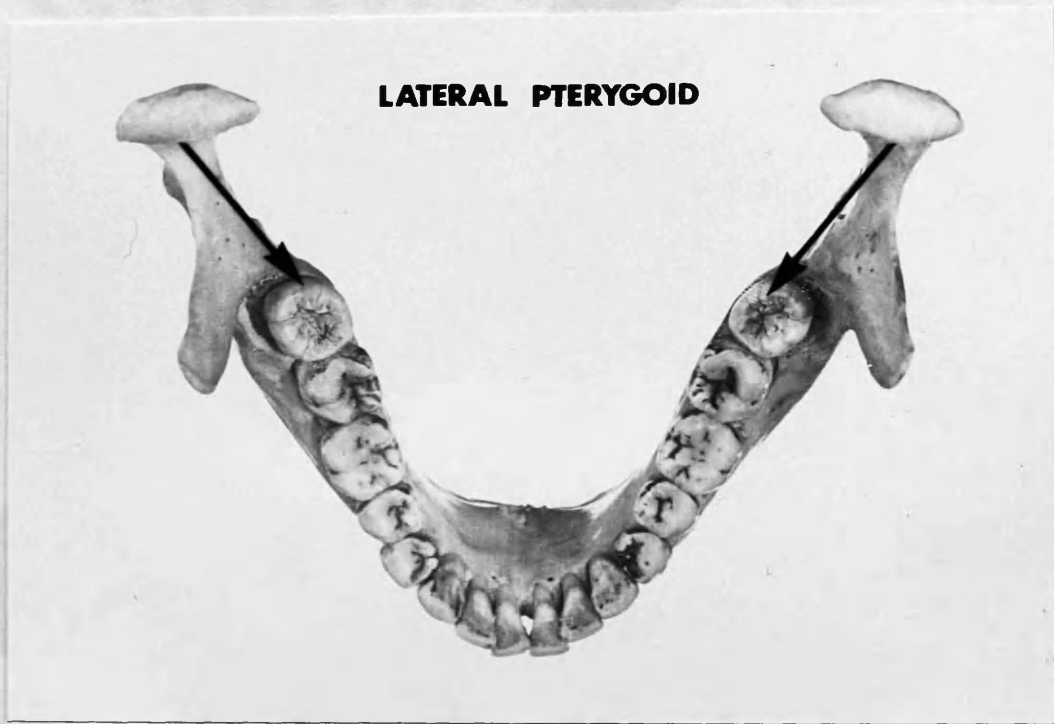
FIGURE 18



Protrusion of the mandible

A medial view of the mandible with the resultant actions of those muscles responsible superimposed

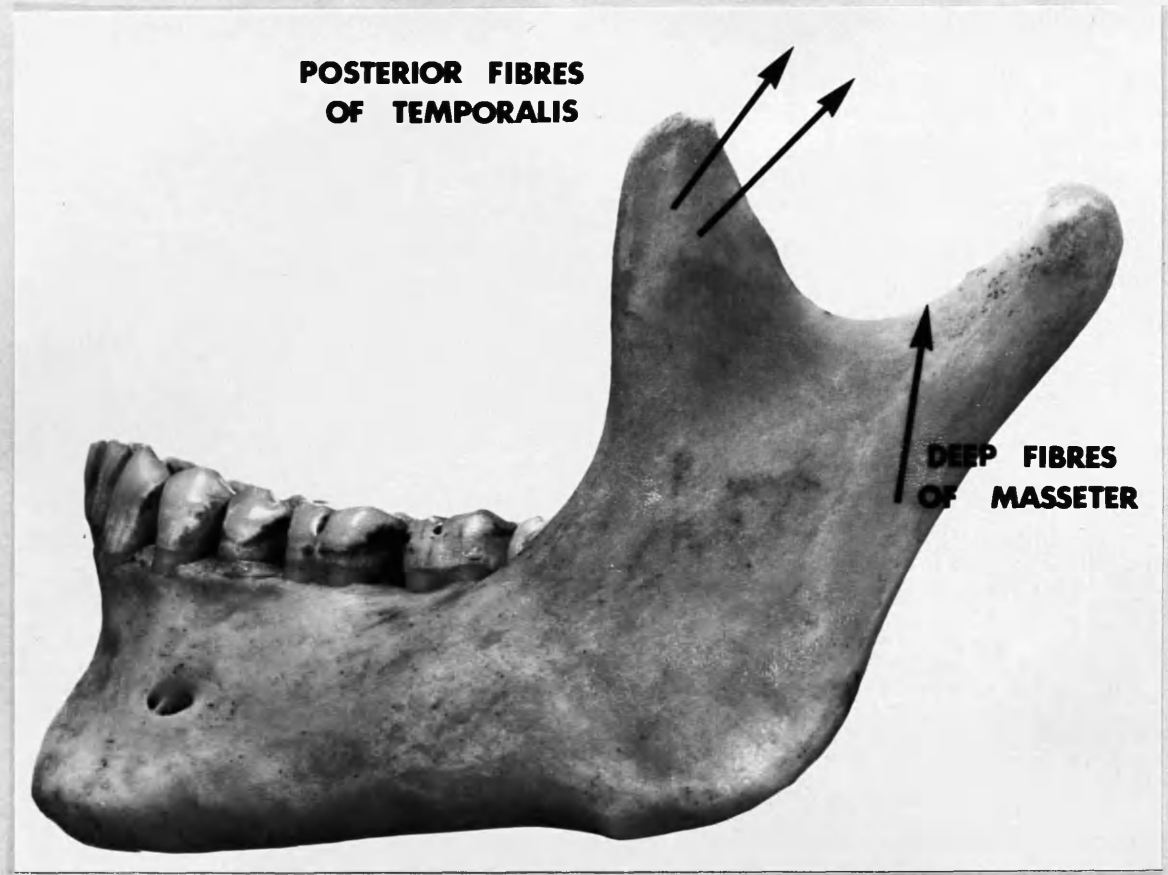
FIGURE 19



A diagram showing the protrusive actiOn of the lateral pterygoid muscles if they contract together

It can be understood from this diagram how the action of one or other lateral pterygoid alone will produce a rotatory, or side-to-side, movement of the mandible

FIGURE 20



A diagram depicting those muscles responsible for retrusion of the mandible

FIGURE 21

The upper deciduous teeth

FIGURE 22

The lower deciduous teeth

FIGURE 23

The upper premanent teeth

FIGURE 24

The lower permanent teeth

FIGURE 25

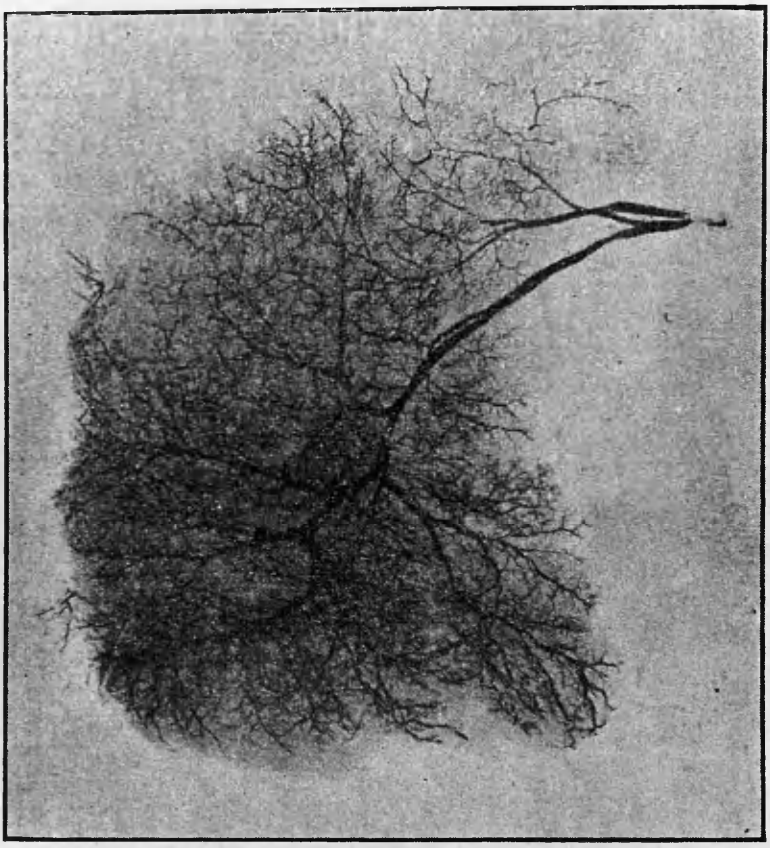
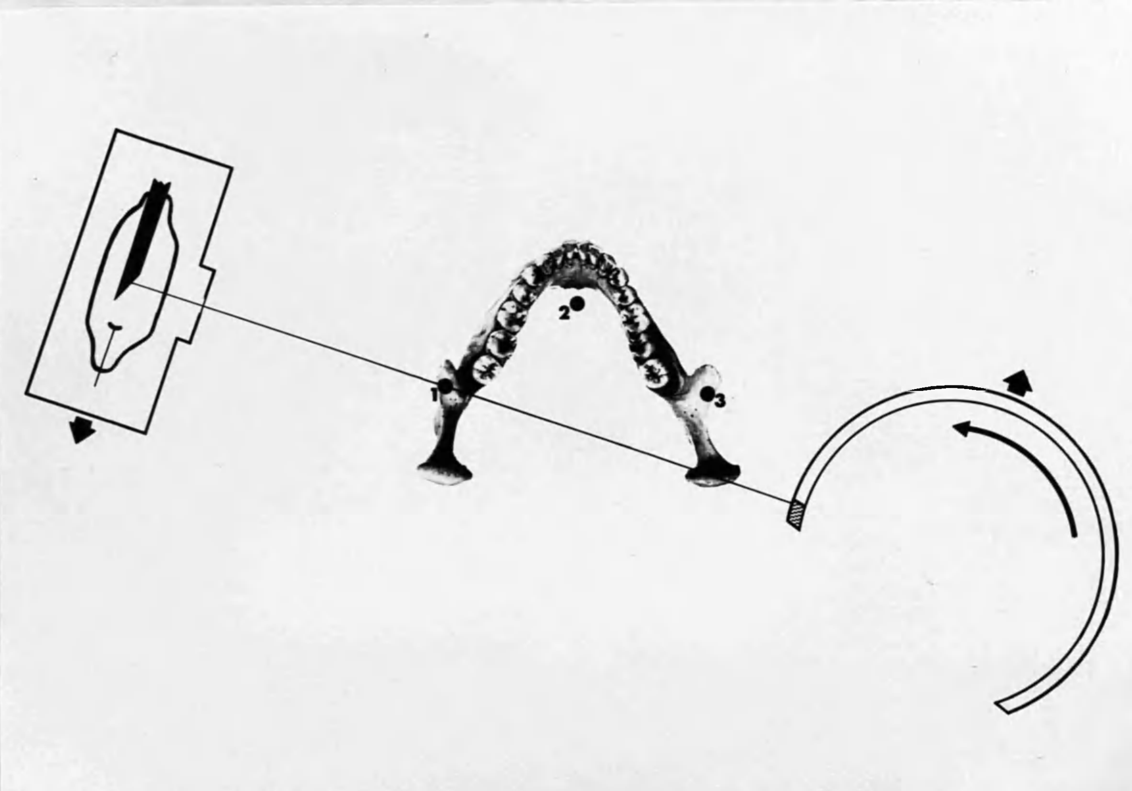


FIG. 345. — Canal de Sténon.
Radiographie après injection au mercure (Charpy).

The original "sialogram"

Figure 345, Page 669, of Volume IV^3 of "Traite D'Anatomie Humaine" by Poirier, P. and Charky, A., published in 1900 by Masson et cie, Paris

FIGURE 26

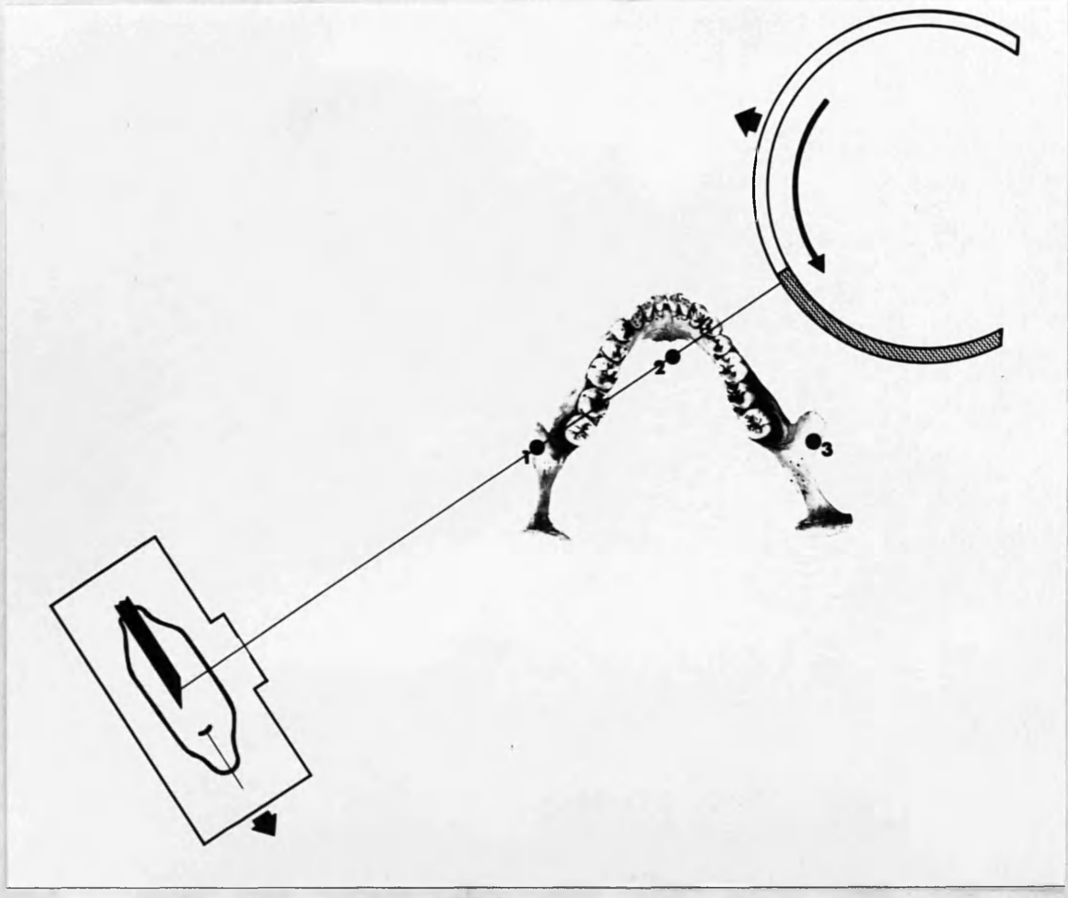


The principle of Orthopantomography

I. The commencement of exposure

The X-ray tube and the film rotate about axis 1 while the film also rotates about a fixed axis

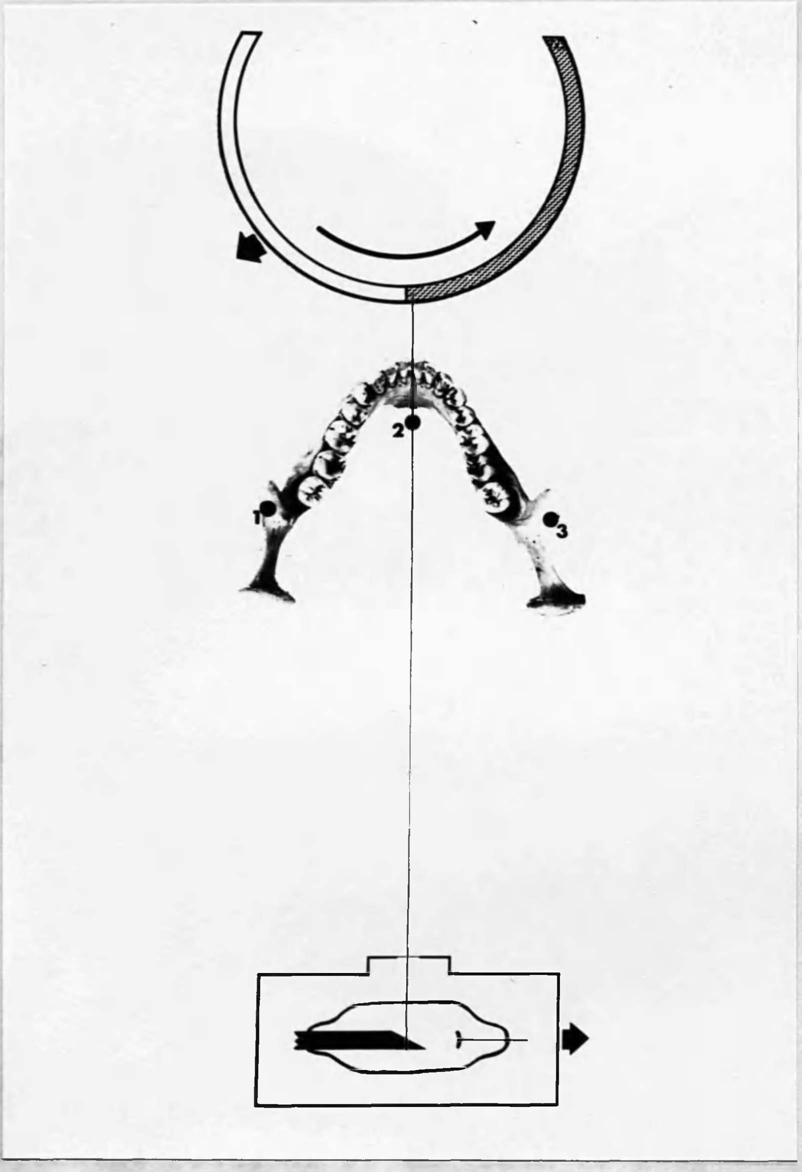
FIGURE 27



The principle of Orthopantomography

II. The film continues to rotate about its fixed axis but the X-ray tube and film now commence to rotate together about axis 2.

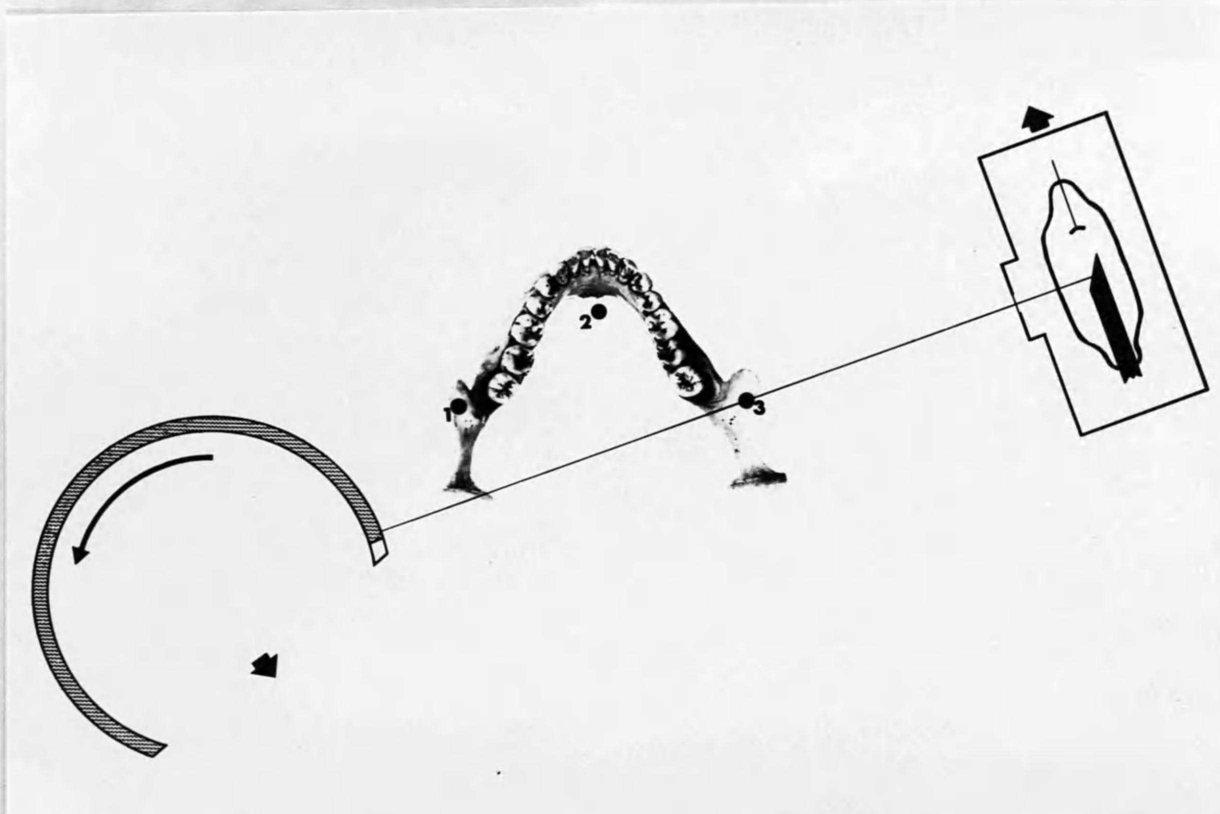
FIGURE 28



The principle of Orthopantomogfaphy

III. Half the film is exposed recording details from one mandibular condyle to the mid-line.

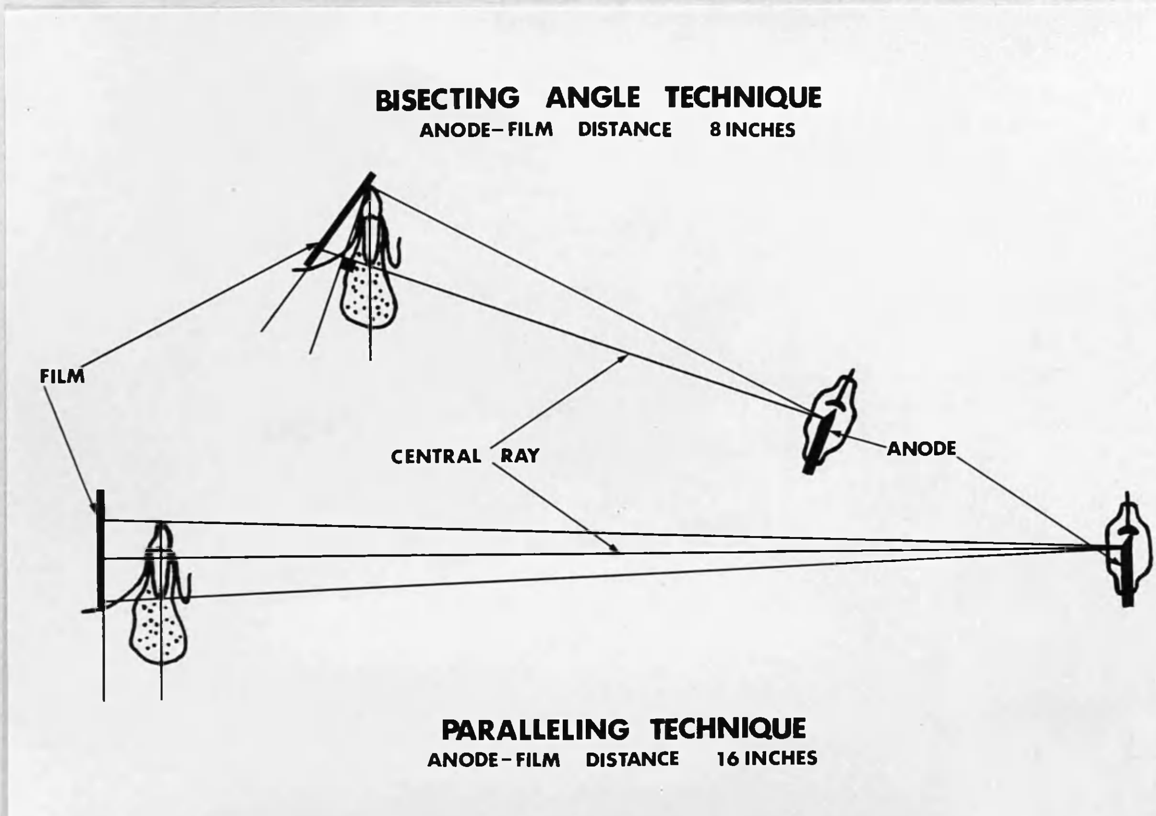
FIGURE 29



The principle of Orthopantomography

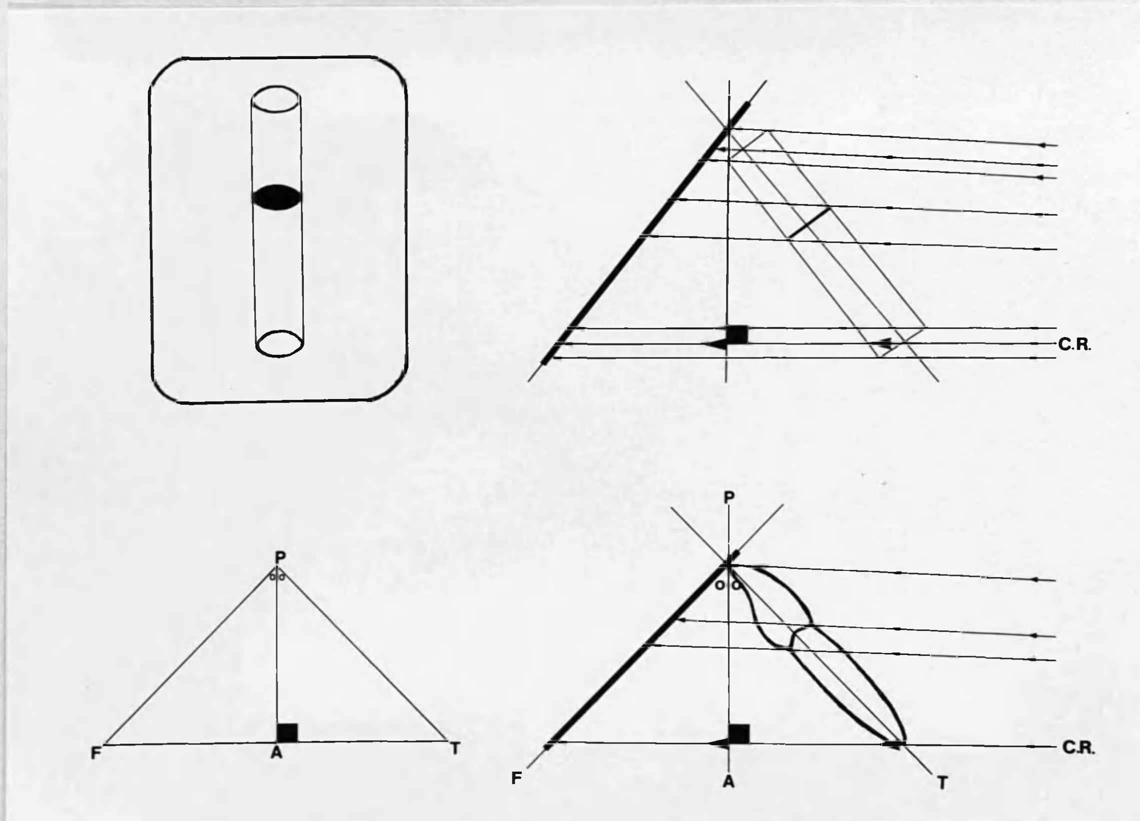
IV. Exposure is completed by the X-ray tube and film, in its casette, rotating together about axis 3. The independent rotation of the film is also complete. Thus a linear tomograph of the complete mandible, from condyle to condyle, is produced.

FIGURE 30



<u>A schematic comparison of the principles of the Bisecting Angle and Paralleling Techniques of dental periapical radiography</u>

FIGURE 31



The Bisecting Angle Technique

$\angle PAT = \angle PAF$ (right angles)

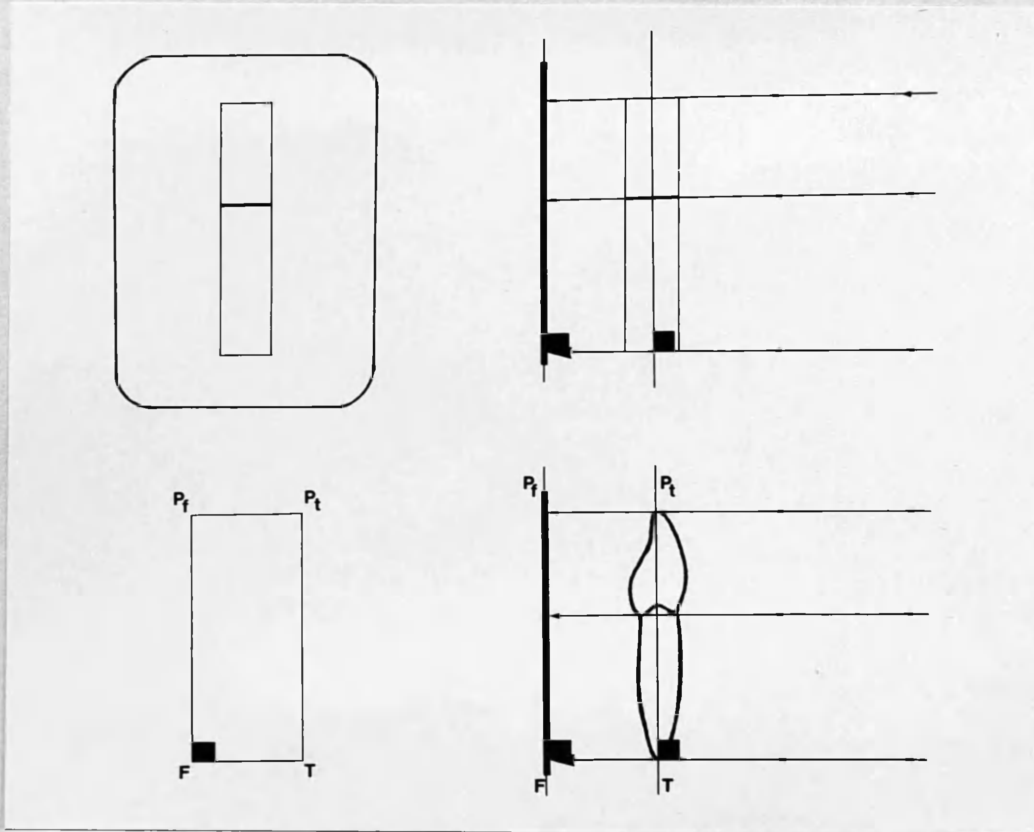
$\angle APT = \angle APF$ ($\angle TPF$ is bisected)

$\therefore \angle PTA = \angle PFA$ (sum of angles of any triangle $\equiv 180^{\circ}$)

$\therefore PT = PF$

However, a tooth is three dimensional and so distortion occurs as illustrated in the upper half of this diagram

FIGURE 32



The Paralleling Technique

$P_tT \parallel P_fF$ (Principle of technique)

$P_tP_f \parallel TF$ (Ideally, if X-rays are parallel)

$\angle TFP$ is a right angle (Principle of technique)

$\therefore P_tTF\,P_f$ is a rectangle

$\therefore P_tT = P_fF$

If the X-rays are parallel no distortion occurs as illustrated in the top half of the diagram. However, too short an anode-film distance will produce divergent rays and so distortion.

FIGURE 33

TEMPORO-MANDIBULAR JOINT STUDY

(G. S. Blair, Glasgow Dental Hospital, 322 7020 Ext. 102)

Name .... Date .... X-ray No. (G.D.H.) ....

Address .... Unit No. (B. St.) ....

.... Unit No. (G.D.H.) ....

Sex .... Age .... Date of Birth ....

Occupation .... Marital ....

Rheumatoid Arthritis | Possible | Probable | Definite | Classical |

Duration of Disease .... years Age of onset .... years

Functional Class | 1 | 2 | 3 | 4 | X-ray Stage | 1 | 2 | 3 | 4 |

Articular Index

Subcutaneous Nodules

Splenomegaly

Clinical Evidence of Arteritis (Neuropathy, Dermal, Infarction, Other)

K.C.S. | Yes | No | Sialography

Salivary Flow Studies

99 Tc Scans

Xerostomia Symptomatic/Objective

R.F. Titre

A.N.F. Titre

Salivary Duct Antibody

Haemoglobin E.S.R.
Albumin Globulin

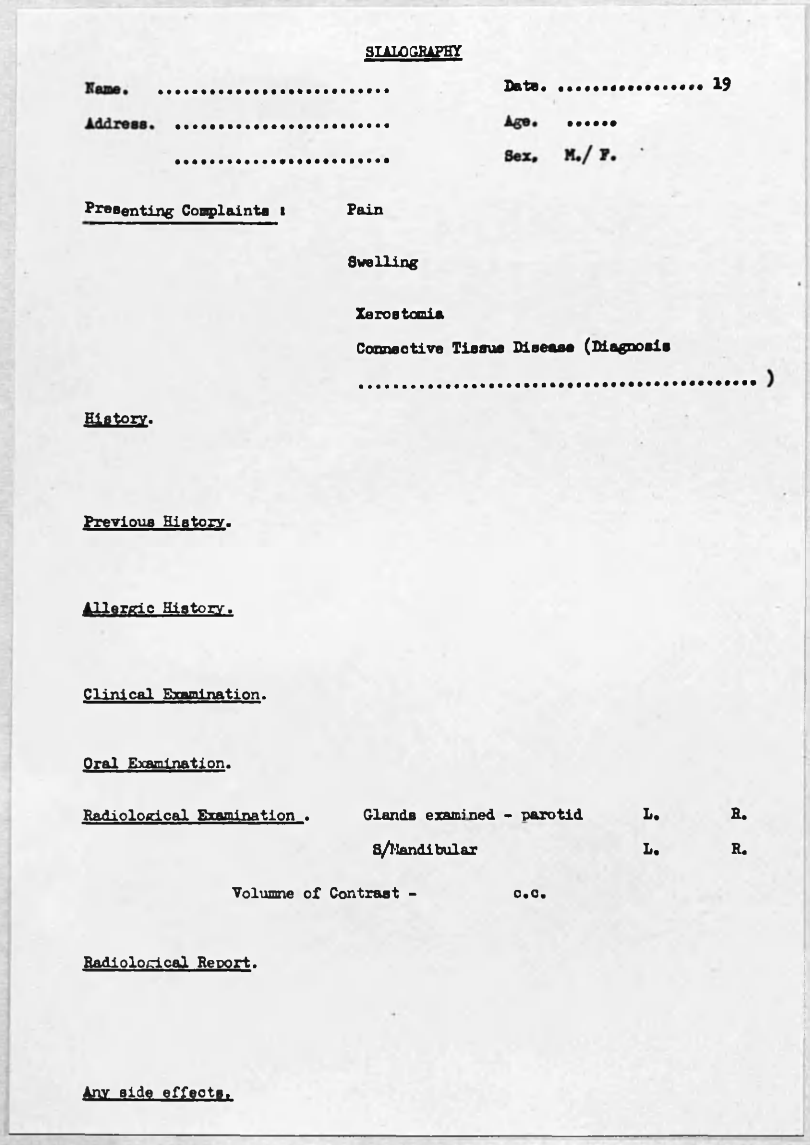
Temporomandibular Joint Right Left

a) Tenderness
b) Tenderness on biting
c) Pain
d) Referred pain
e) Stiffness
f) Reduced mobility
g) Crepitation
h) Clicking
i) Subluxation
j) Swelling
k) Deviation

<u>Proforma for recording details of each patient's degree of involvement by adult rheumatoid arthritis</u>

Confirmation of the main signs and symptoms of temporomandibular joint involvement by this disease could, also, be confirmed using this proforma, although this was not, actually carried out in this study.

FIGURE 34



SIALOGRAPHY

Name. ....   Date. 19

Address. ....   Age. .....

....   Sex. M./ F.

Presenting Complaints :   Pain

Swelling

Xerostomia

Connective Tissue Disease (Diagnosis

....)

History.

Previous History.

Allergic History.

Clinical Examination.

Oral Examination.

Radiological Examination .   Glands examined - parotid   L.   R.

S/Mandibular   L.   R.

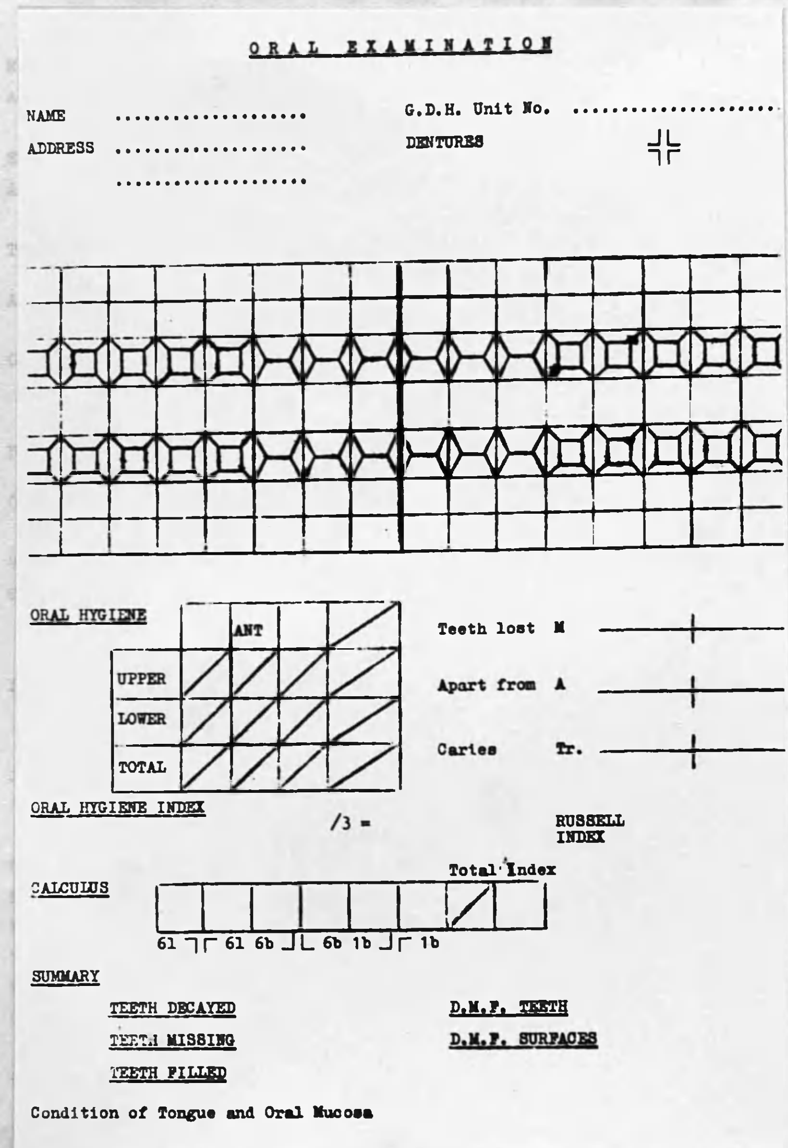
Volumne of Contrast -   c.c.

Radiological Report.

Any side effects.

Proforma on which details of each salivary gland examination were recorded

FIGURE 35



ORAL EXAMINATION

NAME ....

ADDRESS ....

....

G.D.H. Unit No. ....

DENTURES

ORAL HYGIENE

	ANT		
UPPER			
LOWER			
TOTAL			

Teeth lost M

Apart from A

Caries Tr.

ORAL HYGIENE INDEX

/3 =

RUSSELL INDEX

CALCULUS

Total Index

61 61 6b 6b 1b 1b

SUMMARY

TEETH DECAYED

TEETH MISSING

TEETH FILLED

D.M.F. TEETH

D.M.F. SURFACES

Condition of Tongue and Oral Mucosa

Proforma on which the results of each dental examination were recorded

FIGURE 36

NAME .... DATE .... X-RAY No. ....

ADDRESS .... UNIT No. ....

.... HOSPITAL ....

SEX .... OCCUPATION ....

AGE .... DATE OF BIRTH .... MARITAL ....

TEETH PRESENT $\dfrac{87654321\ /\ 12345678}{87654321/\ \ 12345678}$

Arch Relationship Class 1 Class 2 Division 1 Class 3

Division 2

OCCLUSION ....

....

DENTURES $\dfrac{7654321\ /\ 1234567}{7654321/\ \ 1234567}$

OCCLUSION ....

....

Vertical Dimension .... Correct Overclosed ....m.m. Overopen ....m.m.

Condition of Dentures .... Material .... Age ....

Stability ....

Deviation On opening ....

On closing ....

Joint Crepitus ....

Joint Click On palpation Opening.......... Closing ....

Audible Opening.......... Closing ....

Limitation of Movement ....

Stiffness ....

Pain .... Referred Pain ....

Tenderness .... Tenderness on Biting ....

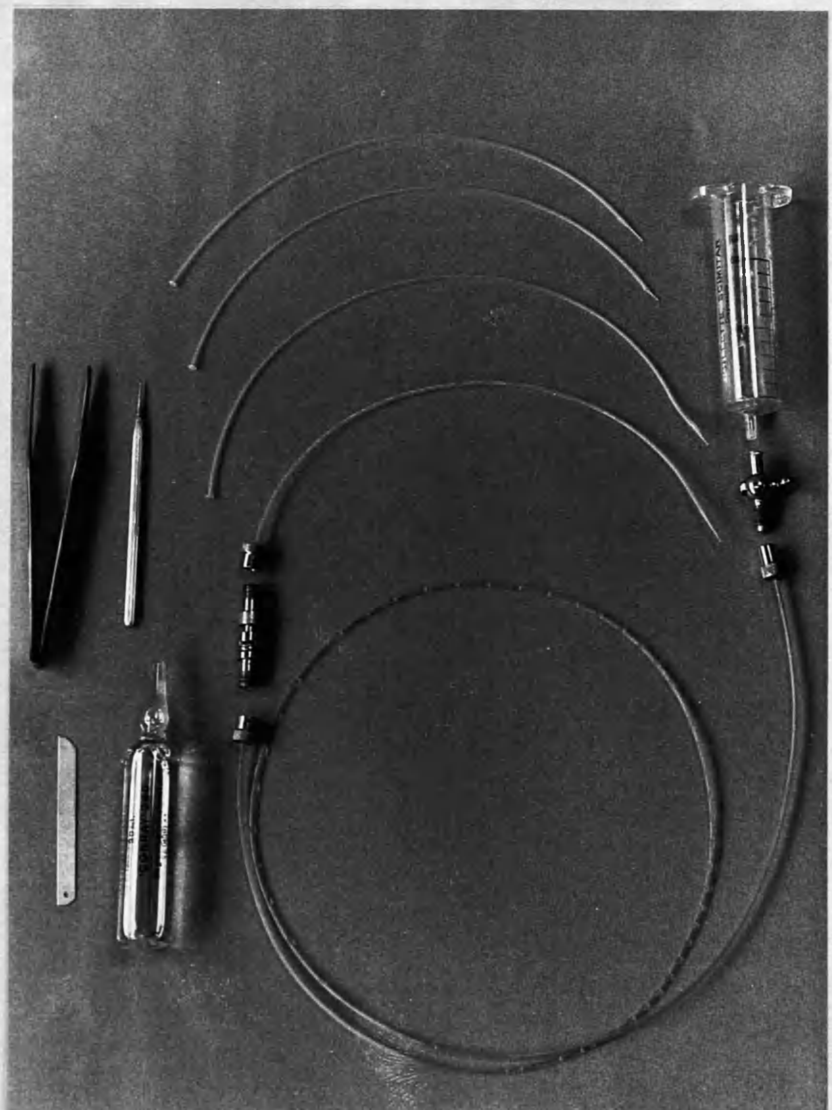
Subluxation .... Swelling ....

Condition of Tongue and Oral Mucosa ....

Connective Tissue Disease Yes No

Proforma on which all the signs and symptoms discovered as a result of the examination of the temporomandibular joints were noted

FIGURE 37



Equipment needed for Hydrostatic Sialography

Reservoir (e.g. barrel of a 20 ml. syringe)
Connector with Luer Lok adaptor and tap and adaptor cap
Polyethylene tubing, PP205, approximately 100 cm. in length
Connector with two adaptor caps
Polyethylene catheter, PP160, approximately 25 cm. in length
(a selection of four catheters is illustrated)
20 ml. vial of Conray 280 plus knife used to break vial
Lacrimal duct dilator
Non-toothed forceps (used, on occasion, to guide catheter into position)

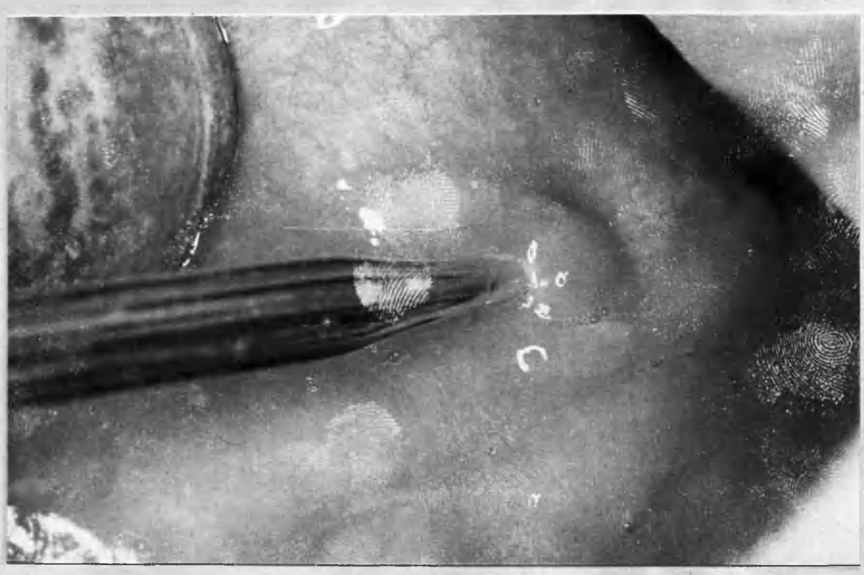
FIGURE 38

Sialography equipment assembled

Any suitable stand can be used to hold the reservoir and tubing. A drip stand has been found to be ideal. The Conray 280 is poured into the reservoir and the tubing filled with the contrast medium.

FIGURE 39

A



B

Left Parotid Duct

A. Clinical appearance of duct orifice on a small papilla on the inner surface of the cheek opposite the first permanent molar region.

B. Dilation of the left parotid duct.

FIGURE 40

A

B

Right Submandibular Duct

A. The sublingual course of both submandibular ducts is clearly illustrated.

B. Dilation of the right submandibular duct.

FIGURE 41

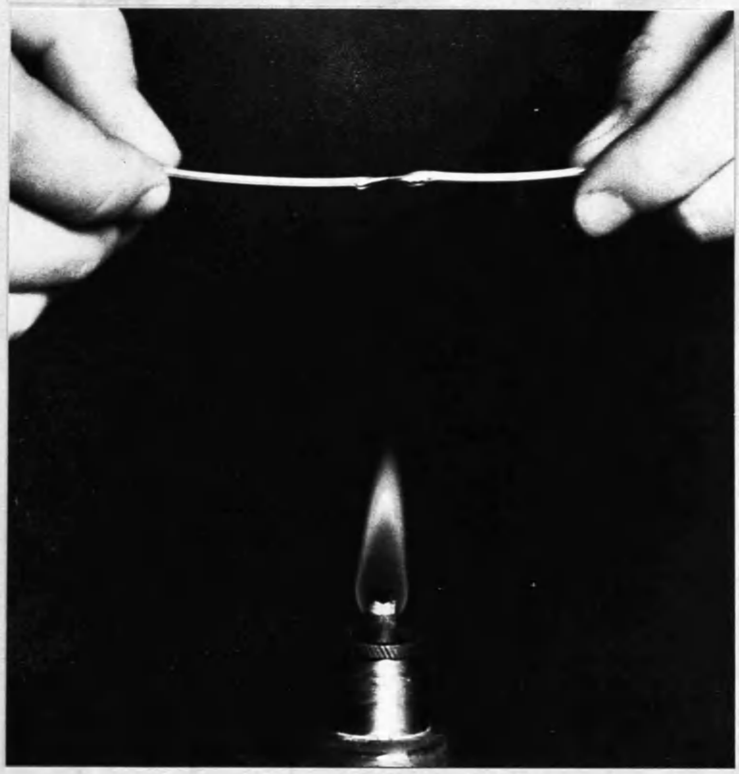
<u>Insertion of polyethylene catheter into left parotid duct</u>

Note the presence of an air bubble in the catheter. This must be avoided if a successful sialogram is to be produced.

FIGURE 42

Insertion of polyethylene catheter into the right submandibular duct

FIGURE 43



A

B

<u>Preparation of polyethylene tubing</u>

A Drawing out of fine tip of catheter

B "Coning" the tubing so that it fits the adaptor cap snugly

TABLE I

Glands Examined

TOTAL	PAROTID	SUBMANDIBULAR	NORMAL PAROTID	NORMAL SUBMANDIBULAR	ABNORMAL PAROTID	ABNORMAL SUBMANDIBULAR
738	657	81	439	32	218	49

TABLE II

The Parotid Gland: The ages and sex of the patients examined; The glands examined and the volumes of contrast medium needed to outline them

	TOTAL	M	F	AGE RANGE (MEAN) YEARS	R.	L.	VOLUME RANGE (MEAN) MILLILITRES
ALL CASES	657	187	470	8 to 94 (51)	282	375	0.1 to 3.0 (0.8)
NORMAL	439	127	312	8 to 94 (52)	181	257	0.2 to 3.0 (0.8)
ABNORMAL	218	60	158	8 to 82 (49)	101	118	0.1 to 3.0 (0.8)
NORMAL LOCAL	93	30	63	16 to 74 (49)	43	50	0.2 to 2.0 (0.8)
NORMAL GENERAL	346	97	249	8 to 94 (53)	138	208	0.2 to 3.0 (0.7)
ABNORMAL LOCAL	96	46	50	8 to 74 (46)	51	45	0.1 to 3.0 (0.9)
ABNORMAL GENERAL	122	14	108	15 to 82 (51)	50	72	0.2 to 2.0 (0.7)

TABLE III

The Submandibular Gland: The ages and sex of the patients examined; The glands examined and the volumes of contrast medium needed to outline them

	TOTAL	M	F	AGE RANGE (MEAN) YEARS	R.	L.	VOLUME RANGE (MEAN) MILLILITRES
ALL CASES	81	26	55	16 to 73 (45)	38	43	0.2 to 2.5 (0.9)
NORMAL	32	11	21	16 to 72 (42)	15	17	0.2 to 2.0 (0.9)
ABNORMAL	49	15	34	18 to 73 (23)	23	26	0.2 to 2.5 (0.8)

TABLE IV

Analysis of sialographic findings in patients referred with pain and/or swelling in the region of a major salivary gland

	NORMAL	INFLAMMATORY	FISTULAE	SPACE-OCCUPYING LESIONS	OBSTRUCTIVE		
					RADIOLUCENT CALCULI	RADIOPAQUE CALCULI	STRICTURE OR STENOSIS
ALL CASES	125	75	5	11	15	18	21
PAROTID	93	57	5	10	11	6	7
SUBMANDIBULAR	32	18	-	1	4	12	14

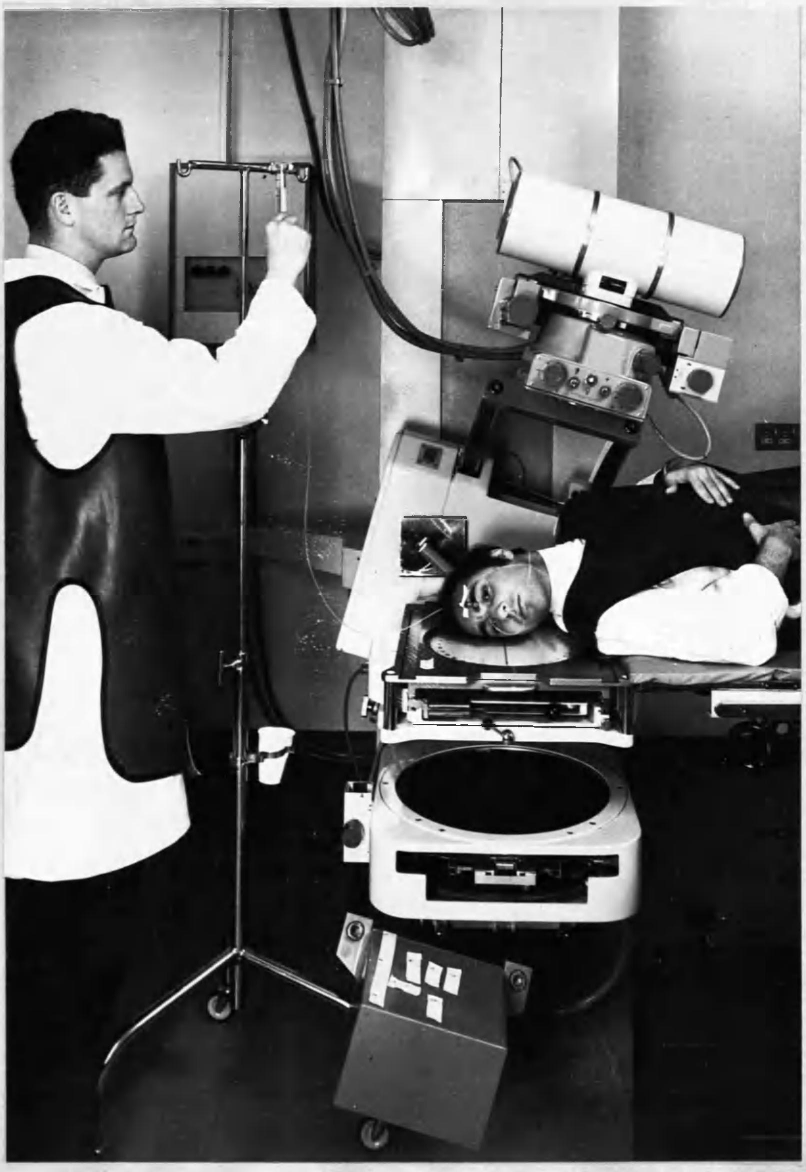
TABLE V

Analysis of sialographic findings in patients with rheumatic disease referred for investigation of salivary gland involvement

<table>
<tr><td colspan="2">346 NORMAL GLANDS</td><td colspan="5">122 ABNORMAL GLANDS</td></tr>
<tr><td></td><td>TOTAL</td><td>ALONE</td><td>PLUS RETENTION</td><td>PLUS DUCT DILATATION</td><td colspan="2">PLUS DUCT DILATATION PLUS RETENTION</td></tr>
<tr><td>Punctate Sialectasis</td><td>30 (AB)</td><td>19</td><td>2</td><td>3</td><td colspan="2">-</td></tr>
<tr><td>Globular Sialectasis</td><td>22 (C)</td><td>7</td><td>3</td><td>5</td><td colspan="2">5</td></tr>
<tr><td>Cavitary Sialectasis</td><td>24</td><td>2</td><td>9</td><td>2</td><td colspan="2">11</td></tr>
<tr><td></td><td></td><td>ALONE</td><td>PLUS RETENTION</td><td>PLUS PUNCTATE SIALECTASIS</td><td>PLUS PUNCTATE SIALECTASIS PLUS RETENTION</td><td>PLUS GLOBULAR SIALECTASIS PLUS RETENTION</td></tr>
<tr><td>Atrophy</td><td>26 (ABC)</td><td>15</td><td>3</td><td>5(A)</td><td>1(B)</td><td>2(C)</td></tr>
<tr><td></td><td></td><td>SMOOTH</td><td colspan="2">SMOOTH PLUS RETENTION</td><td>IRREGULAR</td><td>IRREGULAR PLUS RETENTION</td></tr>
<tr><td>Duct Dilatation Alone</td><td>27</td><td>15</td><td colspan="2">0</td><td>11</td><td>1</td></tr>
<tr><td>Retention Alone</td><td>1</td><td></td><td colspan="2"></td><td></td><td></td></tr>
</table>

(A), (B) and (C). 8 cases are included twice in the overall Total column as indicated

FIGURE 44



Right Parotid Sialography

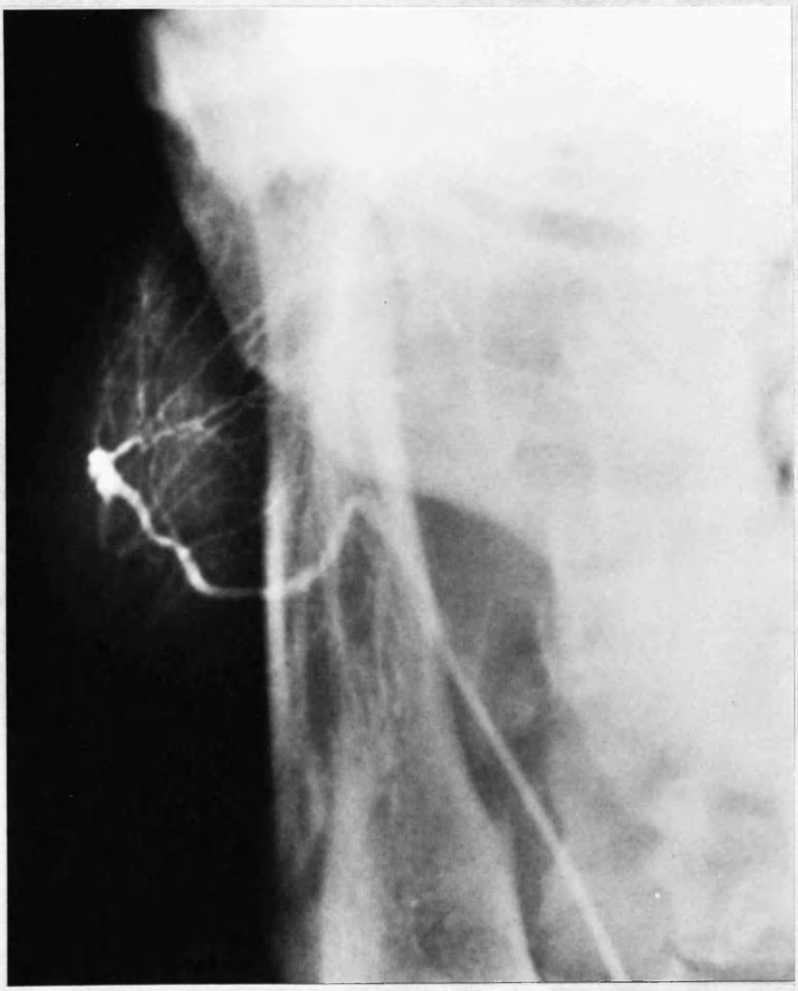
The patient is pdsitioned for a 15° lateral oblique jaw sialogram. The crossed beam of light, one of the features of the CRT-7 unit which facilitates accurate centring, is seen in the region of the left angle of the patient's mandible.

TABLE VI

Volumes of contrast media used by different operators in order to outline the parotid gland for the purpose of sialography

YEAR	OPERATOR	VOLUME (ml)
1925	Carlsten	5.0
1925	Jacobovici, Popolitza and Albu	4.0
1928	Keith	0.5 to 1.0
1930	Rocchi	1.5 to 2.0
1931	Barraud	2.0 to 4.0
"	Payne	0.5 to 1.0
"	Pyrah and Allison	0.5 to 1.0
1932	Barsky and Silberman	1.0 to 2.5
"	Feuz	2.0 to 4.0
"	Hobbs, Sneierson and Faust	1.0 to 1.5
"	Payne	1.0 to 3.0
1932-33	Pyrah	0.5 to 1.0
1933	Jacobovici and Jianu	4.0 to 6.0
1934	Grasso	1.5 to 2.0
"	Simon	2.0 to 5.0
1935	Hare	0.5 to 1.0
"	Kimm, Spies and Wolfe	1.0 to 1.5
1938	Blady and Hocker	1.75
1941	Thoma	1.0 to 1.5
1942	Barsky	1.0 to 2.5
1947	Schulz and Weisberger	1.0 to 1.5
1948	Schulz and Weisberger	Max. 2.0; Ave. 1.5
1950	Dechaume and Bonneau	2.5 to 3.0
"	Putney and Shapiro	1.0 to 1.75
"	Rose	1.5 to 2.0
"	Samuel	0.5 to 1.0
1951	Ollerenshaw and Rose	2.5 to 3.0; Not less than 2.0
1953	Antoine, Gosserez, Zimberger and Treheux	2.5
1954	Rose	2.0
1954	Whinery	Pain + 0.5 to 1.0
1955	Gerry and Seigman	2.0
1956	Thomas	Rarely more than 1.5
"	Winsten and Ward	1.75
1956-57	Ranger	Ave. 0.5
1957	Blatt and Maxwell	0.5 to 1.5; Rarely 2.0
1961	Seward	1.0 to 2.0
1963	Eisenbud and Cranin	Not less than 2.0
1964	Garusi	2.0 to 3.0
"	Schönberger	3.0 to 4.5
1965	Kashima, Kirkham and Andrews	1.0 to 1.5
"	Porter	0.5 to 2.0
1966	Cook and Pollack	0.8 to 1.2
"	Duffy	0.5 to 2.0
"	Einstein	Not less than 2.0
"	Kettunen	2.5 to 3.0
"	Osmer and Pleasants	3.0 to 6.0
"	Park and Mason	0.9 to 3.5
"	White	Not more than 2.0
1967	Carlin and Seldin	Ave. 2.0
1968	Fast and Forest	1.2 to 2.5
"	Hettwer and Folsom	1.5
"	Park and Bahn	0.5 to 3.0
1969	Waite	0.5 to 6.0; Ave. 0.8 to 1.0
1970	Sazama	2.0

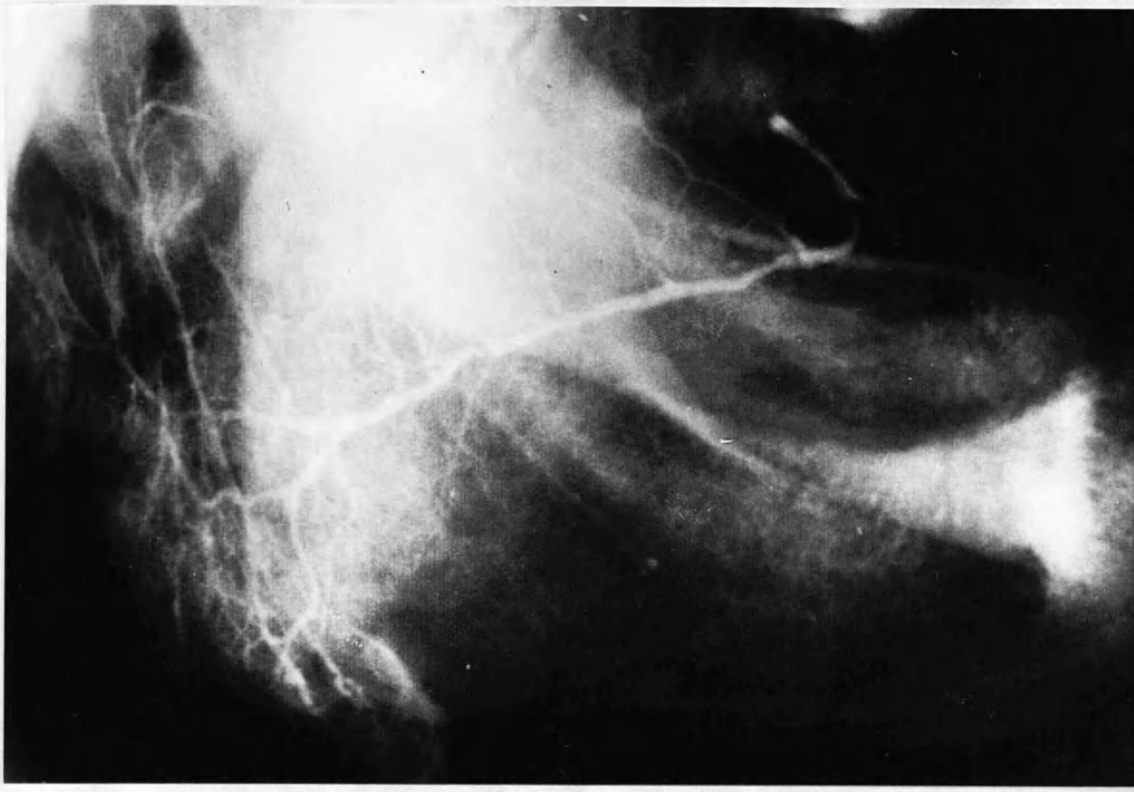
FIGURE 45



Normal Parotid Sialogram

Antero-posterior view

FIGURE 46



Normal Parotid Sialogram

15^{o} lateral-oblique jaw view

FIGURE 47

Normal Parotid Sialogram

"Five-minute secretory film"

FIGURE 48

Abnormal Parotid Sialogram

Punctate sialectasis   A.P. view

FIGURE 49

Abnormal Parotid Sialogram

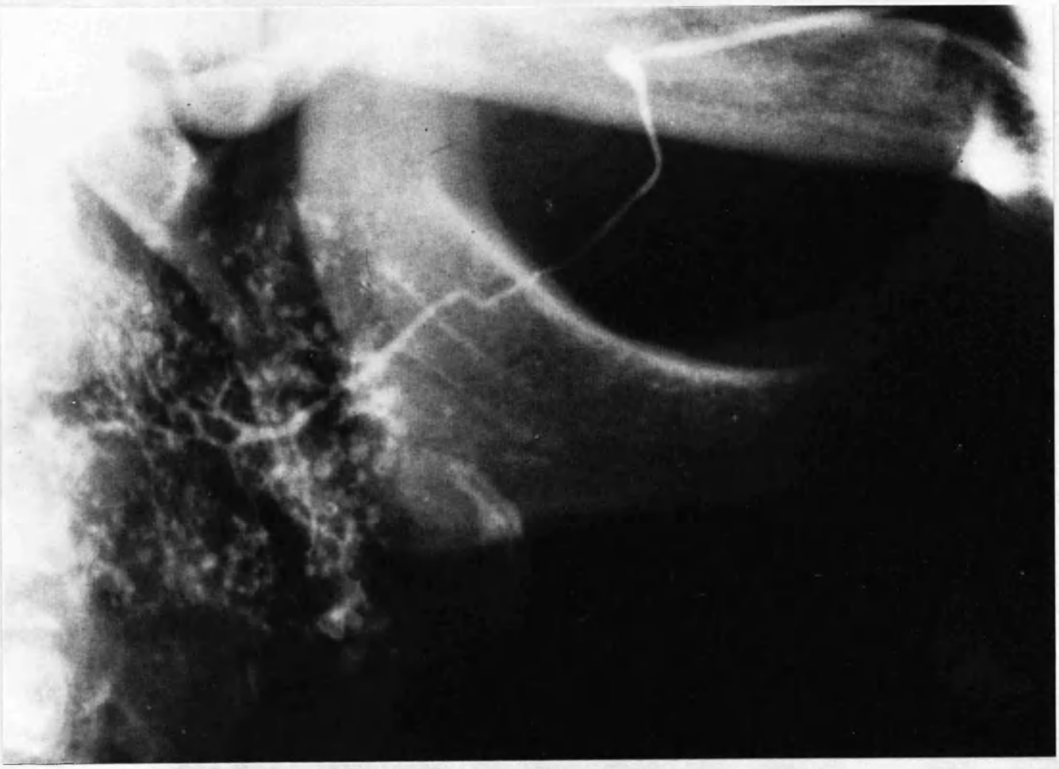
Punctate sialectasis 15° L.O.J. view

FIGURE 50

Abnormal Parotid Sialogram

Globular sialectasis A.P. view

FIGURE 51



Abnormal Parotid Sialogram

Globular sialectasis 15° L.O.J. view

FIGURE 52

Abnormal Parotid Sialogram

Cavitary sialectasis   A.P. view

Irregular main duct dilatation is also evident

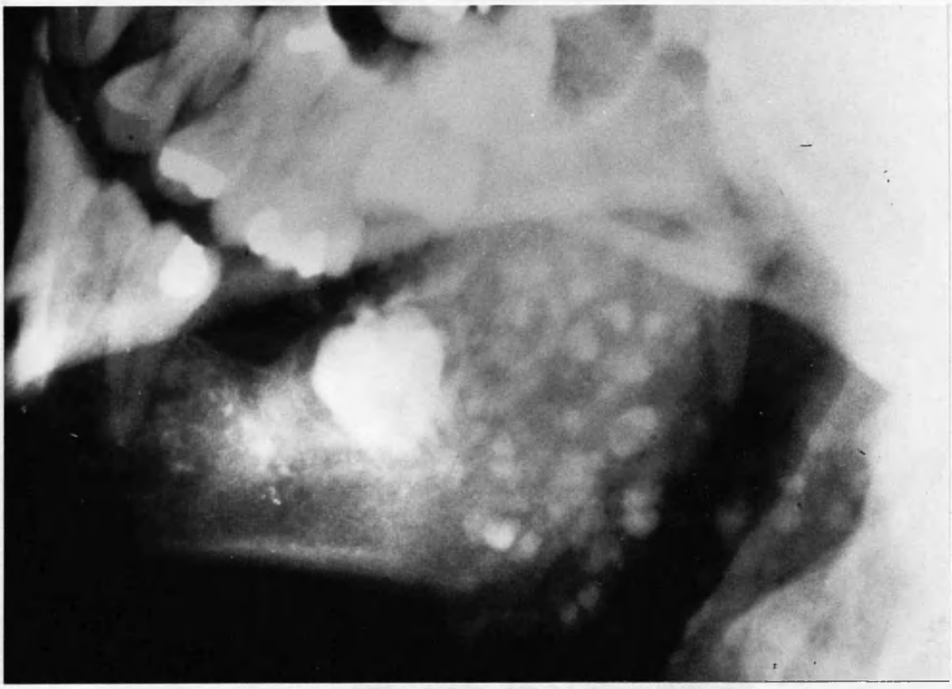
FIGURE 53

Abnormal Parotid Sialogram

Cavitary sialectasis 15° L.O.J. view

Irregular main duct dilatation is also evident

FIGURE 54



Abnormal Parotid Sialogram

Retention of contrast medium

This 15° L.O.J. radiograph was taken five minutes after the completion of sialography. Salivary flow had been stimulated, in the interval, by the patient sucking the juice from a slice of fresh lemon.

FIGURE 55

Abnormal Parotid Sialogram

Atrophy   A.P. view

The subject of this examination was only 31 years of age

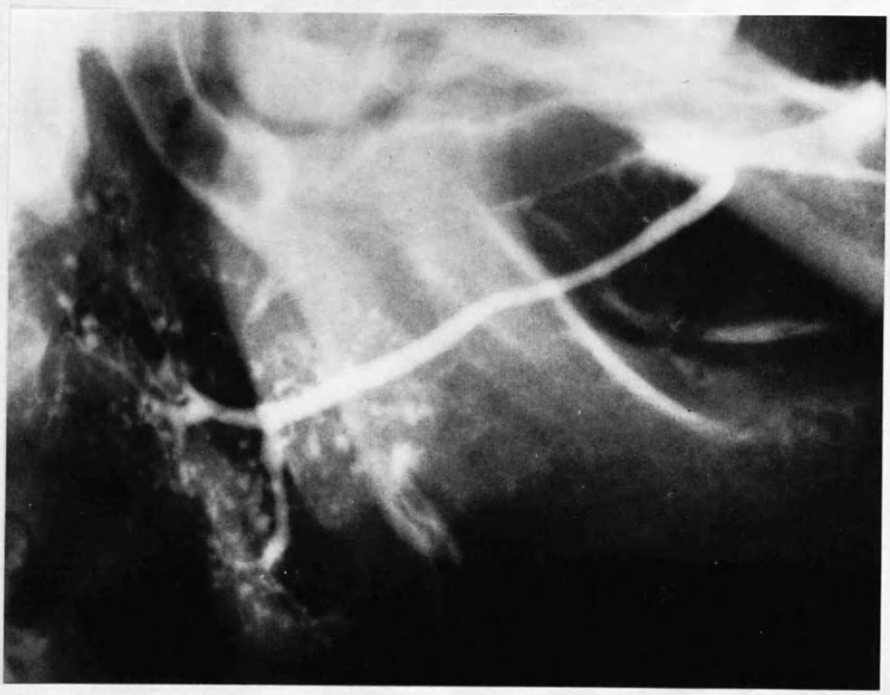
FIGURE 56

Abnormal Parotid Sialogram

Atrophy 15° L.O.J. view

The subject of this examination was only 31 years of age

FIGURE 57

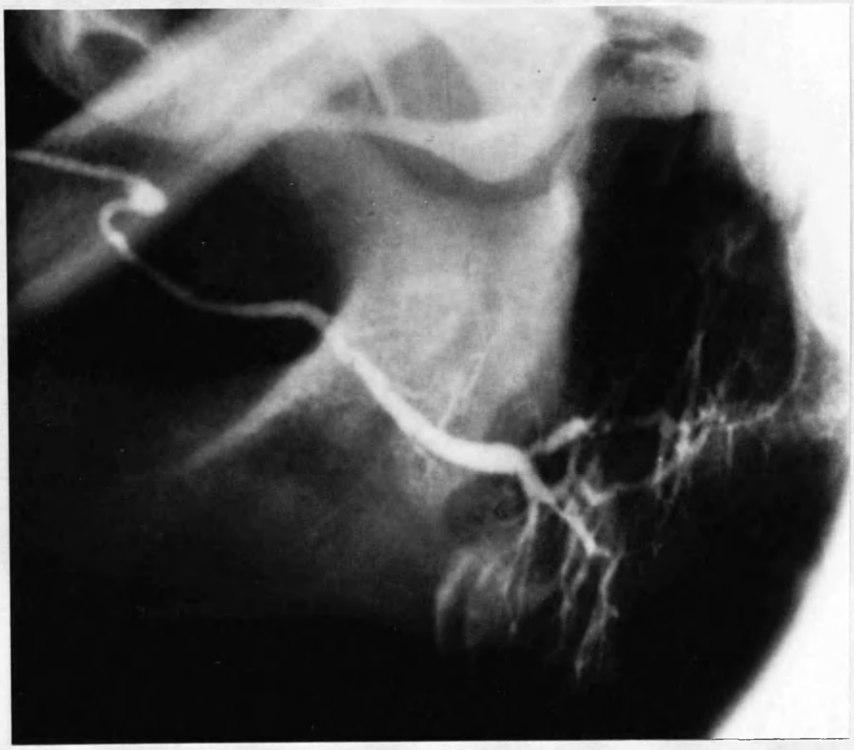


Abnormal Parotid Sialogram

Smooth duct dilatation 15° L.O.J. view

This right parotid gland also exhibits globular sialectasis

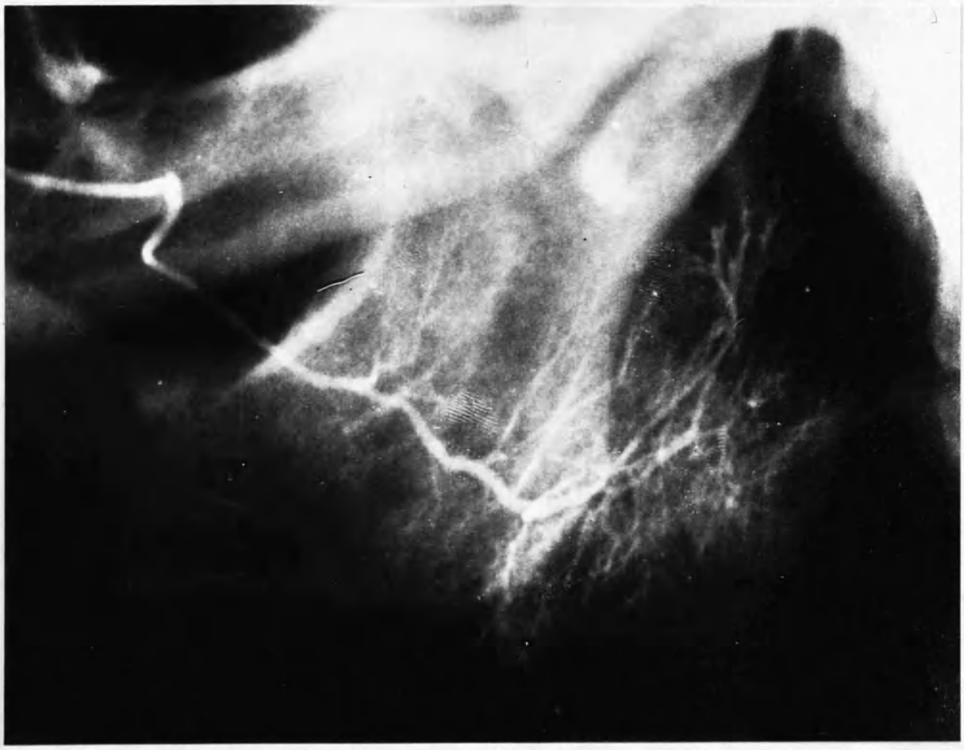
FIGURE 58



<u>Abnormal Parotid Sialogfam</u>

<u>Irregular main duct changes</u> 15° L.O.J. view

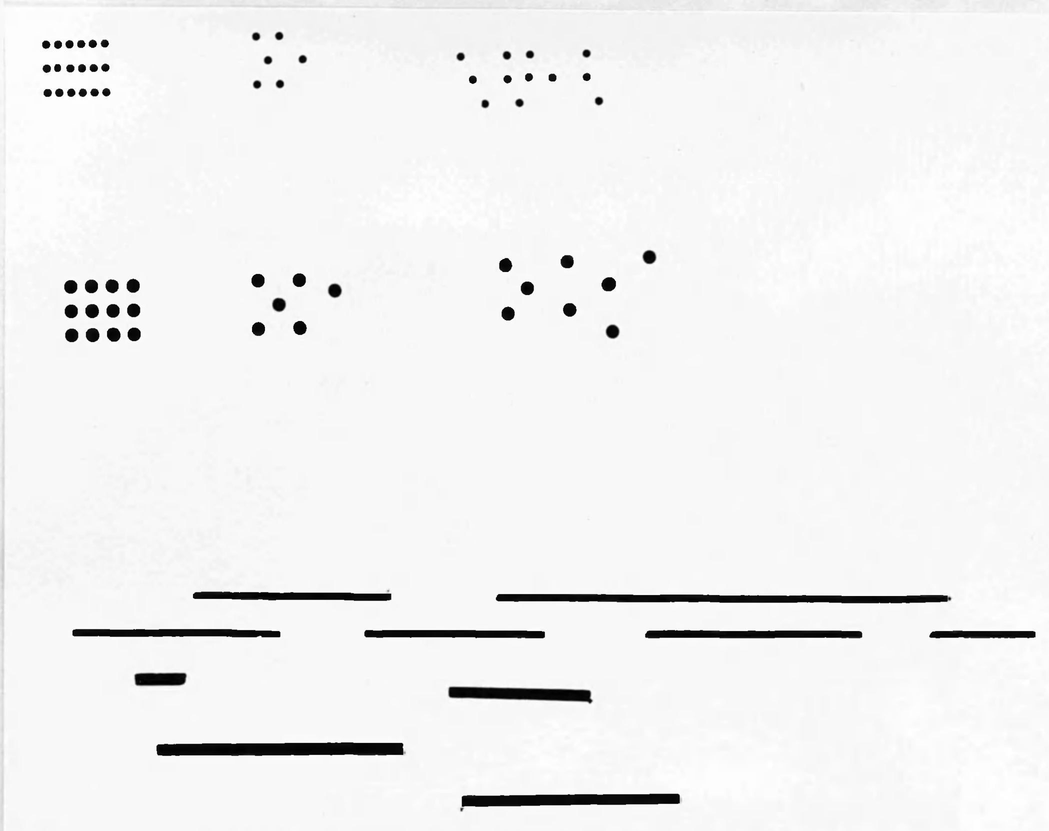
FIGURE 59



Controversial Normal Parotid Sialogram

This sialogram was reported "normal" and "punctate sialectasis" on different occasions. This confusion arose because, by chance, some of the small intro-glandular ducts were radio--graphed "end-on". Once an examiner is aware of this possibility it is usually readily eliminated. Continued doubt can be erased by repeating the procedure at a slightly different angle.

FIGURE 60

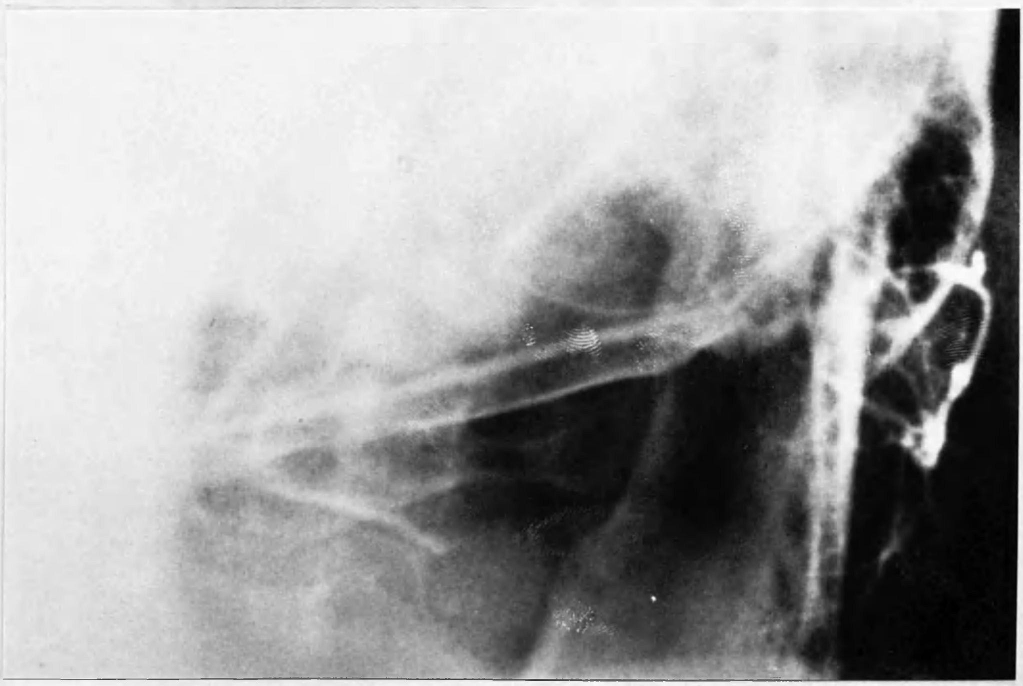


Tem-plate

This tem-plate was manufactured by Mr. John B. Davies, Senior Medical Photographer, Glasgow Dental Hospital and School and designed by the author. The small spots are 1 mm. in diameter as are the narrow lines, the large spots and broad lines being 2 mm. in diameter. If it is laid over any sialogram the exact nature of the sialographic abnormalities seen in Sjogren's syndrome are immediately evident

FIGURE 61

A



B

Poor Radiographic Technique

A. Poor positioning of the film plus inaccurate centring of the X-ray beam

B. Poor positioning of the film. In this instance the central ray has probably passed through the gland being examined.

FIGURE 62

Poor Radiographic Technique

An inexperienced radiographer has attempted to portray both the A.P. view and the 15^{o} L.O.J. view on one film. The result is a double-exposure.

FIGURE 63

Static Electricity

This sialogram is totally useless. The static electricity is probably the result of careless insertion of the film into or careless removal of the film from the cassette. Compare Figure 64 (T. & I. 70).

FIGURE 64

Stricture of the Right Parotid Duct

This abnormality is not one associated with adult rheumatoid arthritis and Sjøgren's syndrome. This illustration is included because it is, in fact, the repeat sialogram of Figure 63 (T. & I. 69) and reveals how much of the grossly abnormal gland was obliterated by the static electricity.

FIGURE 65

The value of the "Scout-Film"

A plain film must always be taken before sialography is carried out. This one shows calcified cervical lymph glands which could have been described as "cavitary sialectasis" if this film had not been available (See Figure 66) (T. & I. 72)

FIGURE 66

Calcified Cervical Lymph Glands

If a plain "scout" film had not been available (Figure 65) (T. & I. 71) this normal right parotid gland could have been reported as the site of cavitary sialectasis.

FIGURE 67

Air Bubble or "Radiolucent" Calculus?

Repeat sialograms will determine the answer (Figure 68)

(T. & I. 74)

FIGURE 68

Normal Submandibular Sialogram

The repeated sialogram reveals no abnormality (Figures 67, 69 and 70) (T. & I. 73, 75 & 76) thus proving that an air bubble had been introduced to the duct system of this gland in the previous examination. Care must always be exercised if this is to be avoided.

FIGURE 69

Air Bubble or "Radiolucent" Calculus?

Parotid Calculi are not as rare as, at one time, was thought.

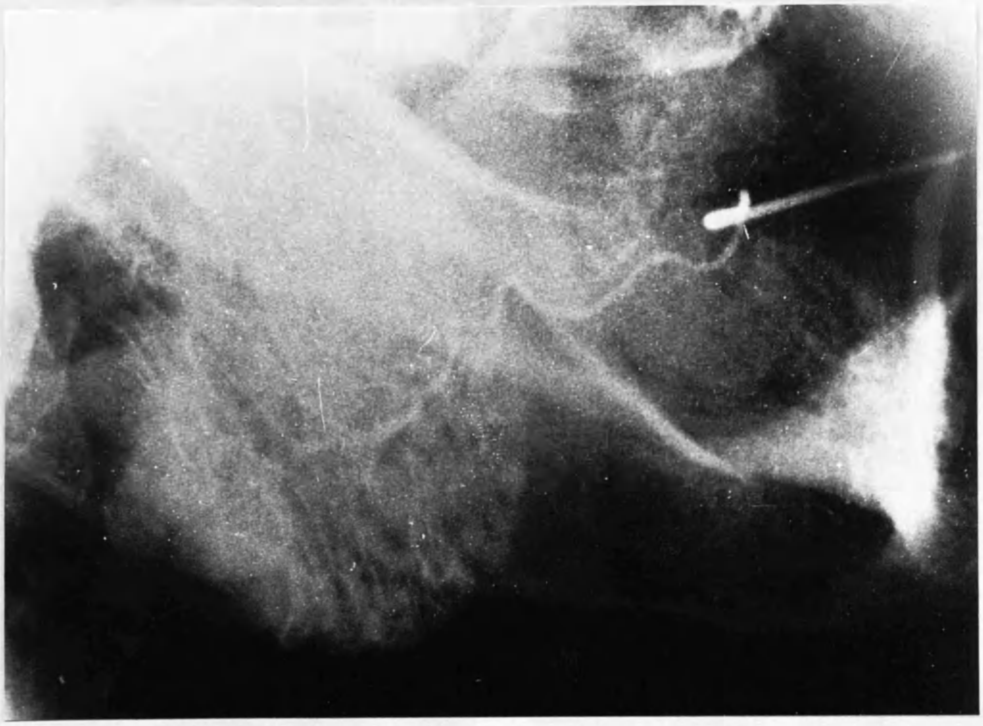
FIGURE 70

"Radiolucent" Parotid Calculus

Minimal filling of a repeat sialogram (of Figure 69) (T. & I. 75) confirms the presence of a "radiolucent" calculus.

Although a hazard of hydrostatic sialography is the ready inclusion of an air bubble in the tubing, the rapid excretion of the water soluble contrast medium used permits rapid re-examination, if necessary.

FIGURE 71



Poor Sialographic Technique

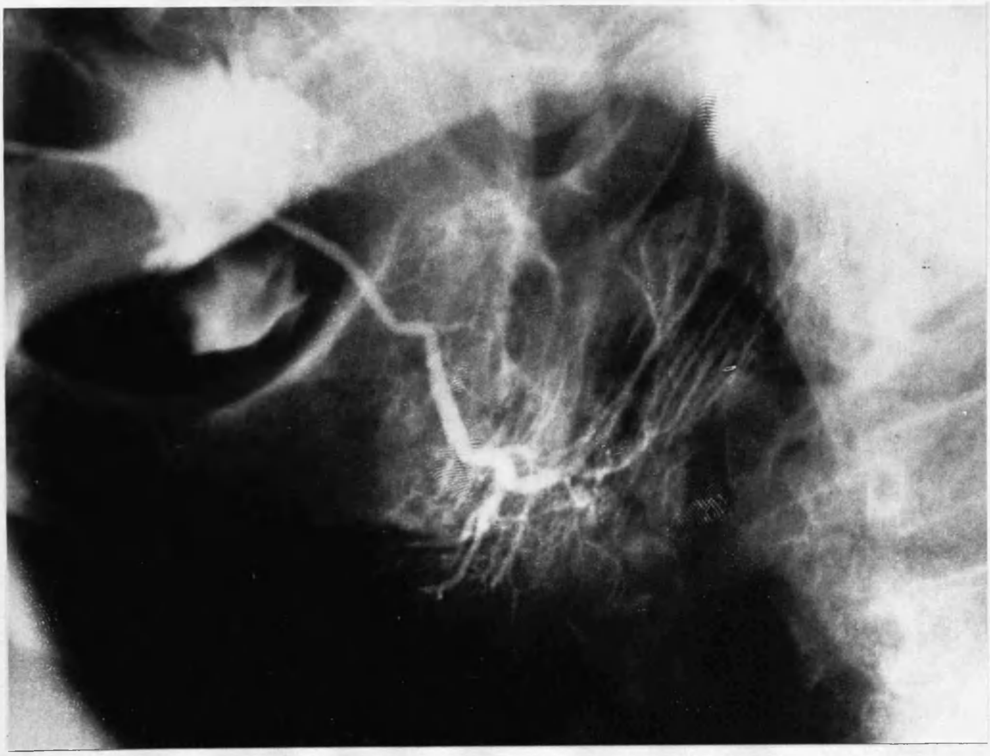
Gross over-filling of the gland being examined with contrast medium has ruined an otherwise good radiograph.

FIGURE 72

Rapid Excretion of Water Soluble Contrast Medium

This radiograph was, genuinely, exposed only five minutes after that shown in Figure 71 (T. & I. 77). This dramatic clearance of all contrast medium from the gland is all the more remarkable in that the subject of this examination was a 92 year old woman.

FIGURE 73



Poor Sialographic Technique

Back-flow of contrast medium into the mouth, due to faulty positioning of the catheter into the duct of the gland being examined, can lead to the reporting of salivary, or other, abnormalities that are, in fact, not present.

FIGURE 74

Poor Sialographic Technique

A few drops of contrast medium were, accidentally, spilled onto the skull table prior to this examination. As a result the normal lower pole of this left parotid gland appears to demonstrate "punctate sialectasis".

FIGURE 75

Normal Parotid Sialogram of Adult

15^{o} L.O.J. view of author's right parotid gland

FIGURE 76

A

B

Normal Adult Submandibular Sialogram

A. 15° L.O.J. view

B. 5 minute secretory film

FIGURE 77

A

B

<u>Normal Parotid Sialogram of an 8 year old child</u>

A. A.P. view

B. 15^{o} L.O.J. view

FIGURE 78

Abnormal Right Parotid Gland (Adult)

This patient suffered from Sjøgren's syndrome. This sialogram reveals cavitary sialectasis and an irregularly dilated main duct. In addition, retention of contrast medium was seen on the five-minute secretory film.

FIGURE 79

Abnormal Left Parotid Gland (Child)

Punctate sialectasis is clearly seen on this sialogram of an 11 year old boy's left parotid gland.

TABLE VII

Clinical Features and Distribution of Sialographic Abnormalities in Patients Studied

Diagnosis	Number of Patients	Mean Age (Years)	Sex	Number of Abnormal Sialograms	Volume of Contrast used (ml) Mean±SD
Controls	74	61.7	57F 17M	5 (6.8%)	0.70 ± 0.50
Rheumatoid Arthritis	123	51.9	93F 30M	12 (9.8%)	0.75 ± 0.41
Sjøgren's Syndrome plus Rheumatoid Arthritis	46	55.3	42F 4M	29 (63.0%)	0.61 ± 0.41
Sjøgren's Syndrome plus Systemic Lupus Erythematosus	2	40.1	2F	2 (100%)	0.50
Sicca Syndrome	54	58.9	49F 5M	29 (53.7%)	0.72 ± 0.46

TABLE VIII

Sialographic Findings in Clinical Groups Studied

Diagnosis	Number Normal	Number Abnormal	Sialectasis			Atrophy	Main Duct Dilatation	Retention of Contrast Medium
			Punctate	Globular	Cavitary			
Controls	69	5	1	-	-	-	5	-
Rheumatoid Arthritis	111	12	2	1	-	2	7	-
Sjøgren's Syndrome plus Rheumatoid Arthritis	17	29	11	7	3	8	9	7
Sjøgren's Syndrome plus Systemic Lupus Erythematosus	-	2	-	1	-	1	1	-
Sicca Syndrome	25	29	7	6	12	3	12	13

TABLE IX

Clinical Features and Distribution of Sialographic Abnormalities in patients seen who were outwith the basic study

Diagnosis	Number of Patients	Mean Age (Years)	Sex	Number of Abnormal Sialograms	Volume of Contrast used (ml) Mean±SD
Psoriatic Arthritis	29	43.8	24F 5M	3 (10.3%)	0.59±0.40
Systemic Lupus Erythematosus	9	27.1	9F	2 (22.2%)	0.66±0.61
Progressive Systemic Sclerosis	7	46.5	7F	1 (14.3%)	0.73±0.59
Polyarteritis Nodosa	1	42.0	1M	-	0.70
Ankylosing Spondylitis	18	44.8	3F 15M	1 (5.6%)	0.53±0.26
Arthritis of unknown aetiology	24	48.3	14F 10M	1 (4.2%)	0.86±0.46
Reiter's Syndrome	9	35.1	9M	2 (22.2%)	0.58±0.46
Sarcoidosis	1	32.0	1F	-	0.35

TABLE X

Sialographic Findings in Clinical Groups which were outwith the basic study

Diagnosis	Number Normal	Number Abnormal	Sialectasis			Atrophy	Main Duct Dilatation	Retention of Contrast Medium
			Punctate	Globular	Cavitary			
Psoriatic Arthritis	26	3	2	-	-	1	2	-
Systemic Lupus Erythematosus	7	2	-	1	-	1	-	-
Progressive Systemic Sclerosis	6	1	-	-	1	-	1	1
Ankylosing Spondylitis	17	1	-	-	-	1	-	-
Arthritis of unknown aetiology	23	1	-	-	-	-	1	-
Reiter's Syndrome	7	2	-	-	-	2	-	-

TABLE XI

Relationship of Main Duct Dilatation and/or Irregularity to Degree of Sialectasis

Degree of Sialectasis	Total	Main Duct Changes	
		Present	Absent
Punctate	23	6 (26.1%)	17
Globular	16	7 (43.75%)	9
Cavitary	16	12 (75.0%)	4
Normal*	323	13 (3.0%)	310
Atrophy	19	0 -	19

* Includes all sialograms having main duct dilatation as an isolated finding.

TABLE XII

Relationship of Retention of Contrast Medium to other Sialographic Abnormalities

Sialographic Abnormality	Retention of Contrast Medium	
	Present	Absent
Punctate Sialectasis	0	23
Globular Sialectasis	6	10
Cavitary Sialectasis	13	3
Atrophy	2	17
Main Duct Dilatation Alone	0	13

TABLE XIII

Sialographic appearances and salivary flow results in 64 patients with Sjøgren's Syndrome

Diagnosis (Sex Distribution)	Total	Normal	Sialectasis			Atrophy	Main Duct Dilatation
			Punctate	Globular	Cavitary		
Combined Sjøgren's Syndrome plus Rheumatoid Arthritis/ Sicca Syndrome Group	124	45	29	15	15	14	6
(Sex distribution)	(111F-13M)	(37F-8M)	(27F-2M)	(12F-3M)	(15F-OM)	(14F-OM)	(6F-OM)
Sjøgren's Syndrome plus Rheumatoid Arthritis	84	37	19	10	4	10	4
(Sex distribution)	(74F-10M)	(29F-8M)	(17F-2M)	(10F-OM)	(4F-OM)	(10F-OM)	(4F-OM)
Sicca Syndrome	40	8	10	5	11	4	2
(Sex distribution)	(37F-3M)	(8F-OM)	(10F-OM)	(2F-3M)	(11F-OM)	(4F-OM)	(2F-OM)
Mean parotid flow rate (lemon juice) ml./min.	-	0.85	0.38	0.34	0.13	0.25	0.32
S.E.M.	-	0.068	0.041	0.063	0.004	0.052	0.067
Range	-	0.26-2.0	0.0-0.8	0.0-1.0	0.0-0.42	0.01-0.5	0.08-0.48

These patients were compared with 45 age and sex matched control subjects without evidence of Sjøgren's syndrome, connective tissue disease or other salivary gland disease. The mean lemon juice stimulated parotid salivary flow rate in this group was 1.29 ml./min. ($\pm$S.E.M. 0.12 ml./min.)

TABLE XIV

Relationship of Main Duct Dilatation to Degrees of Sialectasis in 64 Patients with Sjögren's Syndrome

Degree of Sialectasis	Total	Main Duct Changes	
		Present	Absent
Punctate	29	2 6.9%	27
Globular	15	5 33.3%	10
Cavitary	15	8 53.5%	7
Normal*	51	6 11.8%	45
Atrophy	14	0 -	14

* Includes all sialograms having main duct dilatation as an isolated finding

TABLE XV

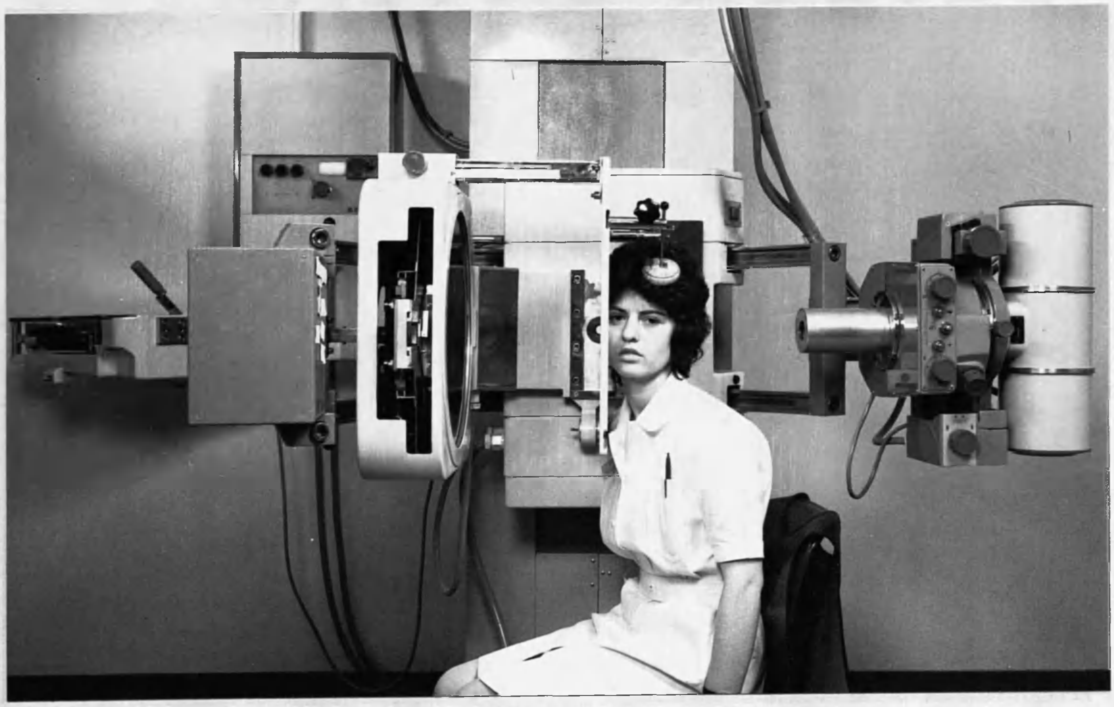
A comparison of the degree of salivary gland involvement, as shown by sialography, in Sjøgren's Syndrome plus rheumatoid arthritis and sicca syndrome

Study	Diagnosis	Number Normal	Number Abnormal	Sialectasis			Atrophy	Main Duct Dilatation
				Punctate	Globular	Cavitary		
A	Sjøgren's Syndrome plus Rheumatoid Arthritis	17 (37.0%)	29 (63.0%)	11 (37.9%)	7 (24.1%)	3 (10.4%)	8 (27.6%)	- -
	Sicca Syndrome	25 (46.3%)	29 (53.7%)	7 (24.1%)	6 (20.7%)	12 (41.4%)	3 (10.4%)	1 (3.4%)
B	Sjøgren's Syndrome plus Rheumatoid Arthritis	37 (44.0%)	47 (56.0%)	19 (40.4%)	10 (21.3%)	4 (8.5%)	10 (21.3%)	4 (8.5%)
	Sicca Syndrome	8 (20.0%)	32 (80.0%)	10 (31.2%)	5 (15.6%)	11 (34.4%)	4 (12.5%)	2 (6.3%)

Study A. Sialographic Abnormalities in Rheumatoid Arthritis and Sjøgren's Syndrome.

Study B. An Evaluation of Hydrostatic Sialography as an Index of Salivary Gland Involvement in Sjøgren's Syndrome.

FIGURE 80



Circular Tomography

The patient positioned prior to radiography of the temporomandibular joint with the teeth in normal occlusion.

FIGURE 81

Circular Tomography

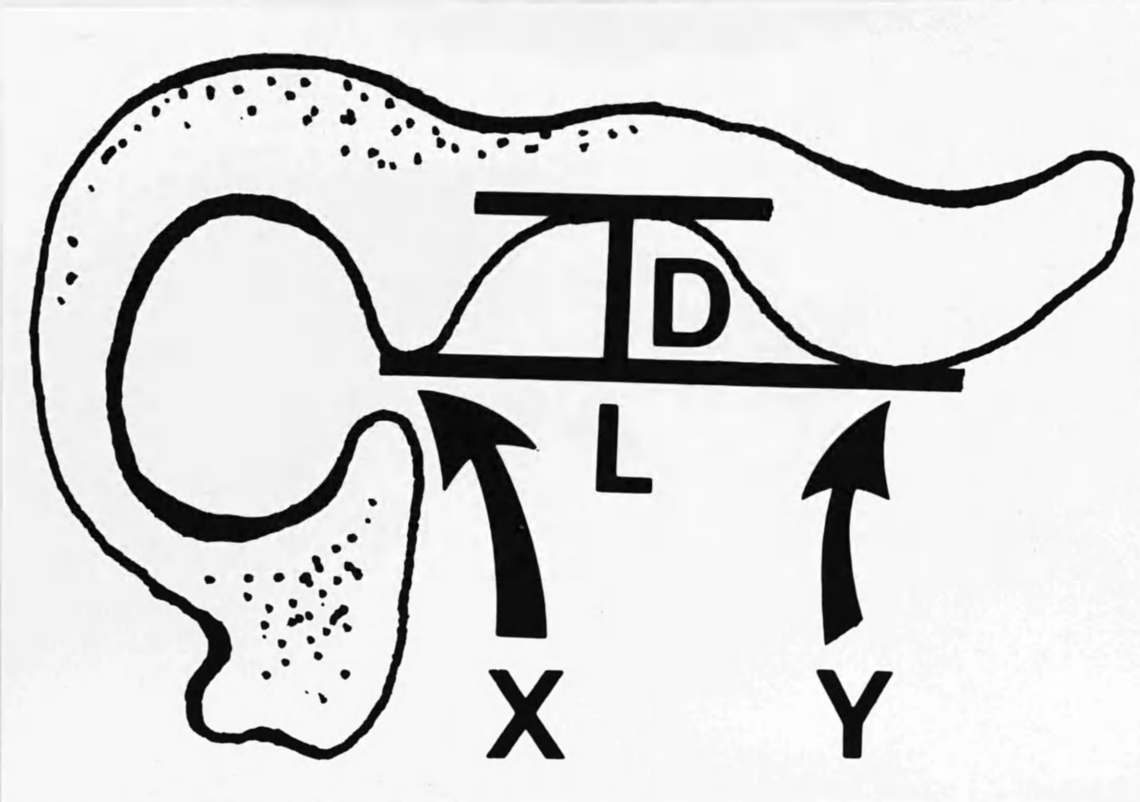
The patient positioned prior to radiography of the temporomandibular joint with the mouth maximally open.

FIGURE 82

Circular Tomography

This oblique view of the patient's position prior to radiography of the temporomandibular joint is included as it clearly indicates the plane of the patient's head and because it illustrates further features of the CRT-7 unit which facilitate accurate centring (cf. Figure 44) (T. & I. 49).

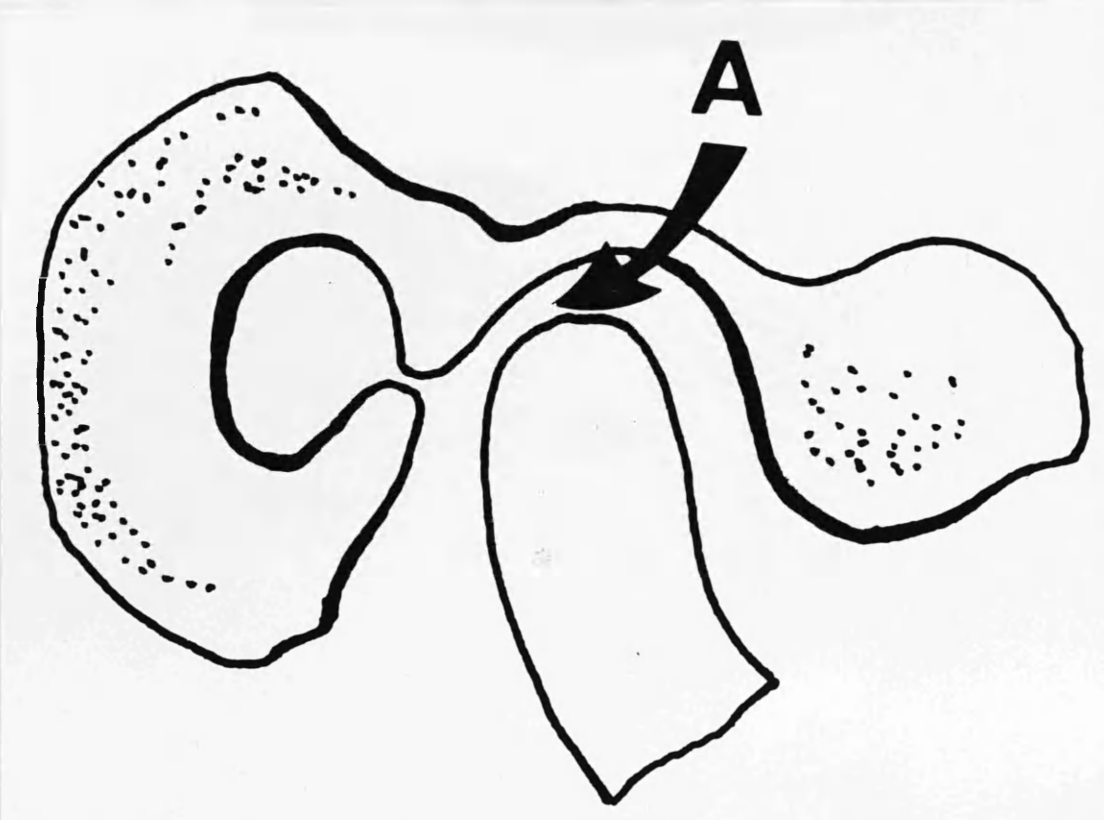
FIGURE 83



Measurements on Tomographs

Diagram illustrating the derivation of parameters L and D.

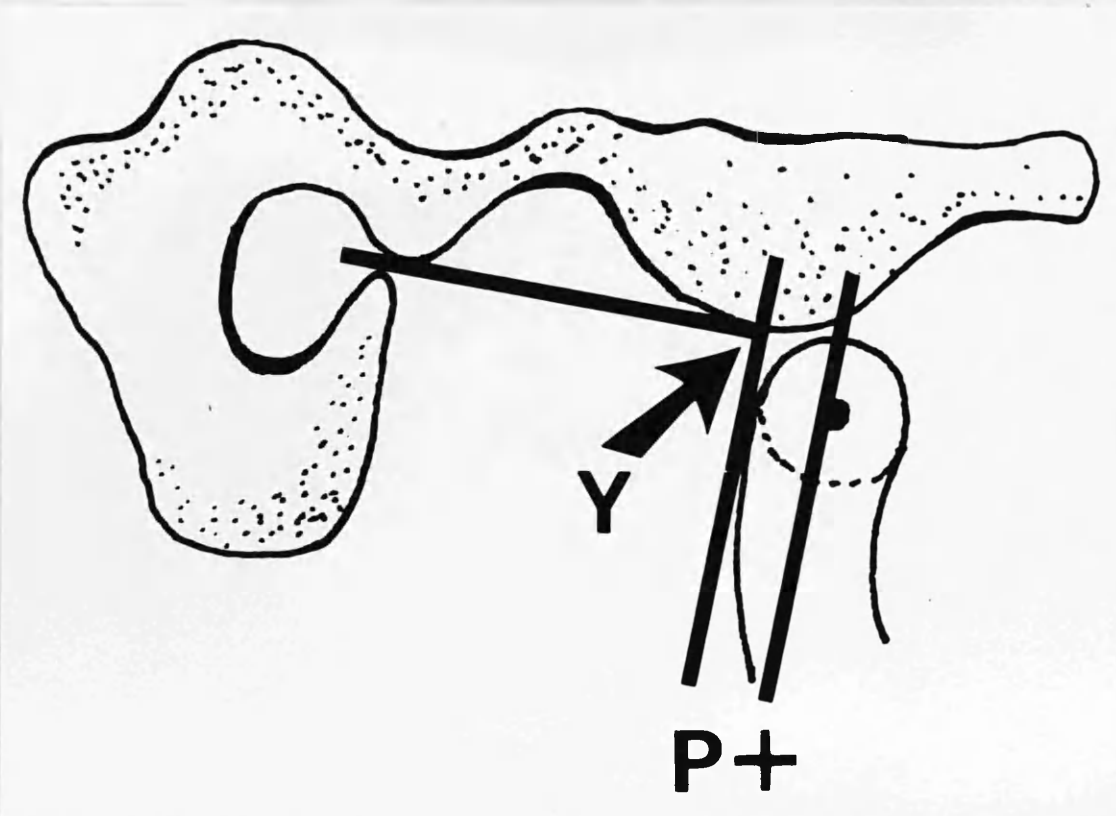
FIGURE 84



Measurements on Tomographs

Diagram illustrating the location of measurement A.

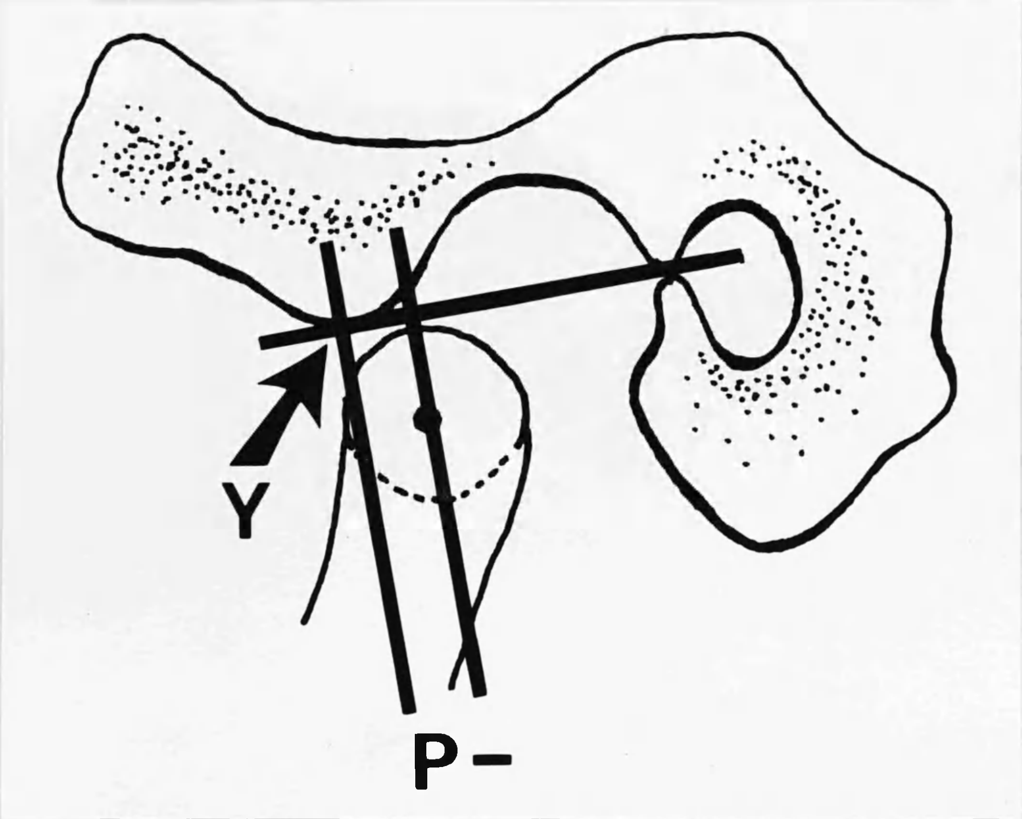
FIGURE 85



Measurements on Tomographs

Diagram illustrating the reference lines required if the value of P (P+) is to be determined when a temporomandibular joint exhibits increased mobility.

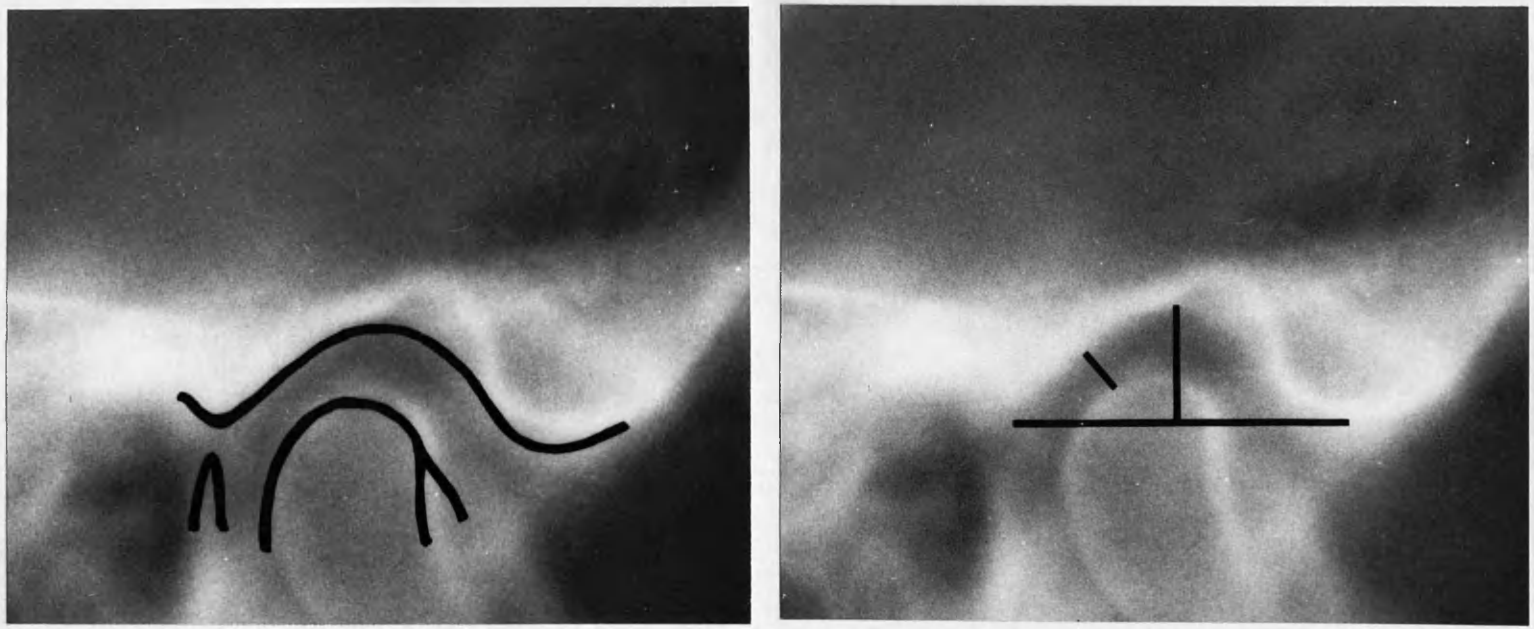
FIGURE 86



Measurements on Tomographs

Diagram illustrating the reference lines needed to determine the value of P (P-) when a temporomandibular joint exhibits reduced mobility.

FIGURE 87



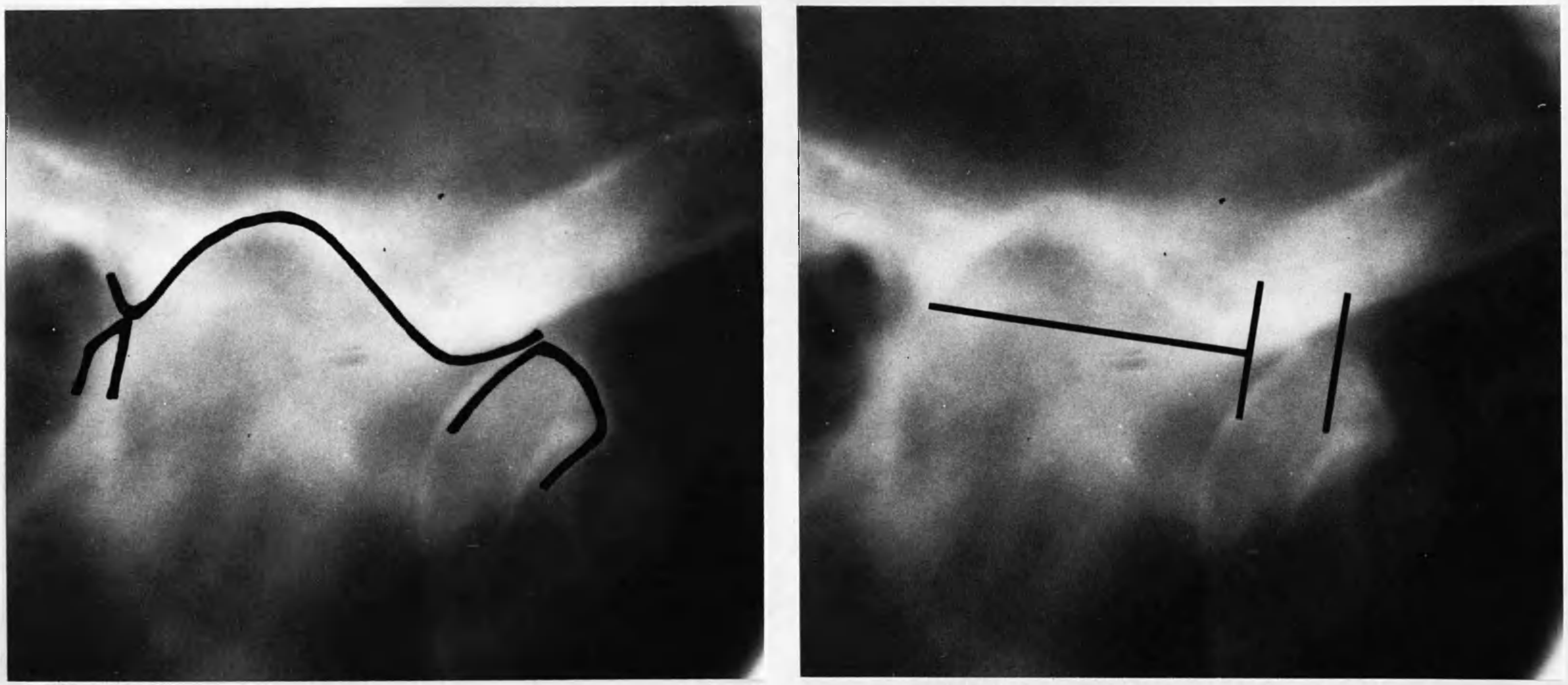
A B

<u>Measurements on Tomographs</u>

A. Tomograph of a temporomandibular joint in the closed position. The articular surfaces and the squamo-tympanic fissure are outlined.

B. The same tomograph with reference lines L. D and A superimposed.

FIGURE 88



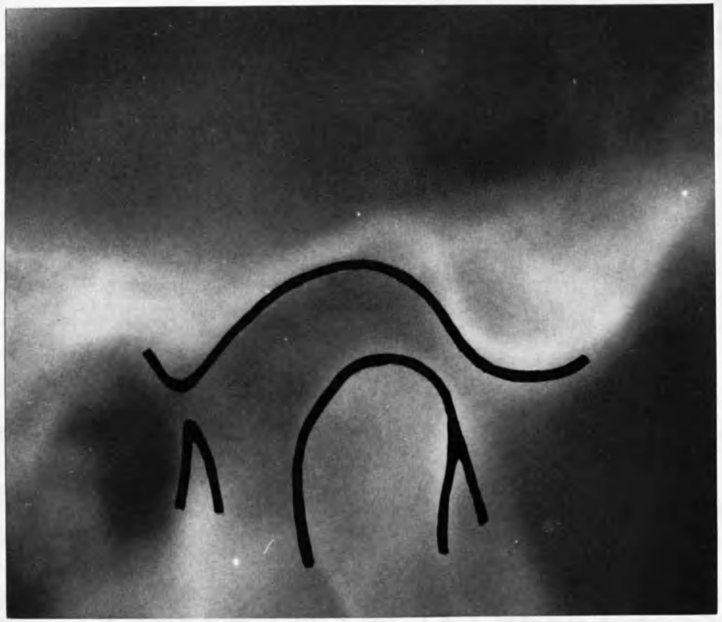
A B

<u>Measurements on Tomographs</u>

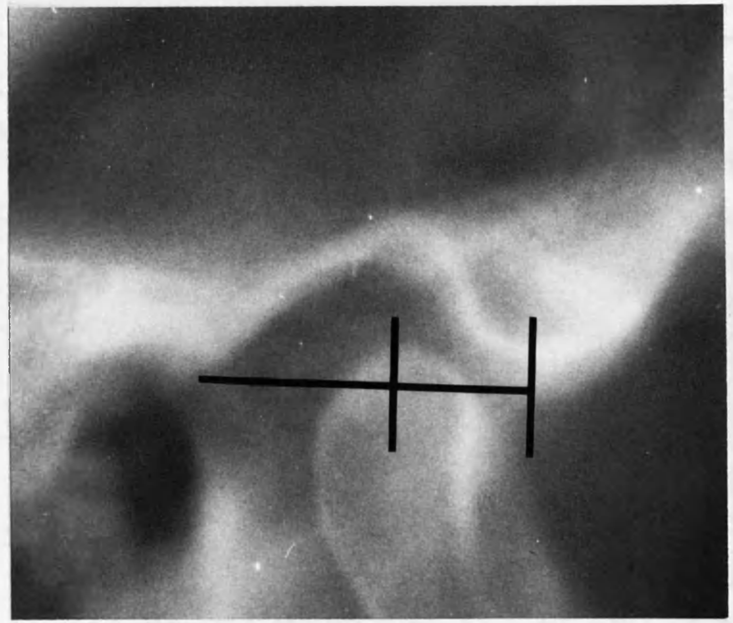
A. Tomograph of a temporomandibular joint with the mouth maximally open showing increased mobility. The articular surfaces and the squamo-tympanic fissure are outlined.

B. The same tomograph with reference lines for measurement of L and P+ superimposed.

FIGURE 89



A



B

Measurements on Tomographs

A. Tomograph of a temporomandibular joint, outlined as Figure 88 (T. & I. 103) is, with the mouth maximally open, showing reduced mobility.

B. The same tomograph with reference lines needed for the measurement of L amd P- superimposed.

TABLE XVI

Evaluation of Circular Tomography. Results of measurements. Figures are in mm. and are means (± standard errors) of 21 readings

Observer	Series I						Series II					
	Teeth Occluded			Mouth Open			Teeth Occluded			Mouth Open		
	D	L	A	D	L	P	D	L	A	D	L	P
AUTHOR 1	8.15 ±0.42	20.14 ±0.54	1.77 ±0.09	8.34 ±0.44	19.88 ±0.50	+3.21 ±1.69	8.50 ±0.41	20.91 ±0.49	1.81 ±0.11	8.44 ±0.44	20.82 ±0.50	+1.92 ±1.74
AUTHOR 2	8.09 ±0.42	20.11 ±0.53	1.79 ±0.07	8.30 ±0.42	19.84 ±0.47	+3.25 ±1.71	8.47 ±0.40	20.92 ±0.49	1.81 ±0.10	8.38 ±0.45	20.90 ±0.51	+1.96 ±1.76
Mr. T. G. LEGGAT	8.39 ±0.43	20.21 ±0.57	1.65 ±0.09	8.56 ±0.44	20.10 ±0.45	+3.20 ±1.73	8.74 ±0.42	21.13 ±0.51	1.74 ±0.12	8.67 ±0.45	20.81 ±0.51	+1.95 ±1.77
Dr. I. M. CHALMERS	8.64 ±0.44	20.54 ±0.54	1.70 ±0.13	8.70 ±0.45	20.74 ±0.53	+2.68 ±1.93	8.59 ±0.38	20.91 ±0.49	1.76 ±0.11	8.60 ±0.42	20.40 ±0.43	+2.31 ±1.76

Recordings Author 2 were performed one month after the completion of recordings Author 1

TABLE XVII

Evaluation of Circular Tomography: Reproducibility. Series I compared with Series II

Observer	View	Measure-ment	Mean of Differ-ence	±S.E.M.	t	p
AUTHOR 1	Teeth Occluded	D L A	+0.34 +0.78 +0.06	0.19 0.23 0.08	1.76 3.82 0.61	N.S. <0.01 N.S.
	Mouth Open	D L P	+0.10 +0.94 -0.51	0.10 0.28 0.60	1.24 3.41 1.04	N.S. <0.01 N.S.
AUTHOR 2	Teeth Occluded	D L A	+0.38 +0.81 +0.02	0.20 0.23 0.06	1.88 3.56 0.32	N.S. <0.01 N.S.
	Mouth Open	D L P	+0.09 +1.11 -0.49	0.12 0.23 0.60	0.73 1.09 0.82	N.S. N.S. N.S.
Mr. T.G. LEGGAT	Teeth Occluded	D L A	+0.34 +0.93 +0.09	0.22 0.37 0.13	1.52 0.76 0.69	N.S. N.S. N.S.
	Mouth Open	D L P	+0.11 +0.75 -0.55	0.13 0.30 0.58	0.83 2.21 0.96	N.S. <0.05 N.S.
Dr. I.M. CHALMERS	Teeth Occluded	D L A	+0.30 +0.72 +0.15	0.20 0.36 0.11	1.55 1.80 0.85	N.S. N.S. N.S.
	Mouth Open	D L P	+0.16 +0.93 -0.31	0.12 0.25 0.62	1.56 3.68 0.50	N.S. <0.01 N.S.

Recordings Author 1 and Author 2 were made one month apart

TABLE XVIII

Evaluation of Circular Tomography

Intra-observer error. Comparison between first and second set of measurements by Observer A

Series	View	Measure -ment	Mean of Difference	$\pm$S.E.M.	t	p
I	Teeth Occluded	D	+0.07	0.04	1.88	N.S.
		L	+0.02	0.06	0.43	N.S.
		A	-0.02	0.03	0.58	N.S.
	Mouth Open	D	+0.04	0.04	1.25	N.S.
		L	+0.04	0.10	1.06	N.S.
		P	-0.06	0.03	1.76	N.S.
II	Teeth Occluded	D	+0.03	0.03	0.86	N.S.
		L	-0.01	0.07	0.22	N.S.
		A	+0.01	0.04	0.11	N.S.
	Mouth Open	D	+0.06	0.05	1.14	N.S.
		L	-0.08	0.07	1.15	N.S.
		P	0.09	0.05	1.22	N.S.

TABLE XIX

Evaluation of Circular Tomography: Interobserver error. Comparisons between the three observers

Observers being Compared	Series	View	Measure-ment	Mean of Differ-ence	±S.E.M.	t	p
AUTHOR 1 vs. Mr. T. G. LEGGAT	I	Teeth Occluded	D	+0.24	0.06	3.82	<0.01
			L	+0.08	0.21	0.36	N.S.
			A	-0.12	0.05	2.44	<0.05
		Mouth Open	D	+0.22	0.04	4.92	<0.001
			L	+0.22	0.14	1.56	N.S.
			P	+0.11	0.07	0.05	N.S.
	II	Teeth Occluded	D	+0.22	0.06	4.26	<0.001
			L	+0.23	0.09	2.58	<0.02
			A	-0.07	0.07	0.39	N.S.
		Mouth Open	D	+0.23	0.07	3.38	<0.01
			L	-0.01	0.17	0.06	N.S.
			P	+0.09	0.13	0.56	N.S.
AUTHOR 1 vs. Dr. I. M. CHALMERS	I	Teeth Occluded	D	+0.30	0.07	4.53	<0.001
			L	+0.23	0.24	0.93	N.S.
			A	-0.09	0.05	1.85	N.S.
		Mouth Open	D	+0.21	0.04	5.84	<0.001
			L	+0.22	0.10	2.16	<0.05
			P	+0.33	0.17	1.92	N.S.
	II	Teeth Occluded	D	+0.27	0.06	3.82	<0.01
			L	+0.18	0.06	3.00	<0.01
			A	-0.03	0.06	0.42	N.S.
		Mouth Open	D	+0.30	0.05	6.10	<0.001
			L	+0.30	0.10	0.60	N.S.
			P	+0.54	0.17	3.20	<0.01
Mr. T.G. LEGGAT vs. Dr. I. M. CHALMERS	I	Teeth Occluded	D	+0.09	0.07	0.92	N.S.
			L	+0.20	0.19	0.84	N.S.
			A	+0.03	0.05	0.19	N.S.
		Mouth Open	D	+0.02	0.04	0.12	N.S.
			L	+0.03	0.10	0.10	N.S.
			P	+0.25	0.15	1.65	N.S.
	II	Teeth Occluded	D	0.00	0.07	0.49	N.S.
			L	-0.10	0.12	0.47	N.S.
			A	+0.04	0.06	0.66	N.S.
		Mouth Open	D	+0.05	0.05	1.52	N.S.
			L	+0.25	0.22	1.03	N.S.
			P	+0.44	0.16	2.98	<0.01

Author 1 represents the first series of measurements made by myself.

TABLE XX

Evaluation of Circular Tomography. Reproducibility of radiographs: Concordance between 42 pairs of reports

	POSITION OF THE CONDYLAR HEAD		
	WITH TEETH IN OCCLUSION	WITH MOUTH MAXIMALLY OPEN	REDUCED INTER-ARTICULAR SPACE, SUBLUXATION AND ANKYLOSIS
Concordant normal	18	14	42
Concordant abnormal	22	27	0
Discordant	2[(a)]	1[(b)]	0
Overall concordance	95%	98%	100%

	CONDITION OF THE CONDYLAR HEAD							
	Osteoporosis	Sclerosis	Surface Erosions	Pocket Erosions	Flatten-ing	Subchondral cysts	Marginal Proliferation	Calcified Articular Disc
Concordant present	22	0	5	0	6	9	0	0
Concordant absent	20	42	37	42	36	33	42	42
Discordant	0	0	0	0	0	0	0	0
Overall concordance	100%	100%	100%	100%	100%	100%	100%	100%

(a) Normo-position in two radiographs of first series and antero-position in second series.

(b) Reduced opening in first series and normal opening in second series. Re-measurement of radiograph from first series confirmed normal opening.

TABLE XXI

Evaluation of Circular Tomography. Intra-observer error in reporting on radiographs: Concordance between 42 pairs of observations

	POSITION OF THE CONDYLAR HEAD		
	WITH TEETH IN OCCLUSION	WITH MOUTH MAXIMALLY OPEN	REDUCED INTER-ARTICULAR SPACE, SUBLUXATION AND ANKYLOSIS
Concordant normal	16	41	42
Concordant abnormal	21	26	0
Discordant	5[(a)]	1[(b)]	0
Overall concordance	88%	98%	100%

	CONDITION OF THE CONDYLAR HEAD							
	Osteoporosis	Sclerosis	Surface Erosions	Pocket Erosions	Flatten-ing	Subchondral cysts	Marginal Prolifer-ation	Calcified Articular Disc
Concordant present	19	0	3	0	7	8	0	0
Concordant absent	18	42	36	42	35	32	42	42
Discordant	5[(c)]	0	3[(d)]	0	0	2[(e)]	0	0
Overall concordance	88%	100%	93%	100%	100%	95%	100%	100%

(a) Reported as normo-position on the first occasion and as retro- (3) or antero-position (2) on the second occasion.

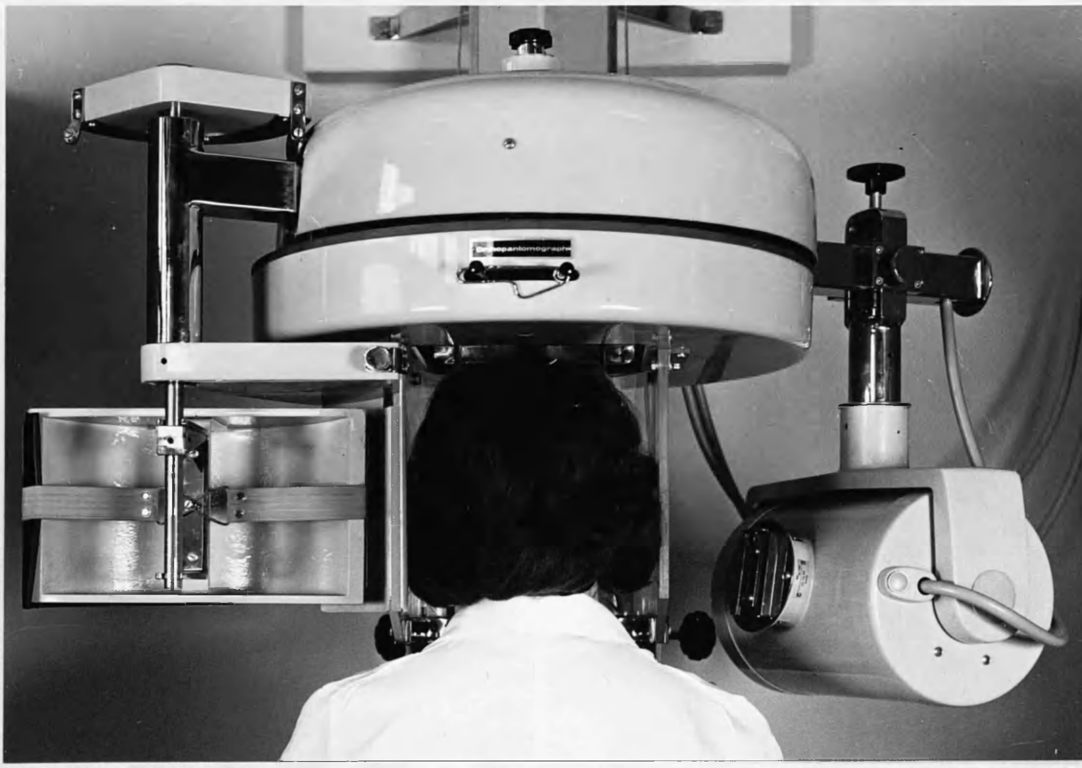
(b) Reported as reduced mobility on the first occasion and normal on the second occasion.

(c) Three cases misinterpreted on the first occasion as osteoporosis as a result of penetration artefact. Two cases reported as normal on the first observation and osteoporosis present on the second.

(d) Surface erosions reported present in three cases on the first occasion but absent on the second. Subsequent re-examination confirmed their presence.

(e) Subchondral cysts reported present in two cases on the first occasion and absent in the second. Presence later confirmed.

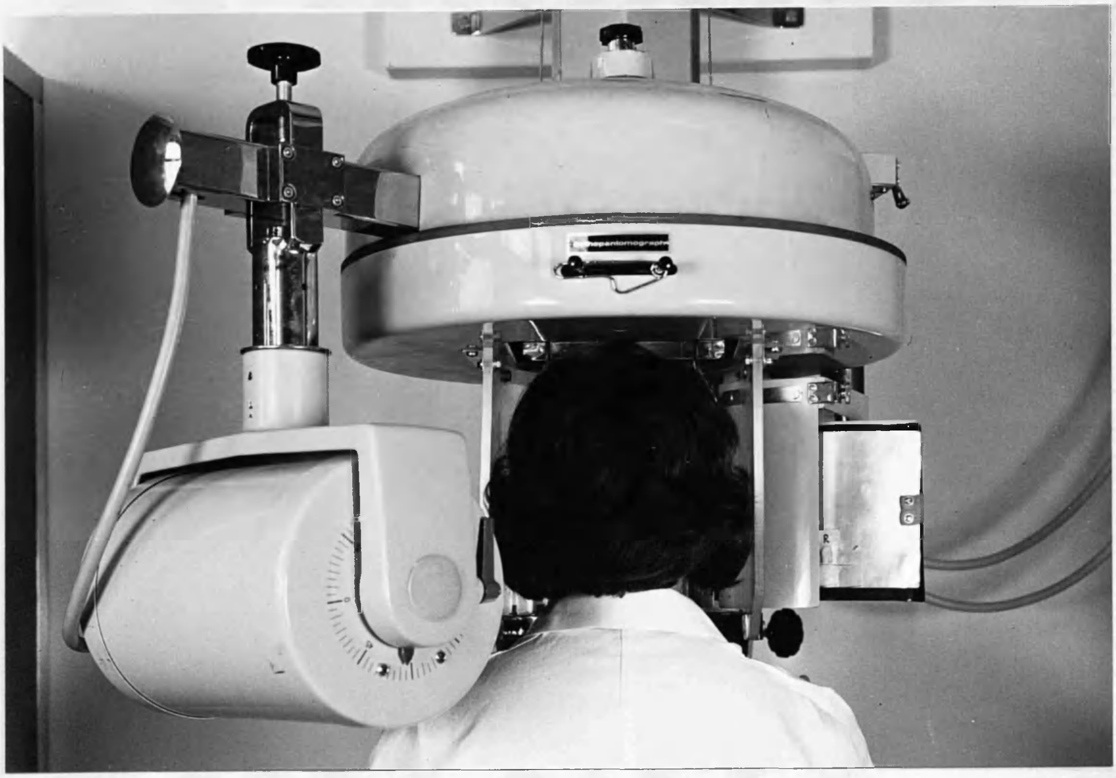
FIGURE 90



Orthopantomography

Patient positioned with the head fixed. The X-ray tube will pass behind the patient's head, the curved cassette containing the film in front of it. Thus the patient is positioned for a postero-anterior projection.

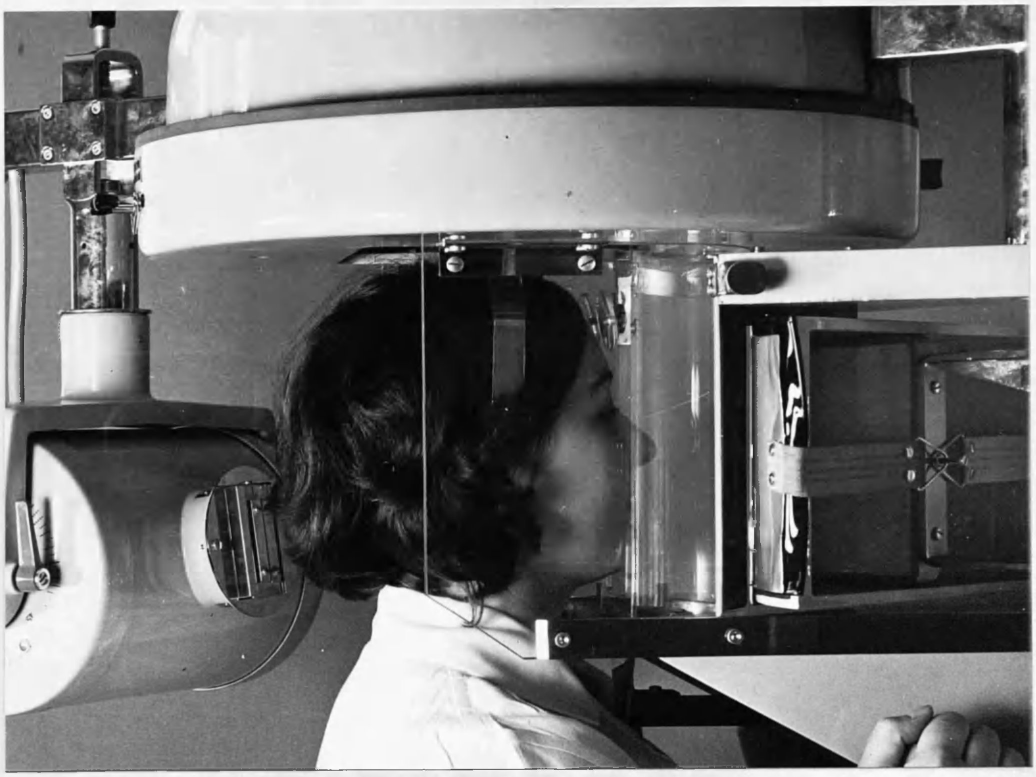
FIGURE 91



Orthopantomography

The X-ray tube and the curved cassette rotate together around three successive axes. The cassette, in addition, rotates independently. Approximately two-thirds of these movements have been completed in this illustration.

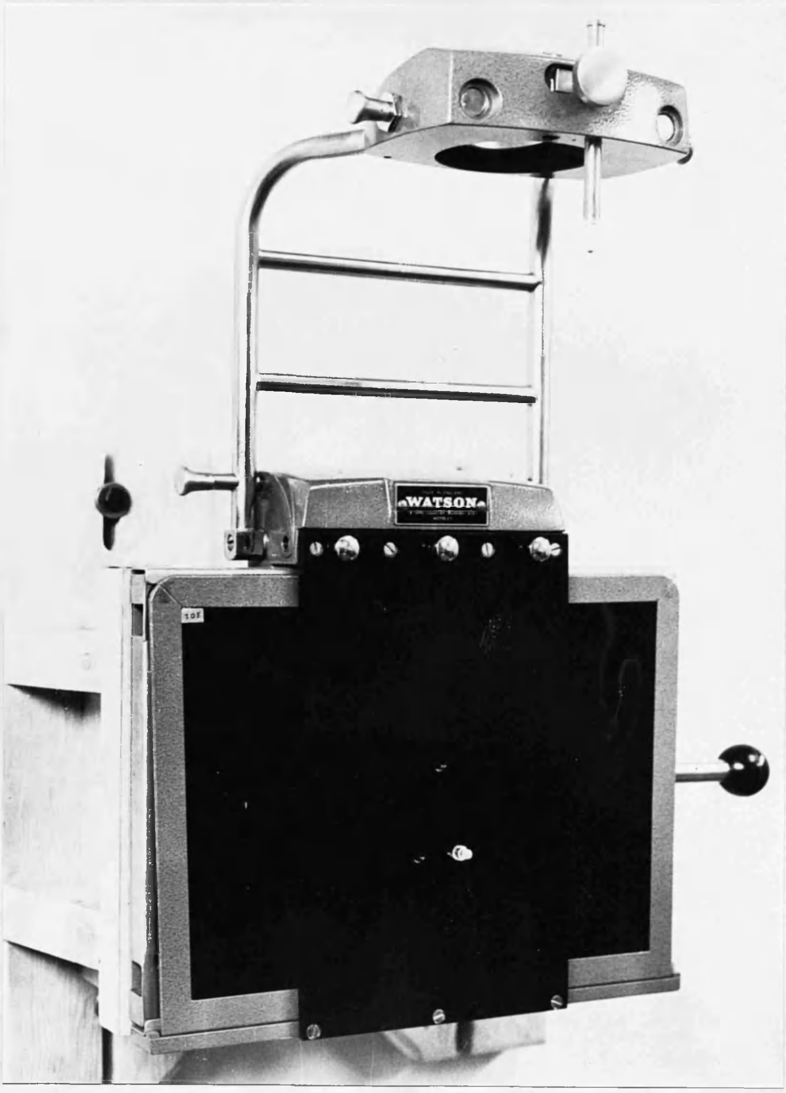
FIGURE 92



Orthopantomography

An oblique view showing exactly the same as is illustrated in Figure 91 (T. & I. 112). It is included to show how the patient's head is fixed, the curved cassette and the narrow perpendicular slit in the X-ray tube through which the X-rays emerge.

FIGURE 93



Lateral Transcranio-oblique Radiography

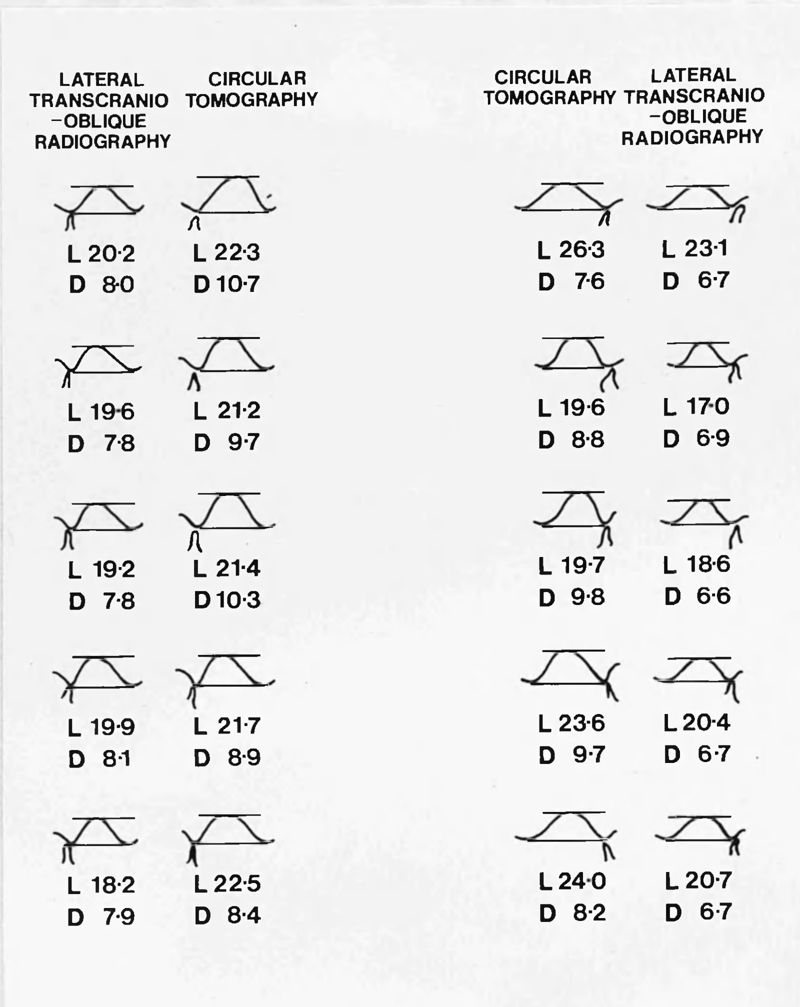
The head positioner is shown with ear-plugs in position to locate the patient for radiography of the **right** temporomandibular joint. The ear-plug on the fixed component of this positioner (marked WATSON) is transferred to the hole on the left for left temporomandibular joint radiography.

FIGURE 94

<u>Lateral Transcranio-oblique Radiography</u>

The patient is positioned, sitting erect, with the right temporomandibular joint located against the fixed component of the head positioner behind which the film is placed. The hinged component of the head positioner is swung over the head which is then positioned accurately by means of the ear plugs. The X-ray tube is exactly located as it fits neatly into the circular window of the hinged component of the head positioner.

FIGURE 95



An example of the method used to determine the degree of magnification of the temporomandibular joint obtained by different radiographic techniques

TABLE XXII

Comparison between circular tomography and orthopantomography: assessment of position of condylar head

	Position with teeth in occlusion	Position with mouth maximally open	Inter-articular space	Ankylosis	Sub-luxation
Number of joints radiographed	53	53	53	53	53
Number unclear with orthopantomography	15	0	15	0	0
Number unclear with circular tomography	2	0	2	0	0
Percent unclear with orthopantomography	28.3%	0%	28.3%	0%	0%
Percent unclear with circular tomography	3.8%	0%	3.8%	0%	0%
Number of joints in concordance study	36	53	36	53	53
Concordant normal	18	28	36	53	47
Concordant abnormal	17	21	0	0	6
Discordant	1	4	0	0	0
Overall concordance	97.2%	92.5%	100%	100%	100%

TABLE XXIII

Comparison between circular tomography and orthopantomography: assessment of condition of joint

	Osteo-porosis	Sclerosis	Surface erosions	Pocket erosions	Flatten-ing	Sub-chondral cysts	Marginal prolifer-ations	Calcified articular disc
Number of joints in concordance study*	53	53	53	53	53	53	53	53
Concordant normal	30	51	45	49	34	50	53	53
Concordant abnormal	18	2	8	4	17	3	0	0
Discordant	5	0	0	0	2	0	0	0
Overall concordance	90.6%	100%	100%	100%	96.2%	100%	100%	100%

* All joints radiographed suitable for study

TABLE XXIV

Comparison between circular tomography and orthopantomography: overall assessment of joint

	Position of condylar head	Condition of joint	Final Report
Number of joints radiographed	53	53	53
Number unclear with orthopantomography	15	0	15
Number unclear with circular tomography	2	0	2
Percent unclear with orthopantomography	28.3%	0%	28.3%
Percent unclear with circular tomography	3.8%	0%	3.8%
Number of joints in concordance study	36	53	36
Concordant normal	23	23	9
Concordant abnormal	11	28	25
Discordant	2	2	2
Overall concordance	94.4%	96.2%	94.4%

TABLE XXV

Comparison between circular tomography and lateral transcranio-oblique radiography: assessment of position of condylar head

	Position with teeth in occlusion	Position with mouth maximally open	Inter-articular space	Ankylosis	Sub-luxation
Number of joints radiographed	44	44	44	44	44
Number unclear on lateral transcranio-oblique films	7	8	7	0	0
Number unclear with circular tomography	2	0	2	0	0
Percent unclear on lateral transcranio-oblique films	15.9%	18.2%	15.9%	0%	0%
Percent unclear with circular tomography	4.5%	0%	4.5%	0%	0%
Number of joints in concordance study	37	36	37	44	44
Concordant normal	16	10	37	44	42
Concordant abnormal	14	19	0	0	2
Discordant	7	7	0	0	0
Overall concordance	81.1%	80.6%	100%	100%	100%

TABLE XXVI

Comparison between circular tomography and lateral transcranio-oblique radiography: assessment of condition of joint

	Osteo-porosis	Sclerosis	Surface Erosions	Pocket Erosions	Flatten-ing	Sub-chondral cysts	Marginal prolifer-ations	Calcified articular disc
Number of joints in concordance study*	39	39	39	39	39	39	39	39
Concordant normal	27	39	36	39	36	39	38	39
Concordant abnormal	2	0	3	0	2	0	0	0
Discordant	10	0	0	0	1	0	1	0
Overall concordance	74.4%	100%	100%	100%	97.4%	100%	97.4%	100%

* 5 out of 44 (11.4%) of joints excluded from study because of lack of clarity of lateral transcranio-oblique radiographs. All circular tomographs were clear.

TABLE XXVII

Comparison between circular tomography and lateral transcranio-oblique radiography: overall assessment of joint

	Position of condylar head	Condition of joint	Final report
Number of joints radiographed	44	44	44
Number unclear on lateral transcranio-oblique films	10	5	10
Number unclear with circular tomography	2	0	2
Percent unclear on lateral transcranio-oblique films	22.7%	11.4%	22.7%
Percent unclear with circular tomography	4.5%	0%	4.5%
Number of joints in concordance study	34	39	34
Concordant normal	23	33	23
Concordant abnormal	10	4	10
Discordant	1	2*	1*
Overall concordance	97.1%	94.9%	97.1%

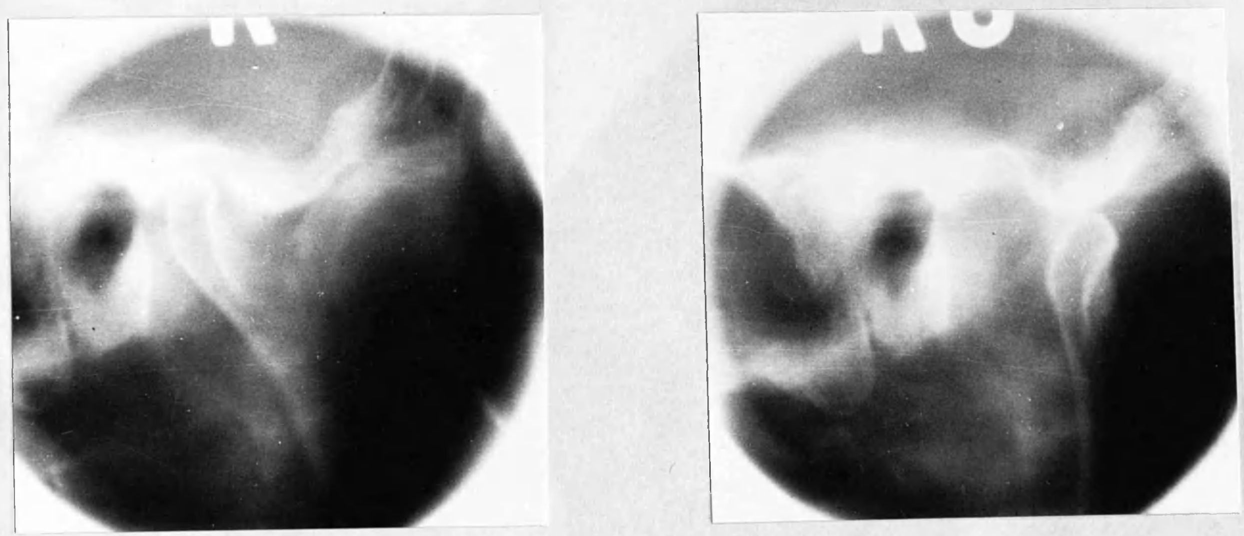
* One of the two discordant results under condition of joint was from a film excluded from the final report because of insufficient clarity of position of condylar head.

TABLE XXVIII

Linear magnification seen on radiographs produced by circular tomography compared with radiographs produced by two other techniques

PARAMETER	L			D		
TECHNIQUE	Mean	Standard Deviation	Range	Mean	Standard Deviation	Range
Orthopantomography	1.06	± 0.16	0.86-1.20	1.10	± 0.18	0.86-1.26
Lateral Transcranio-Oblique Radiography	1.15	± 0.08	1.04-1.31	1.27	± 0.16	1.06-1.69

FIGURE 96



A B

<u>First class radiographs obtained using Circular Tomography</u>

Circular tomograms clearly showing the mandibular condyle and the articular surface of the squamous temporal bone in the (A) closed and (B) maximally open positions.

FIGURE 97

Poor Circular Tomograph

Very indistinct circular tomograph of a temporomandibular joint taken when the teeth were normally occluded.

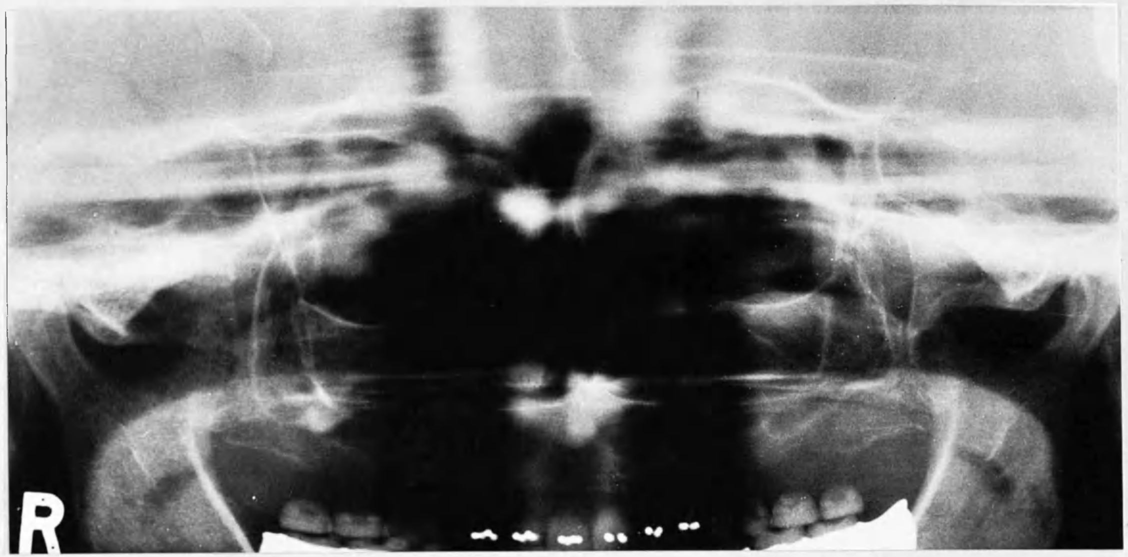
FIGURE 98

A B

<u>First class radiographs obtained using Orthopantomography</u>

A composite illustration clearly showing the details of the temporomandibular joint in the (A) open and (B) closed positions. Orthopantomography was the method used in this case.

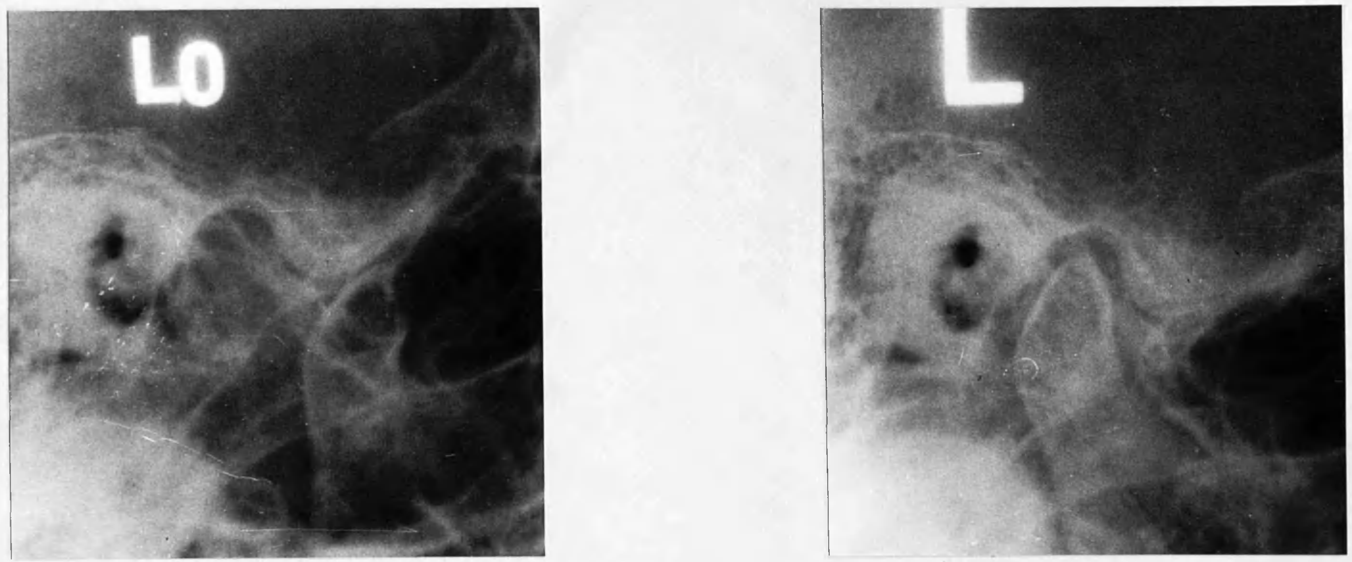
FIGURE 99



Poor Orthopantomograph

An orthopantomograph from which it was not possible to ascertain the condition of the articulating surfaces of either temporomandibular joint.

FIGURE 100



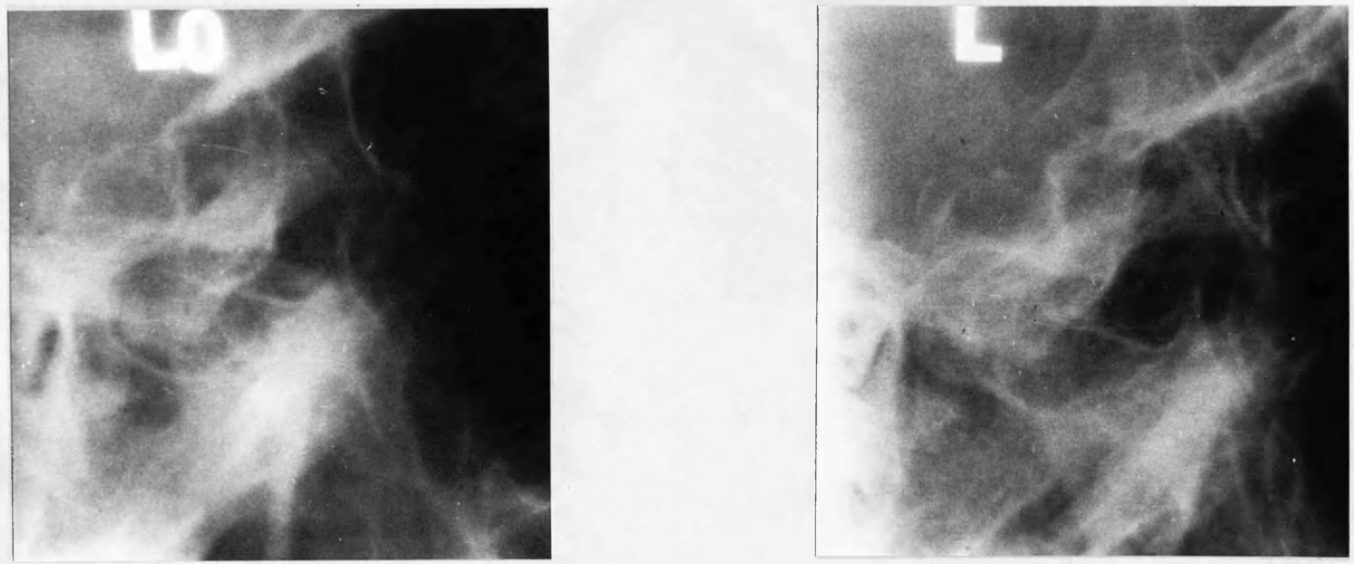
A B

<u>Excellent lateral transcranio-oblique radiographs</u>

Excellent radiographic reproductions of the temporomandibular articulation produced using lateral transcranio-oblique radiograph.

A. maximally open position B. closed position

FIGURE 101



A B

Poor results obtained using lateral transcranio-oblique radiography

Indistinct radiographs of the temporomandibular joint. Lateral transcranio-oblique was the method used, the mouth being held fully open in one instance (A), and the teeth being occluded in the other (B).

FIGURE 102

RADIOLOGY OF THE TEMPOROMANDIBULAR JOINT

A. NORMAL	☐	RIGHT	☐
		or	
B. ABNORMAL	☐	LEFT	☐

B. I Position of the Condylar Head

A. NORMAL ☐

B. ABNORMAL ☐

Normo-Position	☐	Reduced Inter-Articular Space	A1 ☐ mm
Antero-Position	A2 ☐	Retro-Position	A3 ☐
Reduced Mobility	P1 ☐ mm	Fibrous or Bony Ankylosis	☐
Increased Mobility	P2 ☐ mm	Subluxation	☐

B.II Condition of the Condylar Head

A. NORMAL ☐

B. ABNORMAL ☐

Osteoporosis	☐	Sclerosis	☐
Surface Erosions	☐	Pocket Erosions	☐
Flattening	☐	Subchondral Cysts	☐
Marginal Proliferations	☐	Calcified Articular Disc	☐

i.e. Hypertrophy, Osteophytes, etc.

PATIENT'S NAME ______________________________

UNIT NUMBER ______________

TYPE OF X-RAY ______________________________

Radiology of the Temporomandibular Joint

This proforma was designed by the author and was found to simplify and also to increase the accuracy of radiological reporting. The patient's name was inserted once all reporting had been completed. It is for this reason that the space for it is at the foot of the proforma.

FIGURE 103

Radiology of the Temporomandibular Joint

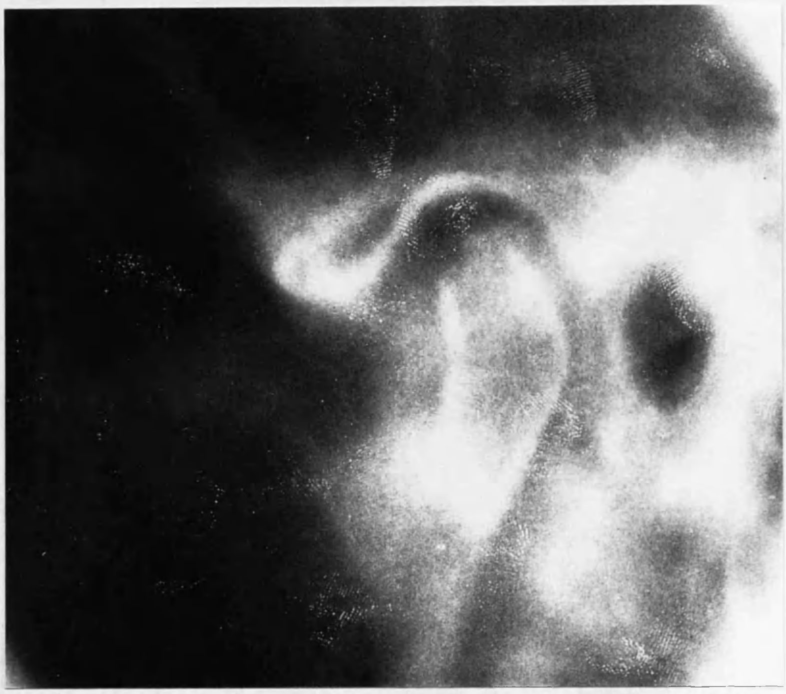
Normo-position: The head of the mandibular condyle lies in the middle of the articular fossa. The radiolucency of the mandibular condyle is described as osteoporosis.

FIGURE 104

Radiology of the Temporomandibular Joint

Antero-position: This joint was radiographed when the patient's teeth were occluding normally.

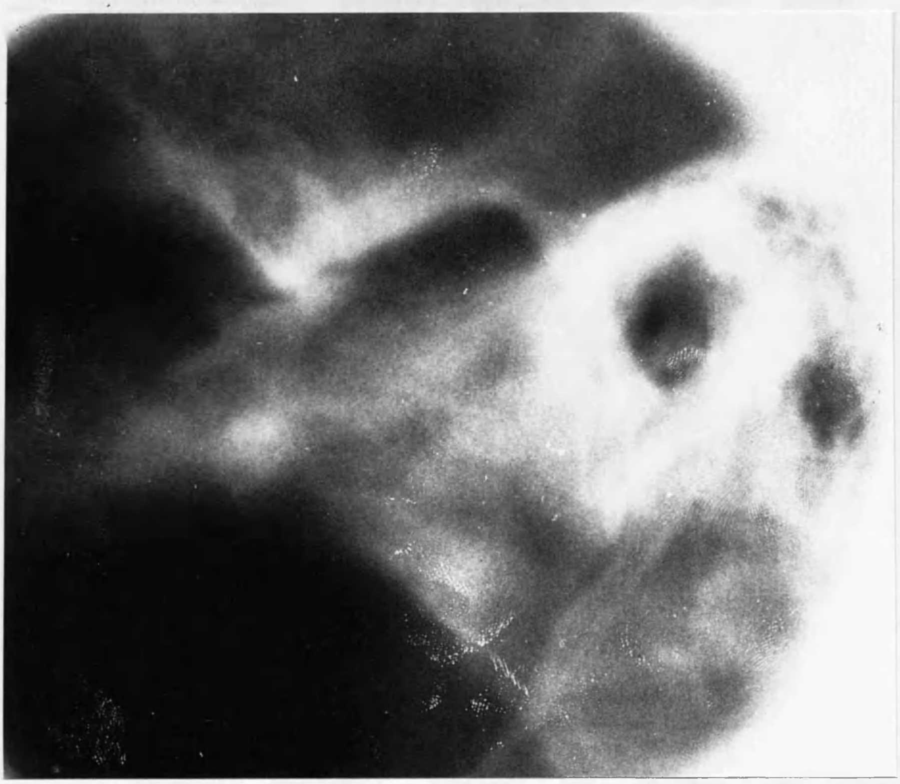
FIGURE 105



Radiology of the Temporomandibular Joint

Retro-position: In addition surface erosions of the anterior margin of the condylar head are evident.

FIGURE 106



Radiology of the Temporomandibular Joint

Subluxation in the closed position

This very flattened condyle fails completely to return to the articular fossa when the teeth are normally occluded.

FIGURE 107

Radiology of the Temporomandibular Joint

Reduced inter-articular space

The articular surfaces of the squamous temporal bone and the retro-positioned mandibular condyle can be seen to be almost in contact towards the posterior margin of the articular fossa.

FIGURE 108

Radiology of the Temporomandibular Joint

Reduced Mobility

The mandibular condyle remains well behind the articular eminence even although the subject of the examination was opening as widely as possible.

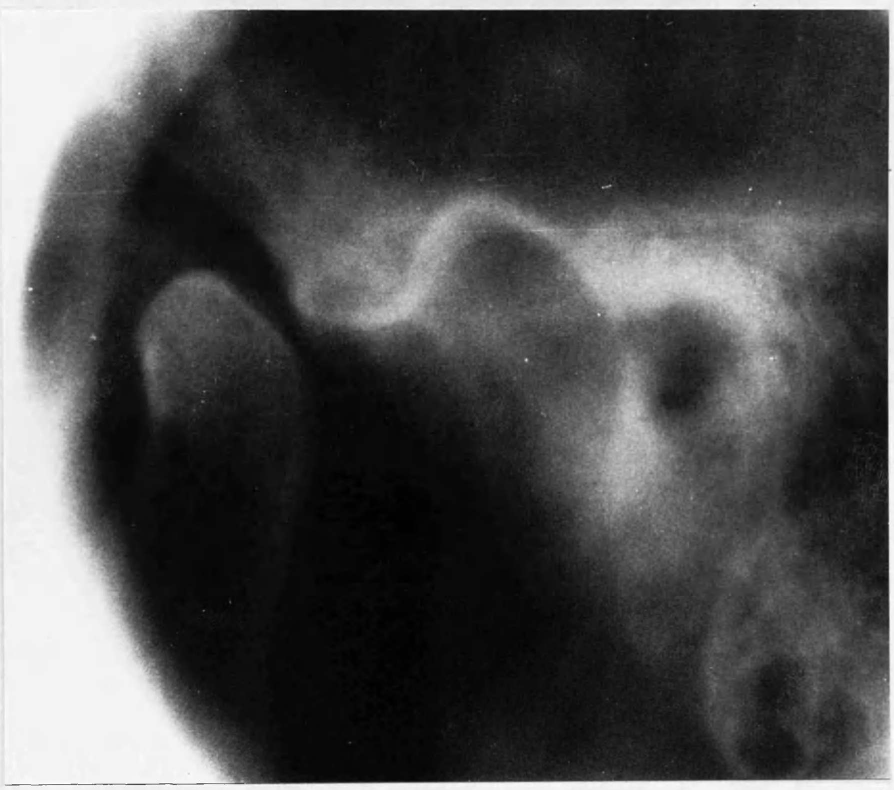
FIGURE 109

Radiology of the Temporomandibular Joint

Increased Mobility

This was not classified as abnormal.

FIGURE 110

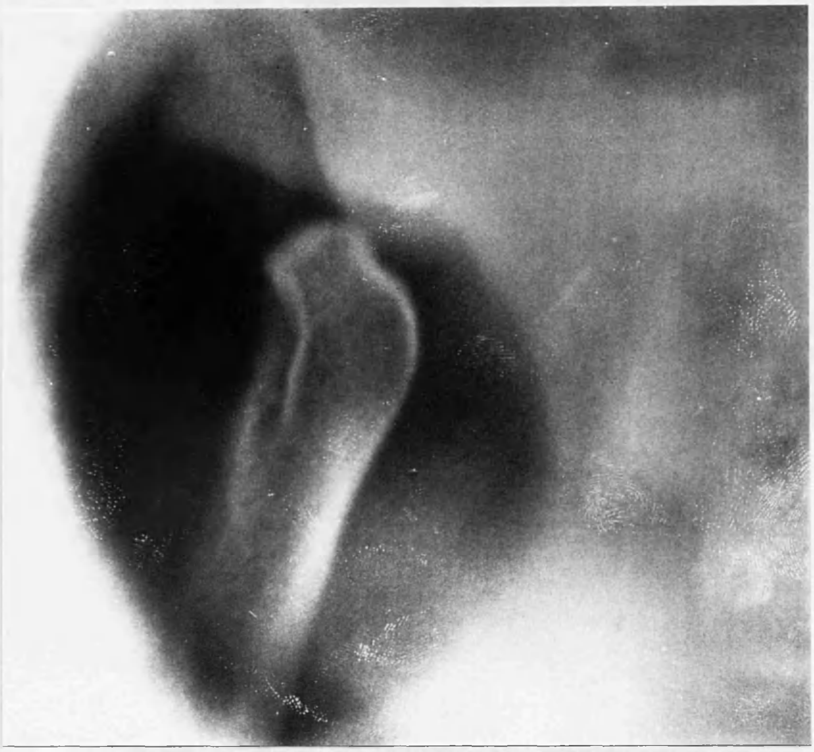


Radiology of the Temporomandibular Joint

Subluxation in the open position

This increased mobility was associated with signs and/or symptoms of temporomandibular joint disease. It is of interest that in these cases the condyle passed not only forwards, but also upwards, in front of the articular eminence (cf. Figure 109) (T. & I. 137).

FIGURE 111



Radiology of the Temporomandibular Joint

Sclerosis, or a clearly seen band of radiopacity outlining the condylar head, is illustrated.

FIGURE 112

Radiology of the Temporomandibular Joint

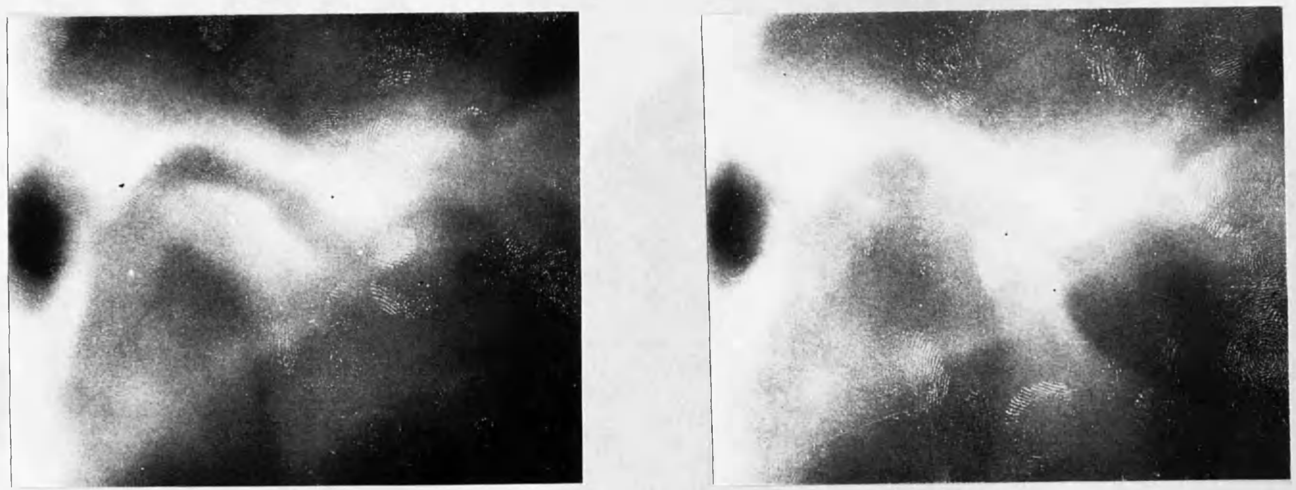
Surface erosions are seen on the superior aspect of this condyle. In addition its anterior aspect is flattened. This tomograph was taken with the mouth held as widely open as possible, i.e. mobility is reduced.

FIGURE 113

Radiology of the Temporomandibular Joint

Pocket erosions, especially marked on the anterior-superior surface of this condyle are evident.

FIGURE 114



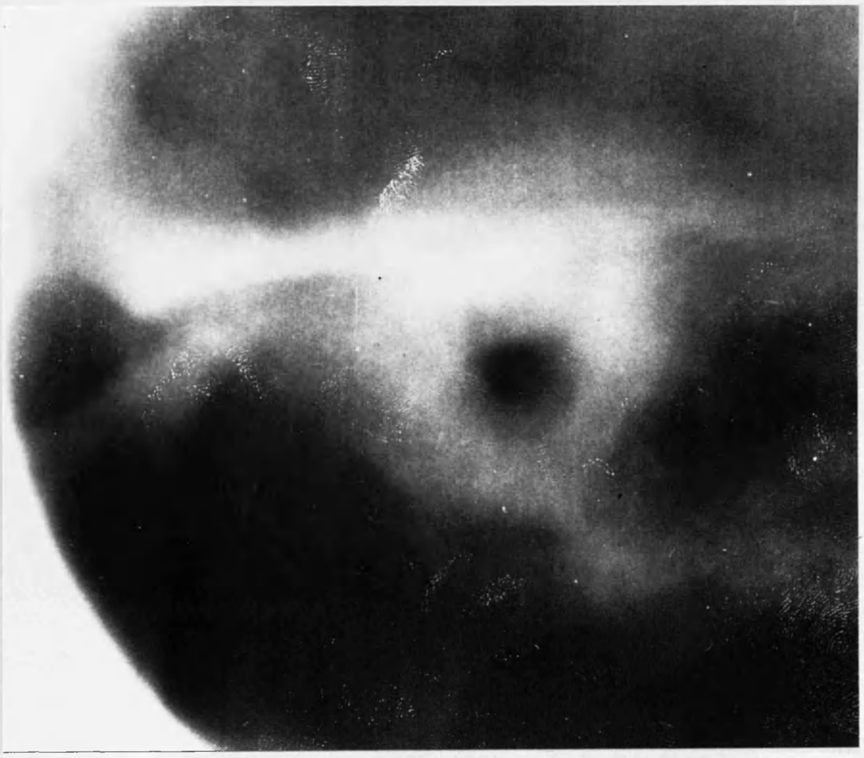
A B

<u>Radiology of the Temporomandibular Joint</u>

A. Closed Position. <u>Flattening of the condylar head</u> is noted.

B. Maximally open position. In addition to this flattening, the condylar head is seen to be behind the articular eminence. It lies less than 0.4 mm. in this direction, however, and so mobility was classified as normal.

FIGURE 115

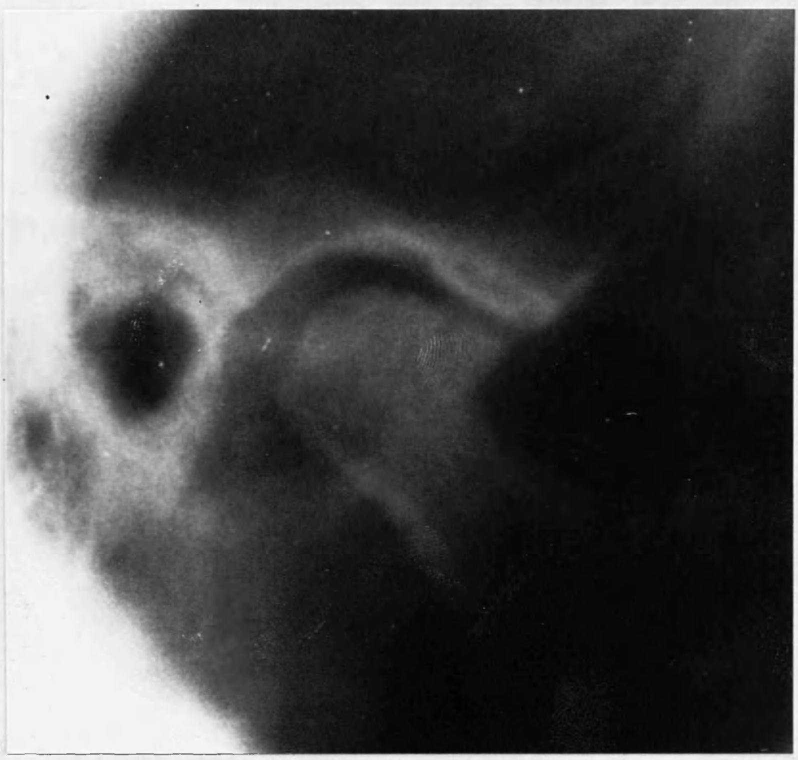


Radiology of the Temporomandibular Joint

The articular eminence and fossa are noticeably flattened

This radiograph was taken with the mouth closed and the teeth occluded yet the condyle remains well outwith the fossa, i.e. this is an example of subluxation in the closed position. The appearance of the condylar head seen in this illustration, a combination of erosion and flattening, is sometimes likened to a clarinet mouth-piece.

FIGURE 116



Radiology of the Temporomandibular Joint

Marginal Proliferation (Osteophyte)

In addition this condyle lies in antero-position.

FIGURE 117

Radiology of the Temporomandibular Joint

Subchondral Cyst

The radiolucency on the anterior border of this condyle has a characteristic radiographic cyst-like appearance.

FIGURE 118

Radiology of the Temporomandibular Joint

Calcified Articular Disc

The outline of the articular fossa and eminence is clearly outlined by a radiopaque border; below this can be clearly seen the more radiolucent, but undoubtedly calcified, form of the complete articular disc.

FIGURE 119

Radiology of the Temporomandibular Joint

Osteoporosis

This condition, if found alone even although as well-marked and radiolucent as is seen in this condyle, was not considered to be an abnormality.

FIGURE 120

Radiology of the Temporomandibular Joint

Deviation

One notable attribute of the orthopantomograph is to confirm deviation radiographically. Although the mobility of both condyles, in this case, is seen to be reduced, this abnormality is much more noticeable on the left side.

FIGURE 121

Radiology of the Temporomandibular Joint

Subluxation in the closed position is confirmed by the use of the orthopantomograph. Antero-position, gross flattening of the condyles and distortion of the body of the mandible close to the angles are other interesting features seen on this radiograph (cf. Figure 130) (T. & I. 170).

FIGURE 122

A

B

The Significance of Overbite

A. Patient photographed with teeth in normal occlusion

B. Blackening of lower anterior teeth records the depth of the overbite

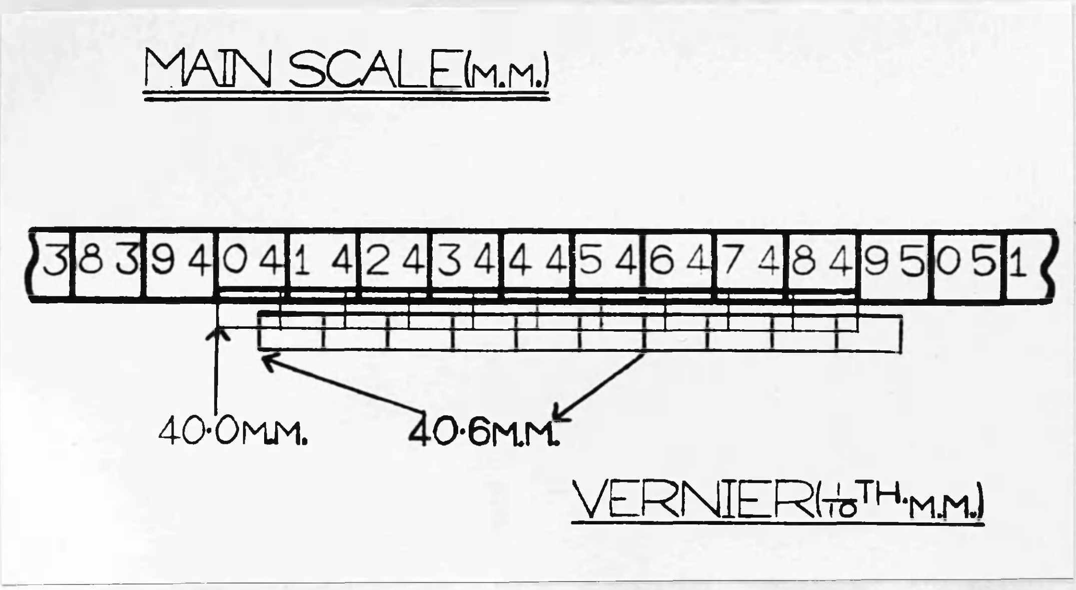
FIGURE 123

Measuring Maximal Opening Clinically

A vernier guage is used and the depth of overbite is included in the measurement.

FIGURE 124

A



B

The Vernier Guage

A. The complete instrument recording a measurement of 40.6 mm.

B. The principle of the vernier scale

FIGURE 125

"Normal" Radiological Opening

The condyle is seen to lie directly, or almost directly, below the articular eminence when the mouth is as widely opened as possible. This feature was used to help determine the lower limit of normal clinical opening.

FIGURE 126

Clinical Subluxation   Full face view

Marked recession of the chin is illustrated (cf. Figure 127)

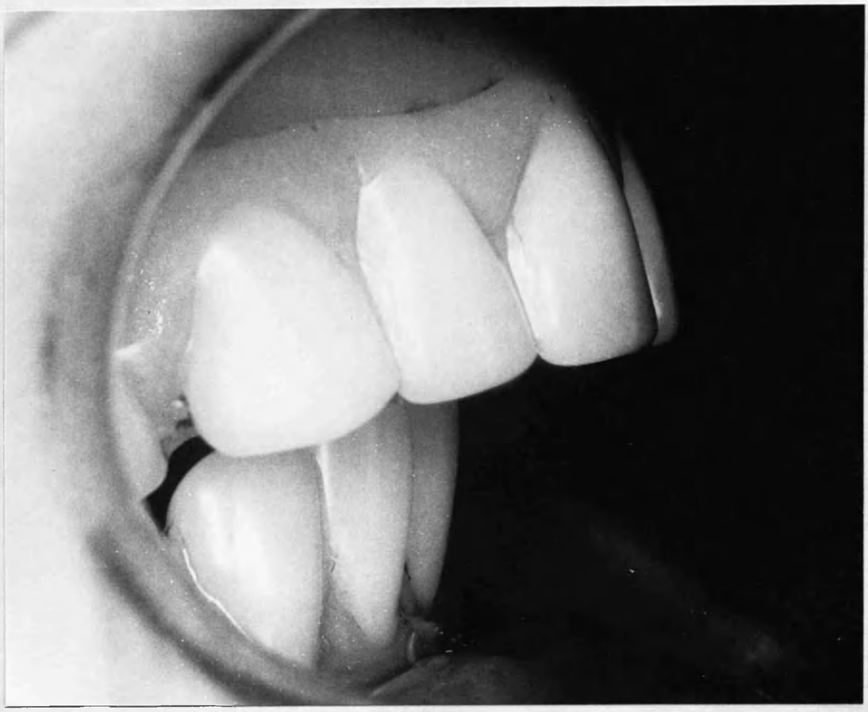
(T. & I. 155)

FIGURE 127

Clinical Subluxation   Lateral view

The marked recession of this lady's chin, which developed as a result of rheumatoid arthritis, may be better understood by reference to the radiographs reproduced in Figures 121 and 130 (T. & I. 149 & 170).

FIGURE 128



Clinical Subluxation   Intra-oral view

The very large overjet developed spontaneously during the course of this patient's disease.

FIGURE 129

Clinical Subluxation   Intra oral view

The provision of exactly made dentures is essential in such cases, if considerable mandibular dysfunction is to be avoided. Thereafter, regular review is necessary.

TABLE XXIX

Clinical comparison between control subjects and patients with osteoarthrosis

Clinical Feature	Control Group		Osteoarthrosis Group	
	Number	Percent	Number	Percent
Deviation	4	9.1	8	20.5
Range of opening less than 35 mm.	2	4.5	1	2.6
Stiffness	1	2.3	0	0
Crepitus	8	18.2	7	17.9
Audible click (subjective and objective)	3	6.8	4	10.3
Palpable click	4*	9.1	12*	30.8
Pain	1	2.3	2	5.1
Referred pain	2	4.5	2	5.1
Tenderness on biting	1	2.3	1	2.6
Tenderness on palpation	4	9.1	3	7.7
Swelling	0	0	0	0
Subluxation	0	0	0	0
Total number of patients with clinical abnormalities	14	31.8	18**	46.2

* Significant difference: $chi^2 = 6.24$, $p<0.02$

** Includes 5 patients with palpable click as the only abnormality

TABLE XXX

Radiological comparison between control subjects and patients with osteoarthrosis

Radiological Feature	Control Group		Osteoarthrosis Group	
	Number	Percent	Number	Percent
Anteroposition	11	13.9	10	13.7
Retroposition	22	27.8	23	31.5
Reduced inter-articular space	0	0	0	0
Reduced mobility	8	10.1	5	6.8
Subluxation (open and closed	2	2.5	6	8.2
Ankylosis	0	0	0	0
Sclerosis	0	0	0	0
Surface erosions	1	1.3	0	0
Pocket erosions	0	0	0	0
Flattening	9	11.4	8	11.0
Marginal proliferations	0	0	1	1.4
Subchondral cysts	4	5.1	3	4.1
Calcified disc	1	1.3	0	0
Osteoporosis	34	43.0	27	37.0
Total number of joints with radiological abnormalities	28	35.4	26	34.7

TABLE XXXI

Relationship between clinical and radiological status

Clinical Status	Radiological Status	Control Group		Osteoarthrosis Group	
		Number	Percent	Number	Percent
Abnormal	Abnormal	6	13.6	7	17.9
Abnormal	Normal	8	18.2	11	28.2
Normal	Abnormal	11	25.0	6	15.4
Normal	Normal	19	43.2	15	38.5

TABLE XXXII

Clinical Comparison between Combined Control Group Subjects and Patients with Rheumatoid Arthritis

Clinical Feature	Combined Control Group 95 Subjects 177 Joints		Rheumatoid Arthritis Patients 100 Patients 197 Joints		Statistical Analysis of Difference
	Number with Abnormalities	Per Cent	Number with Abnormalities	Per Cent	
Deviation	15	15.8	17	17.0	N.S.
Limitation of Opening	3	3.2	23	23.0	χ^2=16.59;p<0.0005
Stiffness	1	1.1	14	14.0	χ^2=11.50;p<0.001
Crepitus	17	17.9	40	40.0	χ^2=11.51;p<0.001
Audible Click (subjective and objective)	9	9.5	13	13.0	N.S.
Palpable Click	19	20.0	18	18.0	N.S.
Pain	4	4.2	8	8.0	N.S.
Referred Pain	5	5.3	14	14.0	χ^2=4.22;p<0.05
Tenderness on Biting	2	2.1	10	10.0	χ^2=5.25;p<0.05
Tenderness on Palpation	8	8.4	17	17.0	N.S.
Swelling	0	0	0	0	-*
Subluxation	0	0	3	3.0	-
Total number of subjects with clinical abnormalities	39	41.1	71	71.0	χ^2=17.76;p<0.0005

* = numbers too small for statistical analysis

TABLE XXXIII

Radiological comparison between combined control group subjects and patients with rheumatoid arthritis

Radiological Feature	Combined Control Group 95 Patients 177 Joints		Rheumatoid Arthritis Patients 100 Patients 197 Joints		Statistical Analysis of Difference
	Number with Abnormalities	Per Cent	Number with Abnormalities	Per Cent	
Anteroposition	22	12.6	45	22.8	$\chi^2=6.87; p<0.01$
Retroposition	49	28.0	41	20.8	N.S.
Reduced inter-articular space	0	0	1	0.5	-*
Reduced Mobility	15	8.6	53	26.9	$\chi^2=21.28; p<0.0005$
Subluxation (open and closed	9	5.1	13	6.6	N.S.
Ankylosis	0	0	0	0	-
Sclerosis	0	0	4	2.0	-
Surface erosions	1	0.6	34	17.3	$\chi^2=30.63; p<0.0005$
Pocket erosions	0	0	10	5.1	$\chi^2=9.23; p<0.005$
Erosions - total	1	0.6	44	22.3	$\chi^2=41.74; p<0.0005$
Flattening	17	9.7	79	40.1	$\chi^2=45.45; p<0.0005$
Marginal Proliferations	1	0.6	11	5.6	$\chi^2=7.56; p<0.01$
Subchondral cysts	7	4.0	8	4.1	N.S.
Calcified Disc	1	0.6	1	0.5	-
Osteoporosis	67	38.3	83	42.1	N.S.
Total Number of Joints with Radiological Abnormalities	60	33.9	155	78.7	$\chi^2=76.50; p<0.0005$

* = numbers too small for statistical analysis

TABLE XXXIV

Relationship between Clinical and Radiological Status

Clinical Status	Radiological Status	Combined Control Group		Rheumatoid Arthritis Patients	
		Number	Percent	Number	Percent
Abnormal	Abnormal	15	15.8	63	63.0
Abnormal	Normal	24	25.3	8	8.0
Normal	Abnormal	18	18.9	16	16.0
Normal	Normal	38	40.0	13	13.0

TABLE XXXV

Comparison between Female and Male Patients

	Clinical or Radiological Feature	Per Cent of Female Patients 77 Patients 151 Joints	Per Cent of Male Patients 23 Patients 46 Joints	Statistical Analysis of Difference
CLINICAL	Deviation	16.9	17.4	N.S.
	Limitation of Opening	27.3	8.7	N.S.
	Stiffness	15.6	8.7	N.S.
	Crepitus	40.3	39.1	N.S.
	Audible Click	14.3	8.7	N.S.
	Palpable Click	19.5	13.0	N.S.
	Pain	9.1	4.3	N.S.
	Referred Pain	18.2	0	$\chi^2=4.86; p<0.05$
	Tenderness on Biting	11.7	4.3	N.S.
	Tenderness on Palpation	19.5	8.7	N.S.
	Total Number of Patients with Clinical Abnormalities	73.1	65.2	N.S.
RADIOLOGICAL	Anteroposition	20.5	30.4	N.S.
	Retroposition	22.5	15.2	N.S.
	Reduced Mobility	28.5	21.7	N.S.
	Subluxation	8.6	0	$\chi^2=4.24; p<0.05$
	Erosions	22.5	21.7	N.S.
	Flattening	43.0	30.4	N.S.
	Marginal Proliferations	5.3	6.5	N.S.
	Subchondral cysts	4.6	2.2	N.S.
	Osteoporosis	45.0	32.6	N.S.
	Total Number of Joints with Radiological Abnormalities	82.8	65.2	$\chi^2=6.48; p<0.01$

TABLE XXXVI

Comparison between Patients with Early and Late Age of Onset

	Clinical or Radiological Feature	Per Cent of Patients with Onset up to Age 40 years 40 Patients 77 Joints	Per Cent of Patients with Onset After Age 40 years 60 Patients 120 Joints	Statistical Analysis of Difference
CLINICAL	Deviation	17.5	16.7	N.S.
	Limitation of Opening	22.5	23.3	N.S.
	Stiffness	15.0	13.3	N.S.
	Crepitus	37.5	41.7	N.S.
	Audible Click	17.5	10.0	N.S.
	Palpable Click	22.5	15.0	N.S.
	Pain	10.0	6.7	N.S.
	Referred Pain	17.5	11.7	N.S.
	Tenderness on Biting	12.5	8.3	N.S.
	Tenderness on Palpation	15.0	18.3	N.S.
	Total Number of Patients with Clinical Abnormalities	67.5	73.3	N.S.
RADIOLOGICAL	Anteroposition	20.8	24.2	N.S.
	Retroposition	18.2	22.5	N.S.
	Reduced Mobility	28.6	25.8	N.S.
	Subluxation	10.4	4.2	N.S.
	Erosions	26.0	20.0	N.S.
	Flattening	45.5	36.7	N.S.
	Marginal Proliferations	0	9.2	$\chi^2=7.48; p<0.01$
	Subchondral cysts	2.6	5.0	N.S.
	Osteoporosis	40.3	43.3	N.S.
	Total Number of Joints with Radiological Abnormalities	81.8	76.7	N.S.

TABLE XXXVII

Comparison between Patients with Disease of Short and Long Duration

	Clinical or Radiological Feature	Per Cent of Patients with Disease of up to 10 Years' Duration 67 Patients 133 Joints	Per Cent of Patients with Disease of More Than 10 Years' Duration 33 Patients 64 Joints	Statistical Analysis of Difference
CLINICAL	Deviation	16.4	18.2	N.S.
	Limitation of Opening	23.9	21.2	N.S.
	Stiffness	14.9	12.1	N.S.
	Crepitus	35.8	48.5	N.S.
	Audible Click	11.9	15.2	N.S.
	Palpable Click	13.4	27.3	N.S.
	Pain	7.5	9.1	N.S.
	Referred Pain	11.9	18.2	N.S.
	Tenderness on Biting	9.0	12.1	N.S.
	Tenderness on Palpation	14.9	21.2	N.S.
	Total Number of Patients with Clinical Abnormalities	68.7	75.8	N.S.
RADIOLOGICAL	Anteroposition	19.5	29.7	N.S.
	Retroposition	28.6	4.7	$\chi^2=14.96; p<0.0005$
	Reduced Mobility	27.1	26.6	N.S.
	Subluxation	4.5	10.9	N.S.
	Erosions	21.1	25.0	N.S.
	Flattening	34.6	51.6	$\chi^2=5.18; p<0.05$
	Marginal Proliferations	3.0	10.9	$\chi^2=5.15; p<0.05$
	Subchondral cysts	3.8	4.7	N.S.
	Osteoporosis	41.4	43.8	N.S.
	Total Number of Joints with Radiological Abnormalities	69.9	96.9	$\chi^2=18.71; p<0.0005$

TABLE XXXVIII

Comparison between Patients of Functional Classes 1 and 2 with those of Functional Classes 3 and 4

	Clinical or Radiological Feature	Per Cent with Abnormal Feature: Classes 1 and 2, 53 Patients, 104 Joints	Per Cent with Abnormal Feature: Classes 3 and 4, 47 Patients, 93 Joints	Statistical Analysis of Difference
CLINICAL	Deviation	18.9	14.9	N.S.
	Limitation of Opening	13.2	34.0	$\chi^2=6.11; p<0.02$
	Stiffness	13.2	14.9	N.S.
	Crepitus	35.8	44.7	N.S.
	Audible Click	18.9	6.4	N.S.
	Palpable Click	26.4	8.5	$\chi^2=5.41; p<0.02$
	Pain	3.8	12.8	N.S.
	Referred Pain	13.2	14.9	N.S.
	Tenderness on Biting	5.7	14.9	N.S.
	Tenderness on Palpation	13.2	21.3	N.S.
	Total Number of Patients with Clinical Abnormalities	66.0	76.6	N.S.
RADIOLOGICAL	Anteroposition	17.3	29.0	N.S.
	Retroposition	20.2	21.5	N.S.
	Reduced Mobility	18.3	36.6	$\chi^2=8.35; p<0.005$
	Subluxation	8.7	4.3	N.S.
	Erosions	15.4	30.1	$\chi^2=6.14; p<0.02$
	Flattening	28.8	52.7	$\chi^2=11.62; p<0.001$
	Marginal Proliferations	5.8	5.4	N.S.
	Subchondral Cysts	3.8	4.3	N.S.
	Osteoporosis	42.3	41.9	N.S.
	Total Number of Joints with Radiological Abnormalities	73.1	84.9	$\chi^2=4.12; p<0.05$

TABLE XXXIX

Comparison between Patients with Low and with High Articular Indices

	Clinical or Radiological Feature	Per Cent with Abnormal Feature		Statistical Analysis of Difference
		Articular Index 0-20 54 Patients 105 Joints	Articular Index 21+ 41 Patients 82 Joints	
CLINICAL	Deviation	18.5	12.2	N.S.
	Limitation of Opening	16.7	31.7	N.S.
	Stiffness	7.4	24.4	$\chi^2=5.35; p<0.05$
	Crepitus	40.7	36.6	N.S.
	Audible Click	18.5	4.9	$\chi^2=3.92; p<0.05$
	Palpable Click	18.5	17.1	N.S.
	Pain	1.9	17.1	$\chi^2=7.00; p<0.01$
	Referred Pain	11.1	22.0	N.S.
	Tenderness on Biting	3.7	19.5	$\chi^2=6.18; p<0.02$
	Tenderness on Palpation	7.4	31.7	$\chi^2=9.37; p<0.005$
	Total Number of Patients with Clinical Abnormalities	68.5	70.7	N.S.
RADIOLOGICAL	Anteroposition	19.0	25.6	N.S.
	Retroposition	26.7	15.9	N.S.
	Reduced Mobility	27.6	25.6	N.S.
	Subluxation	6.7	6.1	N.S.
	Erosions	19.0	25.6	N.S.
	Flattening	34.3	46.3	N.S.
	Marginal Proliferations	6.7	3.7	N.S.
	Subchondral Cysts	3.8	4.9	N.S.
	Osteoporosis	38.1	52.4	N.S.
	Total Number of Joints with Radiological Abnormalities	77.1	80.5	N.S.

TABLE XL

Comparison between Seropositive and Seronegative Patients

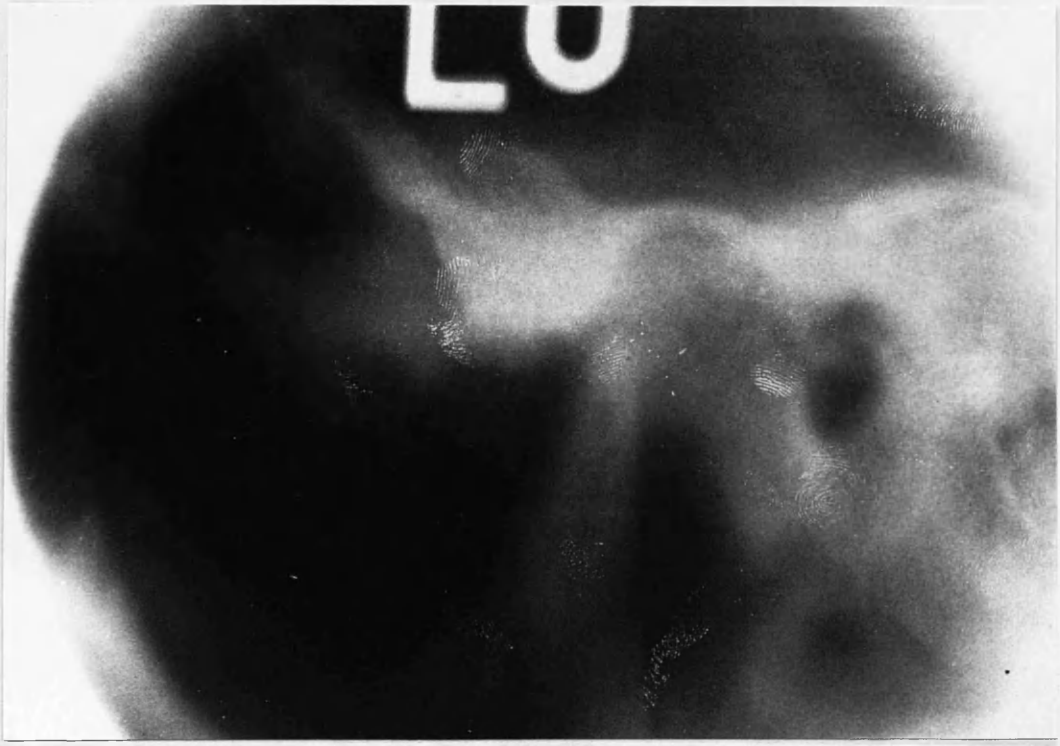
	Clinical or Radiological Feature	Per Cent with Abnormal Feature: Seropositive 72 Patients 142 Joints	Per Cent with Abnormal Feature: Seronegative 28 Patients 55 Joints	Statistical Analysis of Difference
CLINICAL	Deviation	18.1	14.3	N.S.
	Limitation of Opening	29.2	7.1	$\chi^2=5.52; p<0.02$
	Stiffness	15.3	10.7	N.S.
	Crepitus	40.3	39.3	N.S.
	Audible Click	13.9	10.7	N.S.
	Palpable Click	18.1	17.9	N.S.
	Pain	9.7	3.6	N.S.
	Referred Pain	13.9	14.3	N.S.
	Tenderness on Biting	9.7	10.7	N.S.
	Tenderness on Palpation	18.1	14.3	N.S.
	Total Number of Patients with Clinical Abnormalities	73.6	64.3	N.S.
RADIOLOGICAL	Anteroposition	20.4	29.1	N.S.
	Retroposition	23.2	14.5	N.S.
	Reduced Mobility	27.5	25.5	N.S.
	Subluxation	5.6	9.1	N.S.
	Erosions	23.2	20.0	N.S.
	Flattening	42.3	34.6	N.S.
	Marginal Proliferations	7.0	1.8	N.S.
	Subchondral Cysts	5.6	0	N.S.
	Osteoporosis	41.5	43.6	N.S.
	Total Number of Joints with Radiological Abnormalities	83.1	67.3	$\chi^2=5.92; p<0.02$

FIGURE 130

Dental treatment as part of rheumatic therapy

The gross destruction of both temporomandibular joints and the distorted body of the mandible were manifestations of severe rheumatoid arthritis of long duration (cf. Figure 130) (T. & I. 170). The provision of accurately made dentures proved beneficial in this patient's treatment.

FIGURE 131



Rheumatoid arthritis presenting dentally

This patient sought treatment from his dentist for painful temporomandibular joints. Radiographs revealed reduced mobility and a "clarinet mouth-piece" condyle. The significance of these appearances was understood and the patient afforded general as well as dental treatment.

FIGURE 132

Dental Periapical Radiography

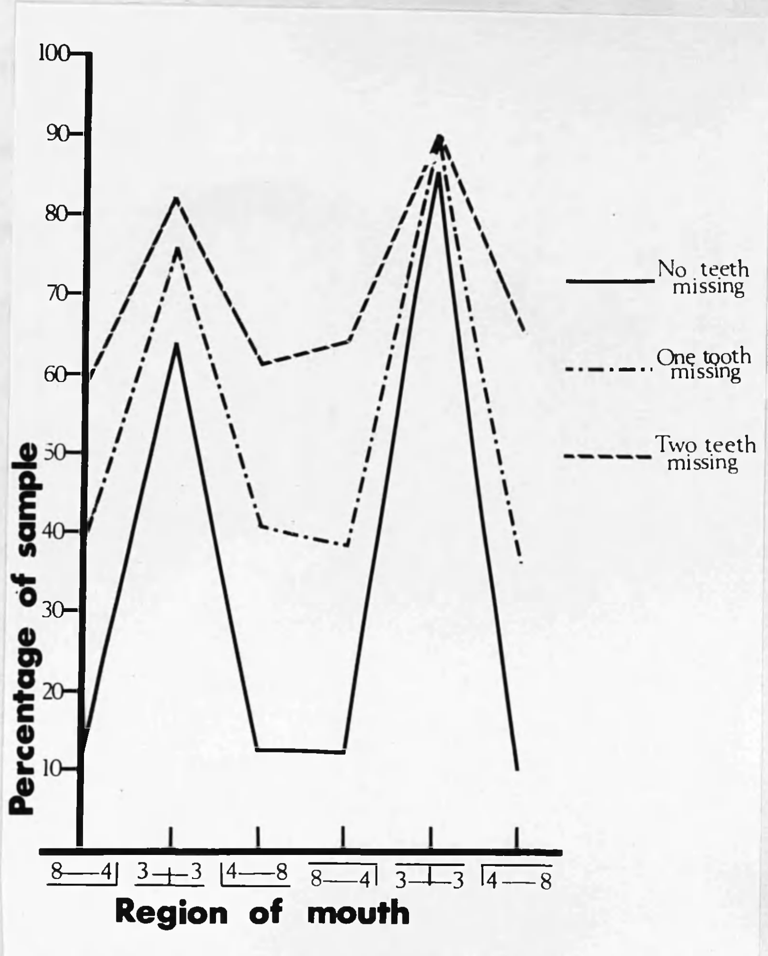
The Paralleling Technique in use to radiograph the lower incisor teeth.

FIGURE 133

Dental Periapical Radiography

Typical radiographs of the lower anterior teeth obtained using the Paralleling Technique.

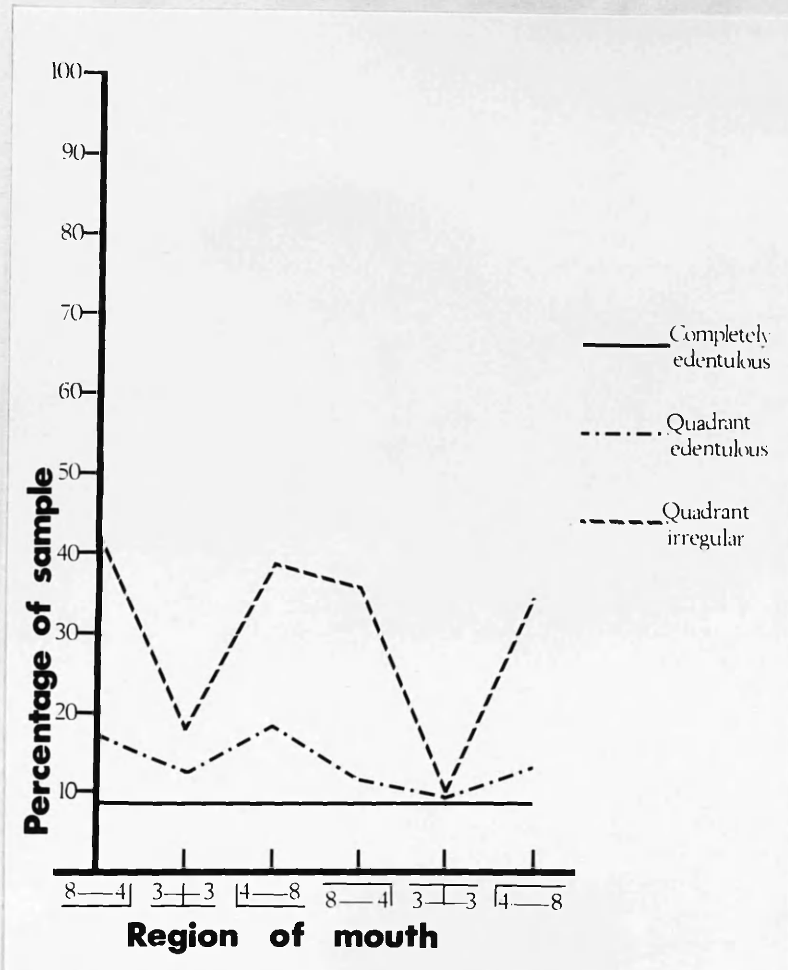
FIGURE 134



Percentage of teeth present in various parts of the mouth

An independent survey revealed that markedly fewer teeth had been lost from the lower anterior region of the mouths of a sample of patients attending Glasgow Dental Hospital and School than from other areas of their mouths.

FIGURE 135



<u>A comparison of the percentages of patients who were edentulous in different regions of the mouth</u>

If the totally edentulous patients are excluded it can be seen that very few of the sample of patients studied in Figure 134 (T. & I. 174) were edentulous in the lower anterior region. Furthermore, very few more had more than two teeth missing from that area of the mouth.

TABLE XLI

The ages at which edentulous patients lost their natural teeth and their present denture requirements

	CONTROL GROUP	OSTEOARTHROTIC GROUP
Number totally edentulous	31 (70.4%)	25 (64.1%)
Age became edentulous		
Range in years	16 to 75	20 to 61
Mean (S.E.M.)	44.2 (±2.6)	42.3 (±2.1)
15 yrs to 30 yrs	5 (16.1%)	3 (12.0%)
>30 yrs to 50 yrs	17 (54.8%)	15 (60.0%)
>50 yrs	9 (29.1%)	7 (28.0%)
Assessment of complete dentures		
First Class	4 (14.8%)(12.9%)	3 (12.0%)
Still Some Use	14 (51.9%)(45.1%)	11 (44.0%)
Need to be Replaced	9 (33.3%)(29.1%)	11 (44.0%)
Dentures missing	2^{c}/c; 2^{-}/c(12.9%)	0

TABLE XLII

The condition of those mouths containing natural teeth

	CONTROL GROUP	OSTEOARTHROTIC GROUP
Number with natural teeth	13 (29.6%)	14 (35.9%)
D.M.F.		
Range (Mean)	10 to 28 (22.3)	15 to 32 (23.6)
0 to 16	2	1
17 to 24	5	6
25 to 32	6	7
D.M.F.S.		
Range (Mean)	35 to 130 (91.0)	58 to 136 (96.9)
0 to 50	2	0
51 to 100	3	8
101 to 148	8	6
Oral Hygiene Index		
Range (Mean)	3.2 to 12.0 (6.8)	2.0 to 8.0 (5.5)
0.0 to 3.0	0	2
$>$3.0 to 6.0	6	6
$>$6.0	7	6
Russell Index		
Range (Mean)	0.64 to 2.8 (1.85)	0.7 to 3.8 (1.65)
0.0 to 1.0	2	3
$>$1.0 to 2.0	8	9
$>$2.0 to 4.0	3	2
$>$4.0	0	0
Calculus		
Range (Mean)	0.0 to 2.7 (1.1)	0.0 to 3.0 (0.72)
0.0 to 1.0	8	10
$>$1.0 to 2.0	4	3
$>$ 2.0	1	1
Dentures	$3^{c}/-$; $1^{p}/-$;	$1^{c}/p$;$3^{c}/-$;$2^{p}/p$;$2^{p}/-$;
Assessment of dentures		
First class		$1^{c}/-$;
Still Some Use	$1^{c}/-$;	$1^{c}/p$; $1^{p}/p$;$2^{p}/-$;
Need to be Replaced	$2^{c}/-$; $1^{p}/-$;	$2^{c}/-$;$1^{p}/p$;
Dentures required	$2^{c}/-$;$5^{p}/p$; $4^{-}/p$;	$2^{p}/p$;$1^{p}/-$;$6^{-}/p$

TABLE XLIII

An analysis of the ages of the various dentures being worn at the time of examination

	CONTROL GROUP			OSTEOARTHROTIC GROUP		
Age of all dentures						
Range in years	0.2 to 35.0			0.3 to 34.0		
Mean (S.E.M.)	11.9 (± 1.6)			9.2 (± 1.3)		
0 yrs to 5 yrs	11 (33.3%)	20	11	13 (39.4%)	23	13
>5 yrs to 10 yrs	9 (27.3%)			10 (30.4%)		
>10 yrs to 15 yrs	1 (3.0%)			6 (18.2%)		
>15 yrs to 20 yrs	5 (15.2%)	13	22	2 (6.0%)	10	20
>20 yrs	7 (21.2%)			2 (6.0%)		
Age of complete ($^c/c$) dentures						
Range in years	1.0 to 30.0			2.5 to 34.0		
Mean (S.E.M.)	10.1 (± 1.6)			10.3 (± 1.6)		
0 yrs to 5 yrs	11 (40.7)	19	11	8 (32.0%)	16	8
>5 yrs to 10 yrs	8 (29.6%)			8 (32.0%)		
>10 yrs to 15 yrs	1 (3.7%)			4 (16.0%)		
>15 yrs to 20 yrs	2 (7.4%)	8	16	3 (12.0%)	9	17
>20 yrs	5 (18.6%)			2 (8.0%)		

TABLE XLIV

Assessment of the occlusion of all patients

Occlusion	CONTROL GROUP			OSTEOARTHROTIC GROUP		
	All patients	Edentulous	Dentate	All patients	Edentulous	Dentate
Excellent	3	2	1	3	3	0
Good	17	14	3	16	13	3
Fair	9	8	1	4	1	3
Poor	3	2	1	7	6	1
Very Poor	12	5	7	9	2	7

TABLE XLV

Summary of the varied and various treatment requirements

	CONTROL GROUP	OSTEOARTHROTIC GROUP
Conservative and/or periodontal	11 (of 13) 84.6%	13 (of 14) 92.9%
Extractions	5 (of 13) 38.5%	5 (of 14) 35.7%
Partial dentures	11 (of 13) 84.6%	10 (of 14) 71.4%
Total, with natural teeth, needing treatment	13 (of 13) 100%	14 (of 14) 100%
Full dentures	13 (of 31) 41.9%	11 (of 25) 44.0%
Total needing treatment	26 (of 44) 59.1%	25 (of 39) 64.1%

TABLE XLVI

The ages at which edentulous patients lost their natural teeth and their present denture requirements

	COMBINED CONTROL GROUP	RHEUMATOID ARTHRITIC GROUP
Number totally edentulous	59 (62.1%)	59 (63.4%
Age became edentulous		
Range in years	16 to 75	17 to 64
Mean (S.E.M.)	42.8($\pm$1.7)	33.2($\pm$1.3)
15 yrs to 30 yrs	10 (16.9%)	22 (37.3%)
>30 yrs to 50 yrs	33 (55.9%)	34 (57.6%)
>50 yrs	16 (27.2%)	3 (5.1%)
Assessment of complete dentures		
First Class	8 (15.1%) (13.5%)	9 (18.4%) (15.3%)
Still Some Use	25 (27.2%) (42.4%)	18 (36.7%) (30.5%)
Need to be Replaced	20 (37.7%) (33.9%)	22 (44.9%) (37.3%)
Dentures missing	3^{c}/c; 3^{-}/c (10.2%)	3^{c}/c; 7^{-}/c (16.9%)

TABLE XLVII

The condition of those mouths containing natural teeth

	COMBINED CONTROL GROUP	RHEUMATOID ARTHRITIC GROUP
Number with natural teeth	36 (37.9%)	34 (36.6%)
D.M.F.		
Range (Mean)	10 to 32 (21.7)	6 to 32 (22.1)
0 to 16	6	7
17 to 24	14	16
25 to 32	16	11
D.M.F.S.		
Range (Mean)	31 to 136 (83.2)	27 to 140 (83.9)
0 to 50	5	4
51 to 100	14	19
101 to 148	17	11
Oral Hygiene Index		
Range (Mean)	0.0 to 12.0 (5.8)	3.5 to 8.7 (6.4)
0.0 to 3.0	5	0
> 3.0 to 6.0	14	14
> 6.0	17	20
Russell Index		
Range (Mean)	0.0 to 3.8 (1.55)	0.26 to 6.0 (1.55)
0.0 to 1.0	9	9
> 1.0 to 2.0	22	21
> 2.0 to 4.0	5	3
> 4.0	0	1
Calculus		
Range (Mean)	0.0 to 3.0 (0.86)	0.0 to 2.0 (0.68)
0.0 to 1.0	26	22
> 1.0 to 2.0	7	12
> 2.0	3	0
Dentures	$1^{c}/p;8^{c}/-;2^{p}/p;3^{p}/-;$	$1^{c}/p;6^{c}/-;1^{p}/p;9^{p}/-;1^{-}/p$
Assessment of dentures		
First class	$1^{c}/-;$	$1^{c}/p;$ $2^{p}/-;$
Still Some Use	$1^{c}/p;1^{c}/-;1^{p}/p;2^{p}/-;$	$5^{p}/-;1^{-}/p$
Need to be Replaced	$6^{c}/-;1^{p}/p;1^{p}/-;$	$6^{c}/-;1^{p}/p;2^{p}/-;$
Dentures required	$3^{c}/-;10^{p}/p;2^{p}/-;12^{-}/p$	$2^{c}/-;2^{p}/p;1^{p}/-;12^{-}/p$

TABLE XLVIII

An analysis of the ages of the various dentures being worn at the time of examination

	COMBINED CONTROL GROUP			RHEUMATOID ARTHRITIC GROUP		
Age of all dentures						
Range in years	0.2 to 35.0			0.1 to 31.0		
Mean (S.E.M.)	10.2 (± 1.0)			9.2 (± 0.9)		
0 yrs to 5 yrs	25 (35.7%)	46	25	26 (35.1%)	50	26
> 5 yrs to 10 yrs	21 (30.0%)			24 (32.4%)		
> 10 yrs to 15 yrs	7 (10.0%)		45	11 (14.9%)		48
> 15 yrs to 20 yrs	8 (11.4%)	24		6 (8.1%)	24	
> 20 yrs	9 (;2.9%)			7 (9.5%)		
Age of complete (^{c}/c) dentures						
Range in years	1.0 to 34.0			0.1 to 31.0		
Mean (S.E.M.)	10.0 (± 1.1)			9.3 (± 1.1)		
0 yrs to 5 yrs	20 (37.7%)	36	20	17 (34.7%)	33	17
> 5 yrs to 10 yrs	16 (30.2%)			16 (32.6%)		
> 10 yrs to 15 yrs	5 (9.4%)		33	7 (14.3%)		32
> 15 yrs to 20 yrs	5 (9.4%)	17		5 (10.2%)	16	
> 20 yrs	7 (13.3%)			4 (8.2%)		

TABLE XLIX

Assessment of the occlusion of all patients

Occlusion	COMBINED CONTROL GROUP			RHEUMATOID ARTHRITIC GROUP		
	All patients	Edentulous	Dentate	All patients	Edentulous	Dentate
Excellent	8	6	2	13	7	6
Good	35	27	8	28	22	6
Fair	15	9	6	21	11	10
Poor	12	8	4	8	2	6
Very Poor	25	9	16	23	16	6

TABLE L

Summary of the varied and various treatment requirements

	COMBINED CONTROL GROUP	RHEUMATOID ARTHRITIC GROUP
Conservative and/or periodontal	31 (of 36) 86.1%	33 (of 34) 97.1%
Extractions	11 (of 36) 30.6%	11 (of 34) 32.4%
Partial dentures	28 (of 36) 77.8%	18 (of 34) 52.9%
Total, with natural teeth, needing treatment	35 (of 36) 97.2%	34 (of 34) 100%
Full dentures	26 (of 59) 44.1%	32 (of 59) 54.2%
Total needing treatment	61 (of 95) 64.2%	66 (of 93) 70.9%

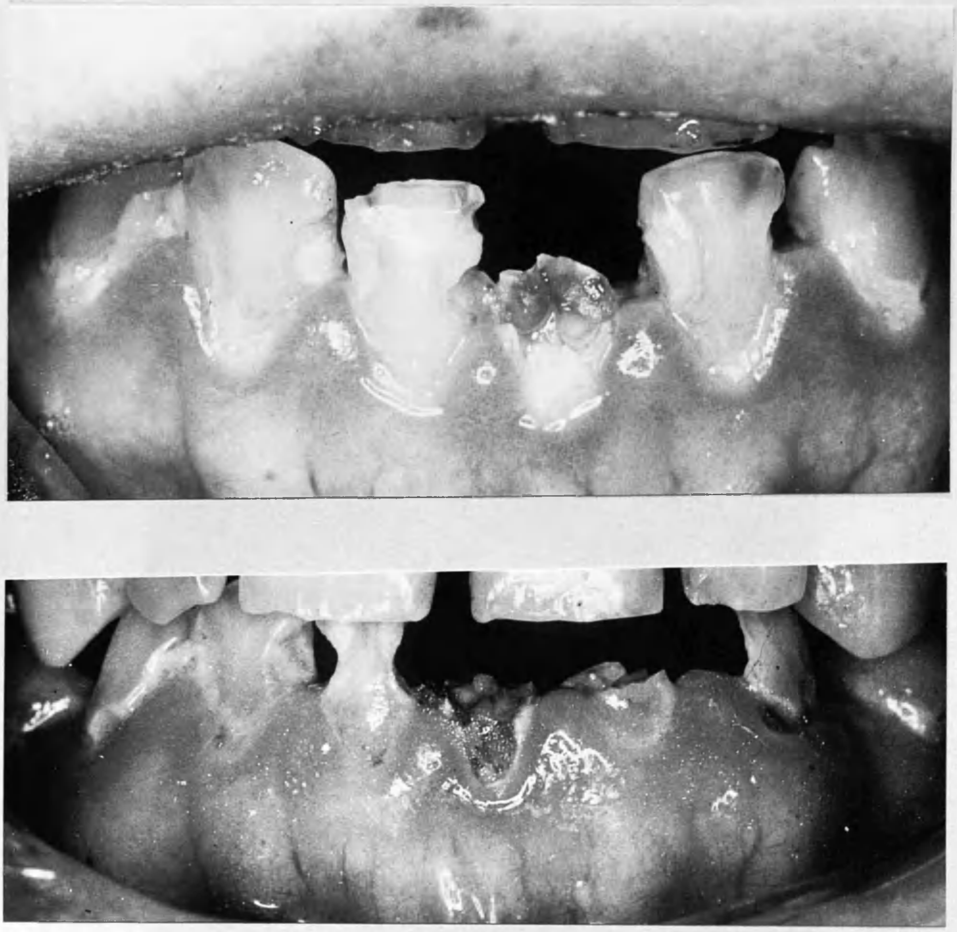
TABLE LI

The deterioration in the dental and oral health of a patient with Sjøgren's syndrome is compared with the maintenance of this health by two control subjects similar in all other respects to the patient with connective tissue disease

	PATIENT WITH SJØGREN'S SYNDROME			CONTROL PATIENTS				
				1 (Aged 19 yrs)			2 (Aged 28 yrs)	
Date	25-9-70	19-2-71	14-9-71	3-2-70	2-2-71	5-4-72	10-3-70	8-9-71
D.M.F.	27	29	32	14	16	16	25	25
D.M.F.S.	68	76	119	38	42	42	71	72
Oral Hygiene Index	8.0	10.0	7.0	6.3	6.0	6.7	7.0	7.3
Russell Index	1.4	2.0	1.5	0.4	0.6	0.4	0.4	0.4
Calculus	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0
Tongue and oral Mucosa	Healthy and wet	Very dry	Inflamed and wet	Healthy and wet	Healthy and wet	Healthy and wet	Healthy and wet	Healthy and wet
Occlusion	Excellent	Excellent	Good	Excellent	Excellent	Excellent	Excellent	Excellent

The photographs shown on the following page (Figure 136) were taken on the occasions of the second and third dental examinations of this patient with Sjogren's Syndrome.

FIGURE 136



A

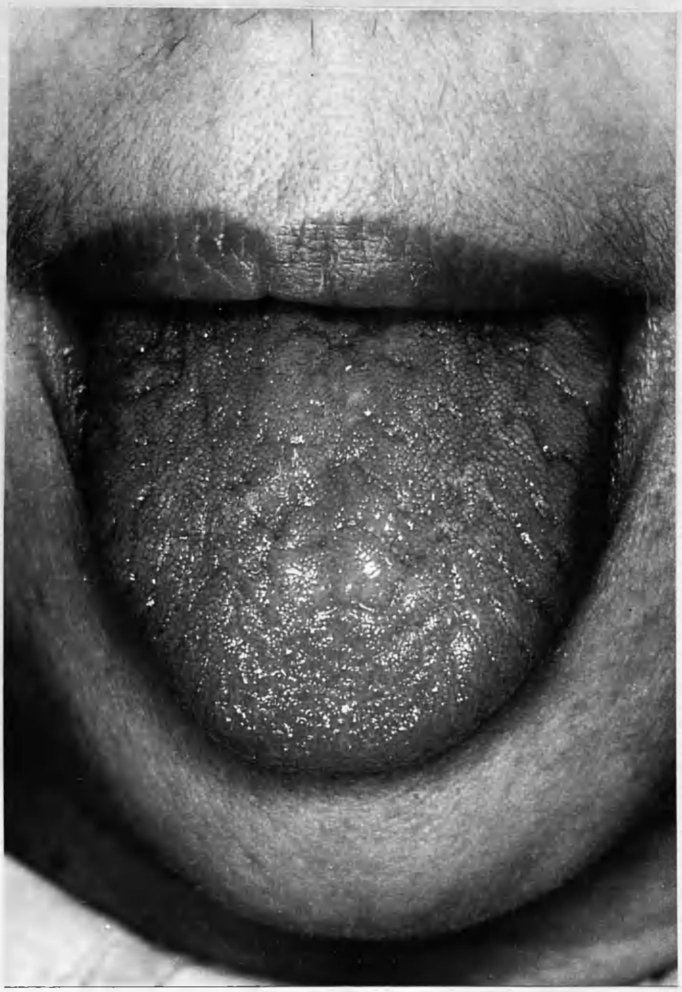
B

Sjǿgren's Syndrome

The deterioration in the condition of the lower anterior teeth of a girl with Sjǿgren's syndrome over a period of seven months is shown.

A. First Examination B. Second examination

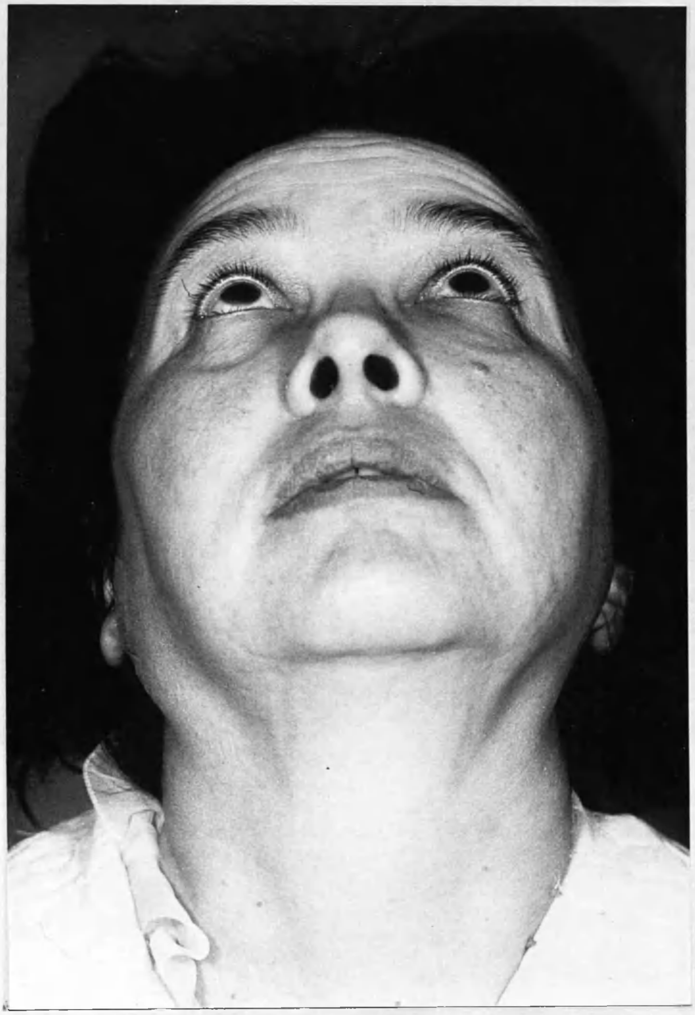
FIGURE 137



Sjøgren's Syndrome

Characteristic dry fissured appearance of the tongue seen in more severe cases of this condition.

FIGURE 138



Sjøgren's Syndrome

Bilateral swelling of the parotid glands.

FIGURE 139

Hands of Rheumatoid Arthritis

The crippling deformities of this disease make it much more difficult to maintain good oral hygeine.

TABLE LII

Abnormalities of the parotid gland and of the temporomandibular joints incidentally detected during the course of this study in patients suffering from psoriatic arthritis

A. The Parotid Glands

Number of Patients	Mean Age (Years)	Sex	Number of Normal Sialograms	Number of Abnormal Sialograms	Abnormalities: Punctate Sialectasis	Abnormalities: Atrophy	Abnormalities: Main Duct Dilatation
29	43.8	24F-5M	26	3(10.3%)	2	1	2

B. The Temporomandibular Joints

Number of Patients	Sex	Age Range (Mean) (Years)	Number of Joints
7	4F-3M	43 to 67 (52.3)	14

Clinical Feature	Number of Patients Affected	Radiological Feature	Number of Joints Involved
Limitation of opening	1	Antero-position	6
Referred Pain	1	Retro-position	2
Tenderness	1	Reduced Mobility	1
		Subluxation	2
Deviation	4	Surface Erosions	2
Palpable Click	3	Flattening	3
Audible Click	1	Calcified Disc	1
		Osteoporosis	5
Total Normal	2	Total Normal*	9
Total Abnormal	5	Total Abnormal	5

* Antero-position, retro-position, increased mobility and osteoporosis were not considered abnormalities in the overall findings.

TABLE LIII

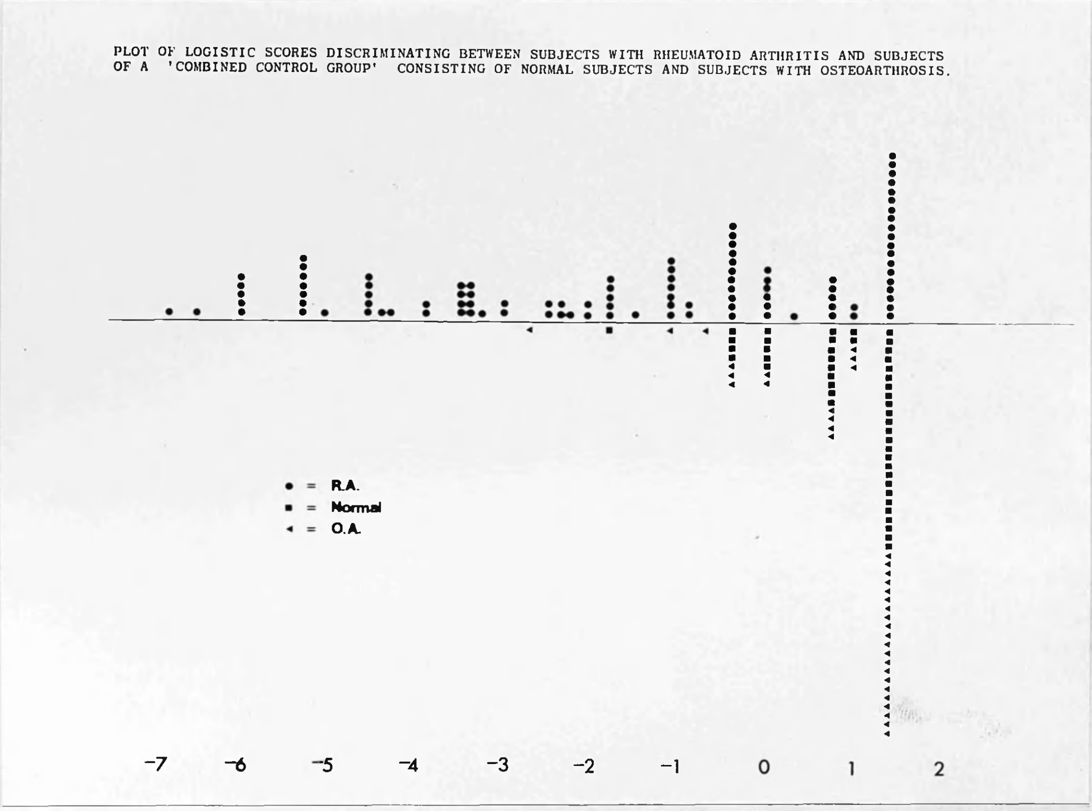
Abnormalities in either or both temporomandibular joints

		Normal Patients	Patients with Osteoarthrosis	Combined Control Group	Patients with Rheumatoid Arthritis
1	Antero-position*	9	6	15	34
2	Retro-position	15	16	31	31
3	Reduced Inter-articular space	0	0	0	1
4	Reduced Mobility**	6	3	9	34
5	Subluxation: Open*	0	1	1	8
6	Subluxation: Closed	2	3	5	4
7	Sclerosis*	0	0	0	3
8	Surface Erosions**	0	0	0	27
9	Pocket Erosions**	0	0	0	10
10	Flattening**	6	5	11	53
11	Subchondral cysts	2	1	3	7
12	Marginal Proliferations*	0	1	1	9
13	Calcified Articular disc	1	0	1	0
	Number of patients in group	47	36	83	99

* Difference between Combined Control Group and Patients with Rheumatoid Arthritis significant at 5% (i.e. $p < 0.05$).

** Difference between Combined Control Group and Patients with Rheumatoid Arthritis significant at 1% (i.e. $p < 0.01$).

FIGURE 140



Differentiation of patients with and without rheumatoid arthritis as a result of studying the radiographs of their respective temporomandibular joints