The Use of Scintigraphy in the Diagnosis of Bone Spavin

by

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"Al meu avi".

Declaration

I, ALEXANDRE FONT , do hereby declare that the work carried out in this thesis is original, was carried out by myself or with due acknowledgement, and has not been presented for the award of a degree at any other University.

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Summary

Bone Spavin (Degenerative Joint Disease of the distal tarsal joints) is a well-known cause of hindlimb lameness in the horse. The diagnosis of this condition is usually achieved by clinical examination, selective analgesia of the hindlimb (including intra-articular anaesthesia of the intertarsal and tarsometararsal joints), and radiography. While the diagnosis of the condition poses no problem in advanced cases, the early stages can escape diagnosis by conventional means. In some cases clinical symptoms can be present for a long time before radiographic changes develop; in other cases, a mild bilateral spavin can present disguised as a back problem.

Gamma-Scintigraphy has been successfully used to investigate osteoarthritis both in Human and Veterinary Medicine. The technique has proven to be an extremely sensitive indicator of joint abnormalities, and because it relays on the metabolical activity and vascularity of bone rather than gross physical changes, it has advantages over radiography in the early detection of bone remodelling.

In the present study, the clinical, radiographic and scintigraphic findings of 17 horses admitted for lameness examination to the Equine Hospital of the University of Glasgow Veterinary School, and in which a diagnosis of Bone Spavin was made are reported. Post-mortem and pathology findings are reported in one case. Bone and Soft Tissue Scintigraphy are compared with conventional methods in its ability to diagnose Bone Spavin, and the correlation between scintigraphy and clinical signs, and scintigraphy and radiography is calculated.

Scintigraphy was carried out using a portable scintillation counter connected to a hand held probe. The isotope used was 99_m Tc- MDP at a dose rate of 2 Mbq/Kg. injected intravenously. Soft tissue scans were performed 25 min. and bone scans 3 hrs. post-injection. A computer soft-ware program base on a commercial worksheet was used to manipulate the numerical data and display the results graphically for easier interpretation. Cases of bone spavin showed marked increases in isotope uptake in the tarsus, usually with peak increases in the DIT and TMT joints. A value of 40% increase over the contralateral limb was considered significant.

The sensitivity of scintigraphy in the detection of Bone Spavin was of 100% in cases of confirmed bone spavin, which compared favourably with the 81,2% of radiography. The correlation between the degree of isotope uptake detected by scintigraphy and the degree of lameness was poor ($\mathbf{r} = 0.17$ for bone phase and $\mathbf{r} = -0.39$ for soft tissue scintigraphy). There was moderate correlation between scintigraphy and radiography. In only 65% of the cases positive radiographic and positive scintigraphic findings were matched. The correlation between the values of the bone scans and the radiological scores of the tarsal joints was good for the left DIT joint ($\mathbf{r} = 0.74$), poor for the right PIT joint ($\mathbf{r} = 0.99$) and moderate for the rest of the joints ($\mathbf{r}$ ranging from 0.45 to 0.59). The correlation coefficients for soft tissue phase scintigraphy were similar.

In three horses, an increase of activity in the tarsal joints was detected by scintigraphy in the absence of radiographic signs of osteoarthritis, and with a clinical picture suggestive of lower back injury. Follow up examinations of these cases revealed that the positive scintigraphic findings had been an indicator of incipient joint degeneration, as they became clinically symptomatic. This findings illustrate the value of scintigraphy in the early detection or "prediction" of bone spavin, and osteoarthritis in general. They also suggest that subchondral bone changes occur very early in the process of osteoarthritis, and add weight to the hypothesis that they may be instrumental in its development.

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INTRODUCTION AND LITERATURE REVIEW

1.1. INTRODUCTION

Bone Spavin (Osteoarthritis of the distal tarsal joints [1]) is one of the oldest recognised conditions causing lameness in the horse. As early as 1551, T. Wilson mentioned "Spauain" as a disease of the horse, and in 1693 Thomas de Grey explained how to diagnose it (Taylor 1977). Since then a large amount of literature, both in textbooks and in scientific articles, have paid attention to the condition. The importance and repercussion that Bone Spavin has in the world of both the competitive and the non-competitive horse have long been recognised. Lameness accounts for a large proportion of the wastage among horses, and spavin is regarded as one of the most common causes of hindlimb lameness. Some authors consider it to be the most frequent cause of lameness associated with the tarsus (Stashak 1987c). In spite of all this, bone spavin remains a poorly understood condition, and debate about methods of diagnosis and treatment, as well as speculation about its aetiology are still very much alive.

While the diagnosis of the condition usually poses no problem in advanced cases, the early stages can escape diagnosis by conventional means, *i.e.:* clinical examination, selective analgesia of the hindlimb and radiography. It is well known that clinical symptoms can be present for a long time before radiographic changes develop (occult spavin). Another particular problem is apparent in cases of mild bilateral hindlimb lameness caused by spavin that present as, and often can be mistaken for, back lameness. With this state of affairs it is obvious that a diagnostic technique that would allow the early and unequivocal detection of the disease, while being practical and cost effective, would be most welcome. Early diagnosis of bone spavin and embarkation on appropriate treatment would be of great benefit to the equine population.

Gamma-scintigraphy is a very sensitive, non-invasive diagnostic method that has been used in human and veterinary medicine for the detection of a wide spectrum of skeletal and medical disorders, including osteoarthritis. Its use in veterinary science goes back to the 1960's, when Holmes (1960) described the first experimental applications. In the field of equine orthopaedics, Ueltschi (1977) and

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1. The correct names of these joints proposed by the *Nomina Anatomica Veterinaria* are Talocalcaneocentralis-Calcaneoquartalis and Centrodistalis articulations, however, in this thesis the more familiar terms of Proximal-Intertarsal, Distal-Intertarsal and Tarsometatarsal joints have been used for easier reading. The abbreviations PIT, DIT and TMT are sometimes used respectively.

Attenburrow (1984) published pioneering articles describing its possible uses. It is interesting to note that reference to the diagnosis of bone spavin was made in these early publications, but no mention has been made since then in the English literature. More recently, probe-point scintigraphy has gained popularity among equine clinicians, mainly in the detection of acute trauma or injury in the racing Thoroughbred (Pilsworth and Webbon 1988; Pilsworth 1989 and 1992; Pilsworth *et al.* 1993 and 1994). A detailed study into bone spavin using probe-point scintigraphy has not been reported.

The Large Animal Surgery Unit at Glasgow University Veterinary School has been using Gamma-scintigraphy as an aid for lameness investigation of the horses referred to the Veterinary Hospital for over four years. It provided an optimum setting and case material for such a study to be carried out.

1.2. LITERATURE REVIEW

1.2.1. Definition of Bone Spavin

Spavin is a lay term commonly used to describe several conditions of the equine tarsus. Although for some authors this term includes all painful conditions of the hock (Shebitz 1967, cited by Richter 1982), for most clinicians it refers to an arthropathy of the distal joints of the tarsus (O'Brien 1974; Hartung 1983; Stashak 1987). Bone Spavin is a more specific term, but also subjected to a diversity of definitions: Medial local Periarthritis of the hock joints (Wamberg 1953), Tarsal Osteoarthrosis (Taylor 1977), Ankylosing Osteoperiostitis of the tarsus (Morgan 1967), Chronic Deformative Arthrosis of the proximal end of the third metatarsal, the third and the central tarsal bones (Hartung 1983). This variety of terminology reflects the imperfect understanding of the condition.

Edwards (1982) has defined Bone Spavin as "an Osteoarthritis and Periostitis which involves the distal-intertarsal, tarsometatarsal and occasionally the proximal-intertarsal joints". Other authors omit the term periostitis, considering it to be primarily an Osteoarthritis or Degenerative Joint Disease of the distal tarsal joints (Moyer 1978; Gabel 1980; Taylor 1977). The tibiotarsal and talocalcaneal joints are rarely affected by osteoarthritis, and are not usually included in the definition (White and Turner 1980)

Distinction has been made between "True" or "Jack" spavin and "Occult" or "Blind" spavin (O'Brien 1974; Gabel 1980; Stashak 1987). True spavin was described as periostitis of the distal hock causing a swelling in that area (O'Brien 1974). Occult spavin was reported as arthritis with "ulceration" of the articular surfaces without the formation of exostoses (O'Connor 1950, cited by Taylor 1977). Later, Adams (1970) used this term when referring to spavin with no radiographic evidence of degenerative changes (Stashak 1987). Originally those two forms were considered to be two separate diseases caused by different processes (Smith 1889, cited by Taylor 1977), but later Rooney (1985) stated that there is no distinction between articular and periarticular spavin, both being different stages of the same process. This view is now generally accepted (Edwards 1982).

Cunean bursitis and tendinitis is a condition that mainly affects trotters and has been regarded as a separate entity, although differentiation from spavin remains difficult (Gabel 1980; Stashak 1987). Bog spavin and Blood spavin are

other terms commonly used. Bog spavin refers to the distension of the tibiotarsal joint, either idiopathic or secondary to osteochondrosis, trauma or infection (Stashak 1987). Blood spavin is an inappropriate term sometimes used to describe a prominent saphenous vein, but has no pathologic implications (Gabel 1980; Stashak 1987).

1.2.2. Spavin as a Form of Osteoarthritis

Since bone spavin is considered to be a form of Osteoarthritis, it is pertinent to elaborate on this concept and its causes before discussing the possible aetiology of bone spavin.

1.2.2.1. Definition and Classification of Osteoarthritis

Osteoarthritis, Osteoarthrosis and Degenerative Joint Disease are terms commonly used to describe a disorder or group of disorders affecting joints characterised by a progressive deterioration of articular cartilage accompanied by changes in the bone and soft tissues of the joint.

McIlwraith (1982) defines Osteoarthritis (He uses the term Degenerative Joint Disease) as "a disease of diarthrodial joints comprising destruction of articular cartilage to varying degrees accompanied by subchondral bone sclerosis and marginal osteophyte formation, synovitis and joint effusion being often associated with the disease".

Other authors have given a more generalised definition, stating that Osteoarthritis is the nonspecific end result of a number of pathological processes which have in common the fact that they destroy articular cartilage. As such, osteoarthritis could be viewed as "joint failure" (Freeman 1979).

Osteoarthritis has been classified conventionally into primary and secondary forms. Primary osteoarthritis refers to an idiopathic, age-related disease of insidious onset, in which there is chronic deterioration of the joint and gradual loss of function (Pool and Meagher 1990). Secondary osteoarthritis is used when a primary aetiologic factor can be demonstrated.

McIlwraith (1987) has divided osteoarthritis in the horse into four entities based upon joint characteristics and predisposing factors:

1. Acute - associated with synovitis and high-motion joints.
2. Insidious - associated with low-motion joints.

3. Incidental or "non-progressive" articular cartilage erosion.
4. Secondary to other identified problems: Intra-articular fractures, luxations, wounds, sepsis and osteochondrosis (McIlwraith 1982).

1.2.2.2. Clinical and Pathological Characteristics

Clinically, the disease is characterised by pain and dysfunction of the joint (McIlwraith 1987). From a pathologic point of view, the articular cartilage, subchondral bone, joint capsule and joint margins are affected.

The articular cartilage undergoes a characteristic, progressive pattern of degenerative changes which include: **(1)** yellowish discoloration, **(2)** dullness, **(3)** fibrillation, **(4)** erosion or ulceration and **(5)** eburnation. Histologically, the counterparts of these changes are, respectively: **(1)** loss of proteoglycans from the matrix, **(2)** fragmentation of superficial collagen fibres, **(3)** loss of the tangential zone of the cartilage with splitting into the radial zone, **(4)** loss of the radial zone of the cartilage and **(5)** polishing of the exposed subchondral bone (Pool and Meagher 1990).

The subchondral bone undergoes sclerosis and occasionally develops areas of focal osteopenia and cyst-like lesions. Sclerosis, as will be discussed later, is the response of the subchondral bone to increased cyclic loading. Cyst-like lesions are thought to develop when localised high pressures enter the subchondral bone marrow (Sokoloff 1979).

Changes in the joint margins include lipping of the border of the articular surface (osteophytes), as a result of remodelling of the junction between cartilage and subchondral bone. Osteophytes have been thought to represent an attempt to enlarge the bearing surface of the joint and thereby reduce pressure, but it is also true that they interfere mechanically with the joint motion (Sokoloff 1979). Another change that can occur at the joint margins is the development of enthesiophytes, which are a reactive bony response to tearing of the attachments of the joint capsule or ligaments (Pool and Meagher 1990).

Joint capsule changes affect the synovial membrane and the fibrous joint capsule. The synovium becomes hyperhaemic and congested, and hyperplastic villi develop in synovial recesses. The joint capsule undergoes fibrosis, resulting in loss of the normal range of motion of the joint (Pool and Meagher 1990).

1.2.3. Aetiopathogenesis of Osteoarthritis

Although the process is clearly progressive and the changes in the cartilage, soft tissues and bone follow a characteristic pattern (Sokoloff 1979; McIlwraith 1982 & 1987; Pool and Meagher 1990), the sequence of events and their mechanisms are not clearly established.

Pool and Meagher (1990) have described possible causes of osteoarthritis in the horse based on the mechanical forces exerted on joints. These are:

1. Concentration of abnormal forces on previously normal joints: Intra-articular malaligment (from delays in ossification of the epiphysis, cuboidal bones,...). Extra-articular malalignment (joint laxity,...). Increased work load placed on unaccommodated joints.
2. Concentration of normal forces on abnormal joints: Abnormal cartilage damaged by osteochondrosis, trauma or infection. Normal cartilage supported by weakened subchondral bone (infection, bone cysts or osteochondrosis). Normal cartilage supported by stiffened subchondral bone (as in third carpal bone disease).

From a general perspective, three broad mechanisms have been used to describe the causative process:

1. Postulates that osteoarthritis begins as an intrinsic degeneration of articular cartilage (the "wear and tear" concept).
2. Emphasises the inflammatory component of osteoarthritis as a possible cause.
3. Maintains that osteoarthritis is caused by abnormal mechanical stresses acting on joints.

1.2.3.1. Biochemical Theory

The first view maintains that the loss of the normal cartilage properties of resistance to "wear and tear" is related to a tipping of the balance between repair and degradation of the cartilage, related or not to the ageing process (Ehrlich and Mankin 1979). The key factor for this event is the loss of proteoglycans of the cartilage matrix.

This proteoglycan depletion is proportional to the severity of the disease and occurs in spite of increased production. It has been demonstrated that

proteoglycan synthesis may double in affected joints and that the increase is also proportional to the disease severity (Ehrlich and Mankin 1979). This increased production has been attributed to clusters of chondrocyte clones seen in osteoarthritic cartilage (Meachim 1979). Although this finding may seem paradoxical, it is explained by two separate mechanisms: alteration of the nature of the proteoglycans synthesised and increase in enzymatic degradation.

Glycosaminoglycans are the basic component of the proteoglycan molecule, and their composition in osteoarthritic cartilage has been shown to differ from that of normal cartilage. The main glycosaminoglycans in normal cartilage are chondroitin-6 sulphate and keratan sulphate, with a ratio of approximately 2:1. In degenerated cartilage, a relative decrease in keratan sulphate and an increase in chondroitin-4 sulphate have been found, both characteristic of glycosaminoglycan production of immature cartilage (Mc Devitt *et al.* 1977; Ehrlich and Mankin 1979).

These changes in glycosaminoglycan composition have been shown to precede articular surface damage and loss of proteoglycans in experimentally induced osteoarthritis in dogs (McDevitt *et al.* 1977). The same group also reported an increase in extractability of the proteoglycans, suggesting a reduced association with collagen, and a decrease in proteoglycan aggregation, with a greater proportion of non-aggregated proteoglycans and a decrease in size of the aggregates.

If there is reduction in proteoglycan contents in spite of increased synthesis, there must be degradation. It is agreed that lysosomal enzymes cause cartilage degradation, but the source of the enzymes is controversial. Acid cathepsins B and D, a type of proteolytic enzymes, have been isolated from chondrocytes of osteoarthritic joints, and have been shown to degrade proteoglycans (Ehrlich and Mankin 1979). However, the extracellular activity of cathepsins is likely to be low due to limitations imposed by pH (May 1993).

Another kind of proteinase capable of proteoglycan degradation -neutral metalloproteinase- has received increased attention more recently. This enzyme has also shown capability of degrading collagen, although this is thought to occur later in the degenerative process (May 1993).

Proteoglycan depletion of the ground substance would cause "unmasking" of the collagen framework that is essential to the structural integrity of the cartilage, leaving the collagen fibres exposed to mechanical damage. Damage to

the collagen framework would cause fibrillation (disruption of the tangential layer) and subsequent tearing and destruction of the deeper layers of the cartilage (Sokoloff 1979).

The view of osteoarthritis as an intrinsic degeneration of the articular cartilage resulting in an increased susceptibility to "wear and tear" has been associated with senescence of the cartilage. This has been based on the belief that chondrocytes, after cessation of skeletal growth, are incapable of mitotic division, and, therefore, they cannot replenish structural components which are depleted by mechanical strains. It is now generally accepted that chondrocyte clones develop in damaged cartilage (McDevitt *et al.* 1977; Ehrlich and Mankin 1979). In addition, Sokoloff (1979) has clearly demonstrated that osteoarthritis of the human femoral head cannot be explained by ageing of the cartilage only.

1.2.3.2. The Role of Inflammation

The view that inflammation plays a key role in the process is sustained by Dieppe *et al.* (1979) after the observation of hydroxyapatite and pyrophosphate crystals in the synovial fluid and synovium of samples obtained from osteoarthritic human joints. Hydroxyapatite crystals can cause inflammation, and the deposition and subsequent release of these crystals from articular cartilage and soft tissues is proposed as a possible mechanism for the inflammatory component in osteoarthritis. The presence of the Galenic signs of inflammation (tenderness, heat, redness and swelling) are common clinical features in some forms of osteoarthritis that corroborate this hypothesis.

From a different starting point, McIlwraith (1987) suggests that acute synovitis and capsulitis resulting from repeated direct trauma to the cartilage and soft tissues may be responsible for the osteoarthritis seen in high-motion joints of young thoroughbreds. As a result of the inflammatory response, leukocytes, prostaglandins, lysosomal enzymes and hyaluronidase enter the synovial fluid, and start the series of events that lead to osteoarthritis (Clyne 1987).

Lysosomal enzymes of chondrocyte origin, as it has been previously stated, cause cartilage degradation; however, there is comparable evidence for the inflamed synovial membrane and fibrous joint capsule as a source of lysosomal enzymes (McIlwraith 1987).

Prostaglandins produced in inflamed joints also may have a deleterious effect on articular cartilage. There is *in vitro* evidence that an indirect route, through which cells of the synovial membrane become activated, may lead to

production of interleukin-1, which in turn would stimulate the production of prostaglandin E2 and neutral metalloproteinases by chondrocytes. Thus, although the synovial cells may not be the important source of cartilage degrading enzymes, they still may be involved in chondrocyte activation and subsequent cartilage degradation (May 1993). Prostaglandins have also been found to suppress glycosaminoglycan and proteoglycan synthesis (McIlwraith 1987).

Collagenase activity is present in affected osteoarthritic cartilage and has also been isolated from synovial membrane (McIlwraith 1987).

In addition to lysosomal enzymes and prostaglandins a third mechanism that may be involved in articular cartilage degeneration is the superoxide radical that is produced in inflamed joints. This would have the ability to degrade proteoglycans, collagen and hyaluronic acid (McIlwraith 1987).

Apart from the changes in articular cartilage, inflammation also affects the synovial fluid. Protein and white cell concentration are increased due to increased synovial capillary permeability. As a result, the synovial fluid becomes less viscous and the transit path for cartilage nutrition is disrupted (Clyne 1987).

1.2.3.3. Mechanical Theory

The third argument is based on the view that in osteoarthritis the cartilage is subjected to an abnormal biomechanical environment. This is clearly the case in congenital or developmental anatomical abnormalities, were abnormal stresses are applied to an otherwise normal joint. Another group of circumstances would comprise the situations where there is a lowered resistance to normal stresses, affecting the bony or cartilaginous structures of the joint (Radin *et al.* 1979).

Cartilage is highly resistant to frictional wear, but is susceptible to repetitive impact loading (Radin *et al.* 1979). It is now generally accepted that cartilage is not involved in impact absorption during locomotion, and that this role falls on the soft tissues and subchondral bone of the joint. The main shock absorption mechanism protecting cartilage from peak loading is the joint motion, resulting in the lengthening of the muscles under tension. Deformation of the subchondral bone is the second mechanism that attenuates peak forces, in this case of a higher frequency range (Radin *et al.* 1979). Clearly, any alteration of these two mechanisms would result in an increased stress exerted upon the articular cartilage.

What is the initial effect of increased stress on articular cartilage ? McDevitt *et al.* (1977) found that the first pathological abnormality detected in

experimentally induced osteoarthritis in dogs was an increase in hydration of the cartilage. The same finding was observed in the cartilage of excised human femoral heads (Maroudas 1979). In both occasions this occurred before there was any modification in proteoglycan or glycosaminoglycan levels.

Proteoglycans have a high affinity for water and it is this osmotic pressure, restrained by the collagen network, that provides stiffness to the cartilage. It has been stated that damage to the collagen network is responsible for the increased hydration of osteoarthritic cartilage. A damaged network of collagen fibres would be unable to restrain the osmotic pressure created by the proteoglycans, causing the cartilage to swell (Maroudas and Venn 1979). Electron microscopy studies have shown ultrastructural separations in the collagen fibre framework in a mild form of cartilage damage in man (Meachim 1979). Freeman (1979) has suggested that fatigue failure of the collagen fibre framework is the possible initiating cause of osteoarthritic breakdown of articular cartilage. He speculates that the loss of fatigue strength in the fibre network is due to disruption of the bonds between fibres and that this occurs after repeated cyclical loading. This phenomenon would be directly responsible for fibrillation of the cartilage and eventually osteoarthritis (Freeman 1979).

Against this stands the fact that not all fibrillation is osteoarthritic in nature and leads to further cartilage degeneration (Meachim 1979).

Cyclical stresses affect the subchondral bone as well as the cartilage. The response of bone to cyclic loading has been extensively studied in experimental animals and in the horse (Lanyon 1982; Riggs and Evans 1990). It is believed that one of the ways in which bone dissipates impact energy is by microfractures, which subsequently heal in the process of bone remodelling. Healing fatigue fractures of individual trabeculae have been observed in the subchondral bone of osteoarthritic human joints (Todd *et al.* 1972). An excessive number of healing microfractures would cause stiffening of the subchondral bone, which would reduce its shock absorption capacity and thus subject the overlying cartilage to increased stress. Furthermore, different degrees of stiffness of the suchondral bone would impose different degrees of deformation to the cartilage, creating a shear stress to which cartilage is very sensitive. This mechanism has been proposed as the primary cause of cartilage breakdown in osteoarthritis (Radin *et al.* 1979).

It is quite possible that all the mechanisms described play a role in the aetiology of osteoarthritis. "Mechanical" and "biochemical" hypotheses are not mutually exclusive. A change in the ground substance properties will affect the mechanical properties of the cartilage and vice versa. Therefore, the initial event in cartilage breakdown need not be the same in every case (Meachim 1979). It is also possible that different joints are affected by different mechanisms at the onset of the disease.

1.2.4. Aetiology of Bone Spavin

1.2.4.1. Predisposing Factors

Several factors including type of work, conformation and metabolic factors have been stated as predisposing a horse to the development of bone spavin. Gabel (1980) stated that spavin is most commonly found in horses that are ridden hard at a gallop, horses that jump and western horses used for reining, roping and cutting. Rooney (1969) argued that horses pulling loads are specially affected. Trotters and pacers have been implicated with a high incidence of both bone spavin and cunean bursitis/tendinitis (Wamberg 1953; Hartung *et al.* 1983). While not contradicting this, most authors believe than any type of horse of any age, with the possible exclusion of the very young, can be affected by the condition (Wyn-Jones 1988).

Tarsal valgus. ("cow-hock") and "sickle-hock" conformation has been associated with bone spavin (Rooney 1961; Stashak 1987). Rooney (1969) stated that "sickle-hocked" horses and horses working in a "sickle-hock" manner (*i.e.* with the tibia and the metatarsus forming an acute angle), like draught horses and trotters, had predisposition for distal-intertarsal joint pathology, while horses working in a "straight-hock" manner (Thoroughbreds) had predisposition for tarsometatarsal joint pathology.

Developmental abnormalities caused by metabolic and nutritional imbalances have been thought to play a role in the development of osteoarthritis in the distal tarsal joints (Gabel 1980; Stashak 1987). Watrous *et al.* (1991) found evidence of osteochondrosis in the these joints and supported the view that osteochondrosis was a possible cause of spavin in young horses. Hartung *et al.* (1983) speculated that the radiographic changes seen in the tarsal joints of young trotters before they had started working were caused by developmental disturbances in the ossification of the tarsal bones. Smallwood *et al.* (1984) reached a similar conclusion after the study of the tarsi of normal foals from birth to six months of age..

Tarsal bone collapse is a condition affecting young foals in which there is wedging and sometimes fragmentation of the central and third tarsal bones (Morgan 1967). Prematurity (Butler *et al.* 1993), dysmaturity, hypothyroidism (Stashak 1987), hypocalcemia (Morgan 1967) and osteomyelitis have been implicated in the disease. Clinically the foal shows a "sickled" and "curby" conformation and may show severe lameness. Tarsal bone collapse can cause secondary osteoarthritis and joint ankylosis in the adult horse, and in some cases can be difficult to distinguish from primary spavin (Butler *et al.* 1993).

Both conformational and metabolic factors may be inheritable in some cases of bone spavin.

1.2.4.2. Biomechanical Factors

While the factors described above can certainly have an influence in the development of spavin in certain cases, there are a large proportion of horses that do not fit in any of these groups and nonetheless develop the condition. The peculiar biomechanics of the hock joint have often been blamed as a direct cause of bone spavin. The angulation of the tibia with the metatarsus creates compression and rotational forces that increase the loading on the dorsal and dorsomedial aspect of the tarsus (Tulamo *et al.* 1983; Driesang and Böhm 1993). In addition, the relatively flat surfaces of the central and third tarsal bones provide little support for shearing forces originating during locomotion, causing tensional stresses on the ligamentous structures around them. These stresses could be directly responsible for the cunean tendinitis and bursitis / tarsitis syndrome in harness race horses (Gabel 1980). Rooney (1969) proposed a biomechanical model in which asynchronous movements of the tarsal bones would be responsible for the pathogenesis of spavin. To understand his theory one must accept that joints rotate as they flex and extend and are completely congruous only in a close-packed position, when maximum surface contact occurs. The metatarsus rotates from medial to lateral during the first phase of the stride and from lateral to medial during the second phase; while the tibia is stationary during the first phase of the stride and rotates from lateral to medial in the second phase. If there is asynchrony between the movements of these two bones, shearing can result between the central and third tarsal bones. It has to be said that this is a theoretical model and that those movements have not been demonstrated on the live horse.

Considerable debate has taken place in the past with regard to whether spavin starts as a periarthritis "inwards" or as an arthritis or osteitis "outwards". The first line of thought attributed the origin of spavin to the soft tissue structures

on the medial hock including the cunean tendon (Dieckerhoff 1875; Wamberg 1953 and 1955; cited by Taylor 1977). More recently Updike (1984) observed that the attachment of the peroneus tertius tendons into the tarsal bones could be implicated in the development of tarsal pathology. A second theory sustained by Dollar (1950, cited by Taylor 1977) was that spavin begins as an osteitis.

While modern thoughts on spavin consider it to be a special form of osteoarthritis, its pathogenesis is still undetermined. Pool and Meagher (1990) suggested that periarticular fibrosis could restrict the movements of the distal tarsal joints and cause increased loading in a small area of articular cartilage, thus initiating a sequence of events that would lead to this particular type of osteoarthritis. In their proposed model, sustained loading in a small area of cartilage and subchondral bone would cause full thickness necrosis of the chondrocyte population and a remodelling response of the subchondral bone. This remodelling would lead to areas of bone resorption and new bone production which would later initiate joint ankylosis.

1.2.5. Diagnosis of Bone Spavin: History and Clinical Signs

1.2.5.1. Clinical Features

Horses with bone spavin usually present with a history of lameness of gradual onset that often improves after exercise (Gill 1974; Gabel 1980; Stashak 1987). Although there may be considerable variation, the typical spavin lameness is characterised by a decreased hock flexion that will cause a reduced height of the foot flight arc and a shortening of the cranial phase of the stride (Stashak 1987). The foot lands on the toe, and in some instances the low foot flight arc will cause dragging of the toe and excessive wear of the shoe (Stashak 1987; Wyn-Jones 1988). In an attempt to reduce the strain on the medial hock, the lame leg is carried towards the midline of the track, causing the foot to land on its lateral quarter (Moyer 1978; Stashak 1987) An asymmetric gluteal rise and hip "hiking" of the affected side may also be present (Stashak 1987).

In other instances the lameness may not be so evident and the horse may be presented with rather unspecific problems like loss of performance, lack of impulsion or unwillingness to jump (Moyer 1978; Wyn-Jones 1988). Cases of mild bilateral spavin are often presented as "back problems" (Gabel 1980). In a

survey by Moyer *et al.* in 1983, 19% of the horses diagnosed as bone spavin were presented as "backs", and 17% as decreased performance.

Originally the diagnosis of bone spavin was made on palpation of the characteristic bony enlargements on the medial hock (Richter 1982; Taylor 1977). This, however, is only present in advanced cases and in older horses and constitutes a relatively uncommon finding in young athletic horses (Wyn-Jones 1988). The "Spavin Test", consisting of holding the hind leg flexed for one minute and trotting the horse immediately afterwards to observe any exacerbation of the lameness, was described by Share-Jones as early as 1903 (Taylor 1977). Although useful, a positive result is not specific to bone spavin, as the reciprocal apparatus of the hindlimb will cause other joints to be flexed as well (Gabel 1980; Stashak 1987; Wyn-Jones 1988). Distension of the tibiotarsal joint is sometimes found in cases of proximal-intertarsal joint degeneration (Butler, Colles, Dyson *et al.* 1993).

1.2.5.2. Selective Analgesia Techniques

Regional and intra-articular anaesthesia are techniques of widespread use amongst clinicians to localise the source of pain in a lame horse (Gill 1974; Moyer 1978; Gabel 1980; Wyn-Jones 1986; Stashak 1987). Anaesthesia of the Tibial and Peroneal nerves as described by Stashak (1987) will cause an improvement in the lameness in cases of spavin, but will also desensitise other structures. This technique should only be performed after an negative result of the "four point" block of the plantar and plantar metatarsal nerves (Wyn-Jones 1988).

Intra-articular anaesthesia of the distal-intertarsal and tarsometatarsal joints constitutes a more specific diagnostic resource (Gabel 1980). These two joints have, until fairly recently, been considered inaccessible for injection (Stashak 1987). Of the various methods described in the literature, the one that is most widely used at present was introduced in 1981 by Sack and Orsini. It consists of injecting with a 1-inch 20-gauge needle 5 ml. of local anaesthetic into the tarsometatarsal joint from the lateroplantar aspect of the tarsus, between the head of the fourth metatarsal bone and the fourth tarsal bone. The distal-intertarsal joint is injected in the same fashion from the medial aspect of the hock, through the most proximal part of the "Y" shaped gap between the fused first and second tarsal bones, the third tarsal bone and the central tarsal bone. The two joints are injected separately because, contrary to what was formerly believed, communication between the two joints only exists in a small percentage of cases - 23.8% (Sack and Orsini 1981), 35% (Dyson and Romero 1993). This technique, though, has some limitations and may not be as specific as it is believed.

Injection of local anaesthetic drugs into the tibiotarsal joint will also desensitise the proximal-intertarsal and the talocalcaneal joints as well, due to the existing communication between them. This technique can be useful to confirm suspected involvement of the proximal-intertarsal joint (Stashak 1987; Wyn-Jones 1988). Decrease in lameness after anaesthesia of the cunean bursa in cases of cunean bursitis/tendinitis in trotters has been reported (Gabel 1980; Stashak 1987). The fact that Gabel (1980) states that a further improvement can be expected in these cases after anaesthesia of the distal-intertarsal and tarsometatarsal joints brings confusion over the distinction between these two conditions.

1.2.6. Radiographic Examination

1.2.6.1. Radiographic Technique

Radiographic examination of the tarsus should include Lateromedial, Dorsoplantar, Dorsolateral-Plantaromedial (DL-PlM O) and Dorsomedial-Plantarolateral (DM-PlL O) oblique views (Stashak 1987). The beam should be centred at the site of principal interest, which for spavin is often the distal-intertarsal joint. Due to the slight angulation of the distal tarsal joints in a proximolateral to distomedial direction, it is recommended to tilt the beam proximodistally at a 10° angle when taking a lateromedial radiograph (Butler, Colles, Dyson *et al.* 1993). Alternatively, one may centre at the lateral malleolus in a horizontal plane so that the periphery of the diverging X-ray beam is parallel to the distal tarsal joints (Shelley and Dyson 1984). There is disagreement over the optimum angle for dorsolateral-plantaromedial oblique views. 45° (Stashak 1987; Wyn-Jones 1988), 35° (Butler, Colles, Dyson *et al.* 1993) and 25° (Dahn and Ueltschi 1989) have been suggested. A plantarolateral-dorsomedial oblique view is often easier and safer to obtain than a dorsomedial-plantarolateral view (Butler, Colles, Dyson *et al.* 1993). Both hocks should be radiographed since the condition is often bilateral.

1.2.6.2. Radiological Evaluatuion

Radiography of the tarsus is the most commonly used ancillary aid in the diagnosis of bone spavin (Taylor 1977; Moyer 1978; Gabel 1980; Richter 1982; Stashak 1987; Wyn-Jones 1988; Laverty *et al.* 1991), but the interpretation and significance of the radiographic findings has always been controversial. While some authors believe that any radiographic abnormality is significant (Gabel 1980; Pilsworth 1992), or that in all cases of spavin radiographic changes can be demonstrated (Taylor 1977), others feel that there is poor correlation between radiographic and clinical signs (Moyer 1978; Moyer, Broken and Raker 1983;

Schmidt and Talazko 1978; Butler, Colles, Dyson *et al.* 1993). Advanced radiographic changes can exist without clinical symptoms, and conversely severe spavin lameness can be present with minimal or even no radiographic changes at all (Schmidt and Talazko 1978; Butler, Colles, Dyson *et al.* 1993). This has led some authors to question the value of radiography in the diagnosis of bone spavin (Hartung *et al.* 1983).

The changes affect primarily the distal-intertarsal and tarsometatarsal joints, the proximal-intertarsal joint being affected less frequently. There is considerable variation in the type, extent and progression of radiographic abnormalities (Butler *et al.* 1993). The detection of changes in the early stages of spavin poses a particular problem. Radiographic features indicative of bone spavin include:

- Periarticular spurs or osteophytes (O'Brien 1974; Shelley and Dyson 1984; Stashak 1987; Wyn-Jones 1988; Dahn and Ueltschi 1989; Butler *et al. 1993*).
- Joint margin irregularity and lucency (Shelley and Dyson 1984; Wyn-Jones 1988; Butler *et al.* 1993).
- Irregular widening of the joint space (O'Brien 1974).
- Subchondral bone lysis (Wyn-Jones 1988; Butler *et al.* 1993).
- Cyst-like rarefactions or cystic lesions (O'Brien 1974; Shelley and Dyson 1984; Stashak 1987; Dahn and Ueltschi 1989; Butler *et al.* 1993).
- Narrowing or collapse of the joint space (O'Brien 1974; Stashak 1987; Wyn-Jones 1988; Butler *et al. 1993*).
- New bone production on the dorsomedial aspect of the tarsus (O'Brien 1974; Taylor 1977; Butler *et al* 1993).
- New bone formation in the tarsal canal (Shelley and Dyson 1984; Dahn and Ueltschi 1989) and in the "synovial fossae" (Dahn and Ueltschi 1989).
- Thickening of the soft tissues overlying the medial aspect of the hock (Dahn and Ueltschi 1989).
- Sclerosis of the third and central tarsal bones (O'Brien 1974; Stashak 1987).
- Joint ankylosis (O'Brien 1974; Taylor 1977; Shelley and Dyson 1984).

The clinical significance of some of these abnormalities is controversial. Hartung (1983) found radiographic signs of spavin in 50 % of a series of young horses (Trotters) that had not started work and were apparently sound. In another radiological study of the hocks of 270 "normal" horses carried out by Dahn and Ueltschi (1989), a mean of 2 to 4.5 abnormalities were found for each radiograph. It was concluded that an ideal tarsus, with no radiographic abnormalities, does not exist, and a tolerance margin was advocated for when interpreting tarsal radiographs.

Periarticular spurs (Osteophytes) are most commonly found in the dorsal and dorso-medial aspect of the distal-intertarsal and tarsometatarsal joints, but can also be found in the tarsal canal (Shelley and Dyson 1984; Dahn and Ueltschi 1989). Most clinicians feel that an isolated bone spur may not be of clinical significance. Smallwood *et al.*(1984) found lipping of the tarsal bones in foals as early as at 5 weeks of age, and speculated that they represent developmental changes in ossification. Nonetheless, bony spurs occur more frequently in clinically affected than in not affected joints (Shelley and Dyson 1984). Some clinicians feel that osteophytes in the distal-intertarsal joint are likely to be more significant than in the tarsometatarsal joint (Butler *et al.* 1993). Large osteophytes in the dorso-proximal aspect of the third metatarsal bone can occasionally fracture (Stashak 1987), and have been associated with incomplete articular fractures of the third metatarsal bone (Pilsworth 1992). True osteophytes in that area must be differentiated from enthesiophytes.

Lucent areas in the joint margins and subchondral bone are indicative of bone resorption and are considered pathological. Similarly, the small cyst-like lesions in the central and third tarsal bones are considered of clinical significance (Shelley and Dyson 1984; Butler *et al.* 1993). These changes may progress to extensive subchondral bone destruction and joint collapse. Narrowing of the joint space is sometimes seen without other radiographic abnormalities, although appreciation of the joint space is difficult since slight alterations in the angulation of the X-ray beam will modify its apparent width (Dahn and Ueltschi 1989).

New bone production in the dorso-medial cortices of the central tarsal, third tarsal and third metatarsal bones is not necessarily associated with intra-articular disease, but it may be so if it is extensive, irregular or accompanied by lysis (Shelley and Dyson 1989; Butler *et al.* 1993). Progression of this changes is thought to lead to joint ankylosis (Edwards 1982; Stashak 1987).

Other conditions affecting the tarsus that should be differentiated radiographically from spavin include:

- Conditions affecting the tibiotarsal joint (osteochondrosis, osteoarthritis, fractures).
- Degenerative joint disease of the talocalcaneal joint (White and Turner 1980).
- Tarsal bone collapse (Morgan 1967).
- Fractures of the third and central tarsal bones (Stover *et al.* 1986; Stashak 1987) and of the proximal cortex of the third metatarsal bone (Pilsworth 1992).

1.2.7. Scintigraphic Examination

1.2.7.1. Principles of Scintigraphy

Gamma-Scintigraphy is a very sensitive diagnostic method based on the detection of radiation emitted by an administered radiotracer. In skeletal scintigraphy, bone seeking radioisotopes are administered intravenously and gradually accumulate in bone over a period of hours. Bone constantly goes through a physiological process of deposition and resorption of its components. Some chemical compounds, when introduced into the blood stream mimic the behaviour of bone constituents and localise in the regions of bone formation (Chaudhuri 1983). Diagnostic radioisotope imaging is based on the fact that areas of bone injury or rapid bone formation or destruction are usually associated with increased metabolic activity and higher rates of bone turnover (Jones *et al.* 1976).

There are many radionuclides that have been used for skeletal imaging after intravenous administration in veterinary and human medicine. Among these, ^{99m} Technetium (^{99m} Tc) offers superior advantages for bone scintigraphy (Francis and Fogelman 1987). The short half life of 6 hours and the favourable monoenergetic disintegrating energy of 140 Kev. make this radioisotope ideal for skeletal imaging. Methylene diphosphonic acid (MDP) is the most widely used labelling agent, and this combination produces excellent bone images due to the high incorporation into the bone and the rapid clearance from surrounding tissues (Lamb and Koblik 1988).

The localisation and deposition of ^{99m} Tc - MDP in all tissues is proportional to the calcium content and the perfusion. The binding of the bone seeking agents can be explained through a reaction of the phosphorus groups with the calcium of hydroxyapatite of bone (ion exchange), or chemisorption of these groups to the crystal surface by electrocovalent binding (Jones *et al.* 1976).

The factors that influence the uptake of the bone seeking agent throughout the body are:

- Radiotracer delivery blood flow. Any changes in the vascular supply, either increases or decreases, will change the distribution of the radiotracer (Jones *et al.* 1976; Lamb and Koblik 1988) .

- Factors affecting the deposition of the radiotracer in bone, such as capillary or barrier permeability, changes in the local extracellular fluid and available bone

crystal surface (Lamb and Koblik 1988; Trout *et al.* 1991). Changes in the ECF such as oedema will alter the distribution. Sites of rapid bone formation or high rate of bone turnover are associated with a large available crystal surface for the exchange sorption of bone seeking agents.

Skeletal scintigraphy can be divided into 3 phases according to the time post injection and the distribution of the tracer before its elimination by the kidneys (Lamb and Koblik 1988):

- Phase I or nuclear angiogram can be obtained 30 sec. post injection while the radioisotope is predominantly in the large vessels. Images are obtained at 8 - 10 sec. intervals.

- Phase II , dynamic blood pool or soft tissue phase represents the subsequent distribution of isotope in the capillary bed and extracellular fluid. This phase lasts until significant isotope has accumulated in the bone and in the horse it can persist for 20 min. (Lamb and Koblik 1988; Steckel 1991). The significance of soft tissue phase is that it can indicate hyperemia such as seen with synovitis and muscular disorders (Metcalf *et al.* 1991).

- Phase III or delayed bone phase is obtained 2 - 4 hours post injection, when the activity in blood and soft tissue surrounding the bones has decreased (Lamb and Koblik 1988).

1.2.7.2. Imaging (Scanning) Techniques

Gamma ray emission can be detected with crystal based scintillation detectors. They depend on the property of certain crystals to emit light when exposed to ionising radiation. The crystal most commonly used in nuclear medicine devices is made from sodium iodide laced with thalium. The crystal is coupled to a photomultipier tube which converts the light signal into an electrical signal. The amplified signal that originates from the PMT has an energy spectrum that is characteristic for each radionuclide (Ward 1994).

The instrumentation that can be used for gamma-scintigraphy detection and imaging are portable scintillation counters with hand held probes and gamma-cameras.

Portable scintillation counters are single photomultiplier tube systems made out of two basic components: the detector or hand held probe with its collimator and a portable electronics device containing an amplifier, high voltage supply to

the probe, pulse height analyser and ratemeter (Ward 1994). Recently, a portable scintillation counter for the use in equine orthopaedics has been developed, based on a caesium crystal and photodiode. Portable scintillation counters display the signal produced in a digital screen as scintillation counts / second. The probe is positioned by hand over anatomical landmarks and the counts at each site are recorded. There are various means of analysis of the data obtained this way, including a recently commercialised computer software package (Pilsworth 1992_a).

Gamma-cameras operate on the same principle as the portable scintillation counter, but are considerably more complicated in construction and operation. They basic components are: head of the camera, which consists of a multi hole interchangeable collimator, a large sodium iodide crystal and a geometric array of PMT which are optically coupled to the crystal. The head of the camera is surrounded by a lead shield and attached to a yoke that permits moderate manoeuvrability. The remaining components are: a large electronics circuit for determining the scintillation in the crystal, a pulse height analyser and various means of display and computer based processing of the image. A gamma-camera produces a two dimensional image in which a variable ammount of anatomical detail of the area scanned can be identified. Areas of increased radioactivity appear darker than the surrounding structures and are termed "hot spots" (O'Callahan 1991; Steckel 1991).

1.2.7.3. Use of Scintigraphy in Equine Orthopaedics

Although X-ray is the primary diagnostic aid for the detection of skeletal conditions, there are many occasions where radiography may initially fail to diagnose the injury (Matin 1988). Some skeletal injuries that cause lameness, especially recent ones, may not show radiographic changes for days or weeks (Baum and Devous 1980). On the other hand, radiographic detection of early osteoarthritis is often difficult (Holder 1990). The high sensitivity of gamma-scintigraphy in detecting early or occult bone pathology is explained by the fact that bone scans reflect changes in bone mineral metabolism, and the relationship between vascular supply and metabolic activity. This is in contrast to radiography, which reflects changes in bone density and structure causing gross anatomical effects (Matin 1988).

Gamma-Scintigraphy is of increasingly widespread use in the diagnosis of musculo-skeletal conditions in the horse. Among the type of injuries that cause lameness in the horse, and where gamma-scintigraphy can be useful are: Periosteal

injuries and stress fractures, joint abnormalities (osteoarthritis), septic arthritis and osteomyelitis, occult fractures and acute muscle injuries (Mitsopoulos 1992).

1.2.7.4. Use of Scintigraphy in Bone Spavin

Pathological conditions of the tarsus diagnosed with Gamma-scintigraphy include: fractures of the central and third tarsal bones (Stover *et al.* 1986), incomplete fractures of the dorsal cortex of the third metatarsal bone (Pilsworth 1992), osteochondritis of the tibiotarsal joint (Attenburrow 1989) and enthesitis of the lateral collateral ligaments of the tibiotarsal joint (Boero *et al.* 1988). However, the application of Gamma-scintigraphy in the diagnosis of bone spavin has received little attention in the English literature. In fact only two articles can be found where express reference to the condition, even if short, is made (Ueltschi 1977; Attenburrow 1984). In contrast, there has been relatively more interest shown in the German literature (Schmidt and Talazko 1978; Ueltschi 1987; Driesang and Böhm 1993). A Gamma-camera has been used as the imaging device in the majority of occasions.

Ueltschi (1994) describes four patterns of scintigraphic findings in the hock:

- Focal increased uptake.
- Diffuse increased uptake.
- No uptake (photon deficient area).
- Normal uptake.

It appears that increased activity in the hock due to bone spavin can present as focal or diffuse uptake (Ueltschi 1977; Driesang and Böhm 1993). When a very intense focal increase is detected, a fracture of the distal tarsal bones should be suspected, even in the absence of radiographic confirmation (Stover *et al.* 1986). Driesang and Böhm (1993) compared qualitative and quantitative methods for the detection of increased isotope uptake in the distal hock. They found that the quantitative method, based on a quotient between the values of the affected region of interest (ROI) and the mean value of three "standard" regions, was superior in the detection of diffuse increases. Focal increases could be detected similarly with quantitative and qualitative (optical) means. They also found that the proximal and dorsal areas of the distal tarsal joints were affected more often than the distal and plantar regions. No differentiation was made between lateral and medial regions because all the scintigrams were lateromedial projections.

An overall good correlation between radiographic and scintigraphic findings in cases of spavin has been found (Ueltschi 1977; Schmidt and Talazko 1978),

although discrepancies occasionally occur. There may be horses with scintigraphic positive tarsi and no radiographic changes. It has been proposed that these represent early stages in the development of bone spavin (Ueltschi 1977; Driesang and Böhm 1993). On other occasions, no increased scintigraphic activity was found associated with advanced radiographic changes and ankylosed joints in asymptomatic horses (Ueltschi 1977; Schmidt and Talazko 1978). Ueltschi (1977) suggested that radiotracer activity decreased as osteoarthritic processes advanced. All the authors above have emphasised the value of scintigraphy in situations where radiographic changes were minimal or undetectable.

1.2.8. Pathology

As with radiographic changes, the correlation between pathological lesions and clinical signs in bone spavin is not always a good one. An extreme case of this situation was reported by Wamberg (1953), who found pathological changes in 80-90% of horses with functionally sound hocks examined at post-mortem, and disclaimed any association between the clinical picture and the presence of lesions.

1.2.8.1. Gross Pathology of Bone Spavin

The most common pathological findings in advanced bone spavin are the development of exostoses on the medial aspect of the central, second and third tarsal bones and occasionally on the proximal third metatarsal bone (Taylor 1977; Richter 1982); and the degeneration and progressive destruction of articular cartilage in the tarsometatarsal, distal-intertarsal and, to a lesser extent, proximal-intertarsal joints (Pool and Meagher 1990).

The bony exostoses are responsible for the hard enlargements that are customarily observed on the "seat of spavin". They are formed on the dorso-medial cortices of the distal bones of the tarsus, at the areas of insertion of the joint capsule, dorsal oblique ligament of the tarsus, tendon of the tibialis cranialis muscle and cunean tendon (O'Brien 1974). The dorsal and medial attachments of the peroneus tertius muscle have also been implicated (Updike 1984). The histological appearance of these exostoses is characteristic of mineralised entheses, with Sharpey fibres penetrating the bone surface and anchoring in the osteonal bone. Fibrocartilage is often present at the junction of the fibrous tissue and bone (Laverty *et al.* 1991). Swelling on the "seat of spavin" can exist without bony proliferation, resulting in this case from fibrous thickening of the mentioned structures (Shelley and Dyson 1984).

Periosteal new bone production may be extensive enough to produce complete ankylosis of the tarsometatarsal and/or distal-intertarsal joints (Edwards 1982; Stashak 1987). In other occasions, obliteration of the joint space with minimal new bone production externally may be present. Both of these situations represent end stages of the disease and are usually not associated with lameness (Shelley and Dyson 1984). Ankylosis is most commonly found in the distal-intertarsal joint, and does not usually affect the proximal-intertarsal joint (Wamberg 1953). In the "ulcerative" form of the disease, areas of cartilage erosion are present without any bone proliferation (Rooney 1969). It has been stated that in these cases the development of ankylosis is unlikely (Edwards 1982).

1.2.8.2. Early Pathological Lesions

Of greater interest are the pathological and histological findings in the early stages of the disease, although literature in this area is scarce. The articular cartilage and subchondral bone in spavin show pathological changes that are similar to those found in osteoarthritis of other joints, but have some unique characteristics. There is close similarity between the lesions found in bone spavin and in other high-load / low-motion joints, especially the proximal interphalangeal joint (McIlwraith 1987; Pool and Meagher 1990). The main pathological features of the early stages of the disease are: lesions in the articular cartilage, joint margin changes, irregularities in the subchondral bone plate and subchondral bone sclerosis.

Early lesions in the articular cartilage consist of chondrocyte necrosis and loss of proteoglycans, with chondrocyte proliferation in the adjacent viable cartilage (Laverty *et al.* 1991). Areas of full-thickness chondrocyte necrosis constitute a characteristic lesion sometimes observed in spavin (Pool and Meagher 1990). This necrotic cartilage eventually undergoes thinning and collapse (Laverty *et al.* 1991).

Bone production at the joint margins takes the form of lipping of the articular margins (osteophytes) and enthesiophyte formation. Histologically, osteophytes originate at the junction of cartilage, synovium and subchondral bone and eventually may grow into capsular or ligamentous attachments (Sokoloff 1979). They start as accumulations of chondrocytes around which woven bone is deposited. Later the woven bone is remodelled into cancellous bone, which trabeculae merge with those of the parent bone (McDevitt *et al.* 1977). The surface of the osteophyte is covered mainly by fibrocartilage (Sokoloff 1979), although hyaline cartilage may also be present (Laverty *et al.* 1991). The large spurs seen on the proximal aspect of the third metatarsal bone are often

enthesiophytes associated with the insertion of the dorsal tendon of the tibialis cranialis muscle and the dorsal tarsometatarsal ligament (Butler, Colles, Dyson *et al.* 1993), and are characterised by replacement of cancellous bone by osteonal bone (Laverty *et al.* 1991). They do not reflect intra-articular damage, but may represent an old injury to these structures (Butler, Colles, Dyson *et al.* 1993). In a series of post-mortem specimens examined by Laverty *et al.* in 1991, significant cartilage damage and other histopathological changes were not found in association with mild marginal bone production, suggesting that joint margin changes have minimal clinical significance in the absence of other abnormalities. They also concluded that spurs in the distal-intertarsal joint are likely to be more clinically significant than changes of the tarsometatarsal joint.

Subchondral bone plate irregularities created by bone remodelling are often seen underlying areas of damaged cartilage. These consist of areas of bone resorption arising from hypertrophied capillaries (Laverty *et al.* 1991), and appear as lucencies of the subchondral bone in radiographs (Butler, Colles, Dyson *et al.* 1993). These lesions are characteristic of the high-load / low-motion joints and are rarely seen in high-motion joints (Pool and Meagher 1990). In some areas bone remodelling replaces the zone of calcified cartilage with bone tissue and thus the subchondral bone plate advances towards the joint surface. Granulation tissue is laid down by these bony extensions, and they can bridge with similar lesions arising from the opposing joint surface, establishing a fibrous union (Laverty *et al.* 1991). In advanced cases the granulation tissue is substituted by woven bone and eventually by lamellar bone, establishing complete ankylosis (Bohanon *et al.* 1991).

Watrous *et al.* (1991) observed osteochondrosis-related lesions on the joint surfaces of the arthrodial joints of the tarsus. Those consisted of focal areas of raised and thickened cartilage, retained cartilage cores with a trapezoidal or triangular shape and subchondral cyst-like lesions. It is interesting to note that some of the lesions described by these authors have great similarities to lesions attributed to primary osteoarthritis by other researchers. This is especially true of the cyst-like lesions.

Subchondral cyst-like lesions are occasionally seen near the joint margins of the proximal and distal-intertarsal joints. They are similar structures to those found in other equine and human joints, but of a smaller diameter (Shelley and Dyson 1984; McIlwraith 1982)). They are commonly filled with granulation tissue (Hoffman *et al.* 1985) and communicate with the joint surface by a narrow "neck" (Butler, Colles, Dyson *et al.* 1993) . Laverty *et al.* (1991) found increased

vascularity and articular cartilage damage associated with these lesions, concluding that they are of clinical significance.

Compaction (sclerosis) of the subchondral and medullary bone of the central and third tarsal bones follows a progressive pattern in which three stages have been identified: **(1)** Thickening of the subchondral bone plate parallel to the joint surface. **(2)** Widening of the subchondral bone plate forming arches into the medullary bone **(3)** Bridging between the joint surfaces by compacted bone. This extensive bone remodelling is achieved by either replacement of cancellous bone by secondary osteonal bone or by thickening of the trabeculae by many layers of lamellar bone (Laverty *et al.* 1991).

1.2.9. Treatment of Bone Spavin

While it is not the object of this thesis to discuss the treatment of bone spavin, a brief mention will be made here to complete the clinical perspective.

Treatment options range from surgical arthrodesis of the affected joints to conservative treatment. It is generally accepted that rest is of little benefit for the condition (Wyn-Jones 1987), so conservative treatment is usually aimed at maintaining the horses function while awaiting spontaneous arthrodesis to occur. Arthrodesis of the distal-intertarsal and tarsometatarsal joints, be it by natural or surgical means, frequently results in resolution of the lameness. Most clinicians recommend a graduated exercise programme with the use of a low dose of analgesics such as phenylbutazone to palliate the lameness (Moyer 1978; Wyn-Jones 1987). Corrective shoeing in the form of outside trailers or lateral extensions has been reported to give good results (Moyer 1978). Intra-articular injections of corticosteroids or sodium hyaluronate have also been recommended (Moyer 1978; Kold 1994). Stashak (1987) stated that approximately half of the horses treated conservatively remain lame.

Different types of surgical treatment for bone spavin have been used through the years. Firing and cunean tenotomy were popular in the past (Taylor 1977). Wamberg's operation, which he called a peripheral neurectomy, was introduced in 1953 and consisted of a rhomboid incision on the medial side of the distal hock (Wamberg 1953). Neurectomy of the tibial and deep peroneal nerves has been carried out (Stashak 1987). All these techniques have given limited results. Surgical arthrodesis of the distal-intertarsal and tarsometatarsal joints was introduced by Adams in 1970 (Stashak 1987). It consisted of destroying at least 60% of the articular cartilage of the joints by drilling from the medial side and

parallel to the articular surfaces. A modification of this technique, where only three holes are drilled through each joint, is the most widely used today (Stashak 1987). Edwards (1982) reported a 85 % success rate and Wyn-Jones and May (1986) reported a 78% success rate with this technique, although some degree of stiffness may be a sequel. The outcome was worse when the proximal-intertarsal joint was arthrodesed. Modifications of the technique by the introduction of lag screws and bone plates have been tried (Wyn-Jones and May 1986) without a definite improvement in the outcome. Subchondral bone fenestration (Sonnichsen and Svalastoga 1985) and fusion of the distal-intertarsal and tarsometatarsal joints using intra-articular sodium monoiodoacetate (Bohanon *et al.* 1991) have been reported.

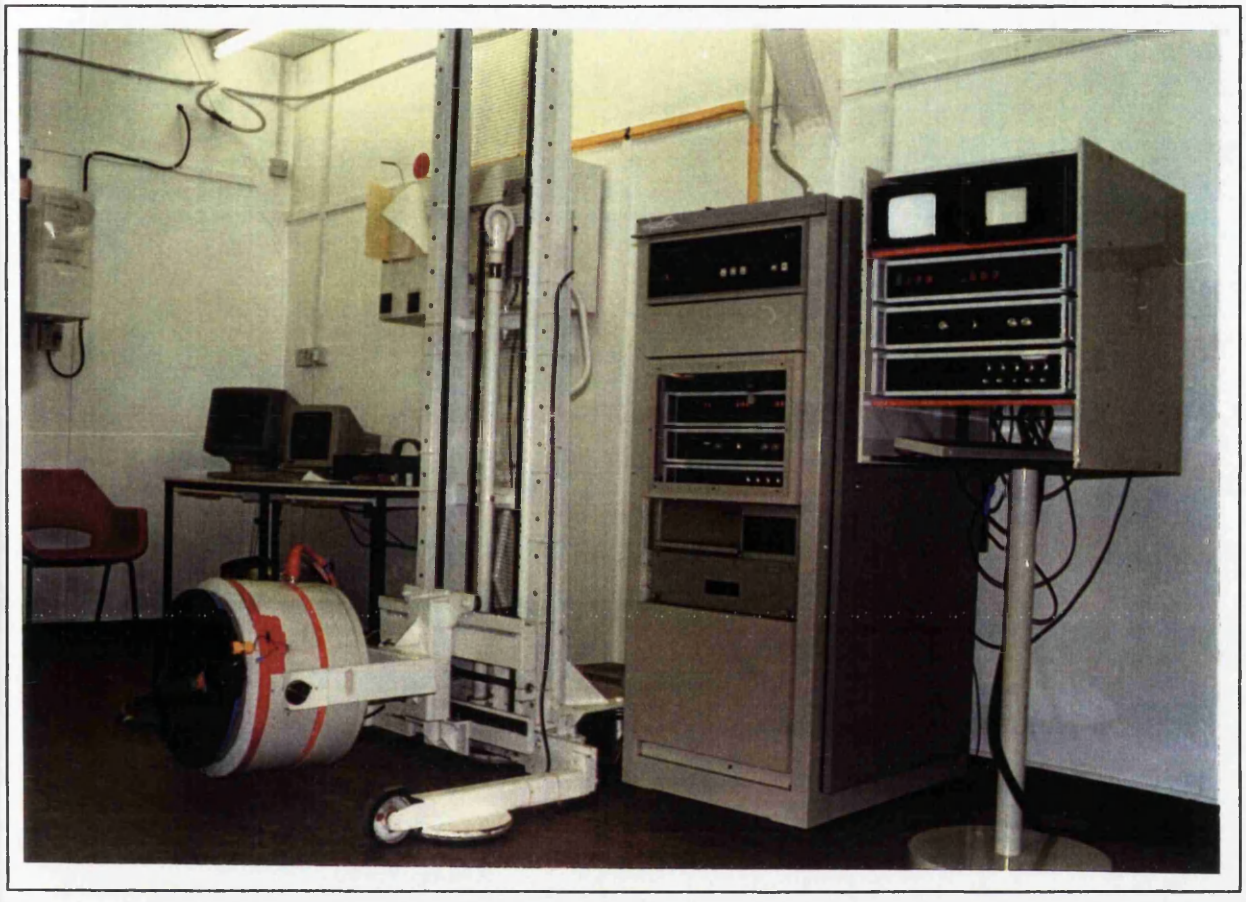


Figure 1.1. *Gamma-camera facilities for use in the equine species.*

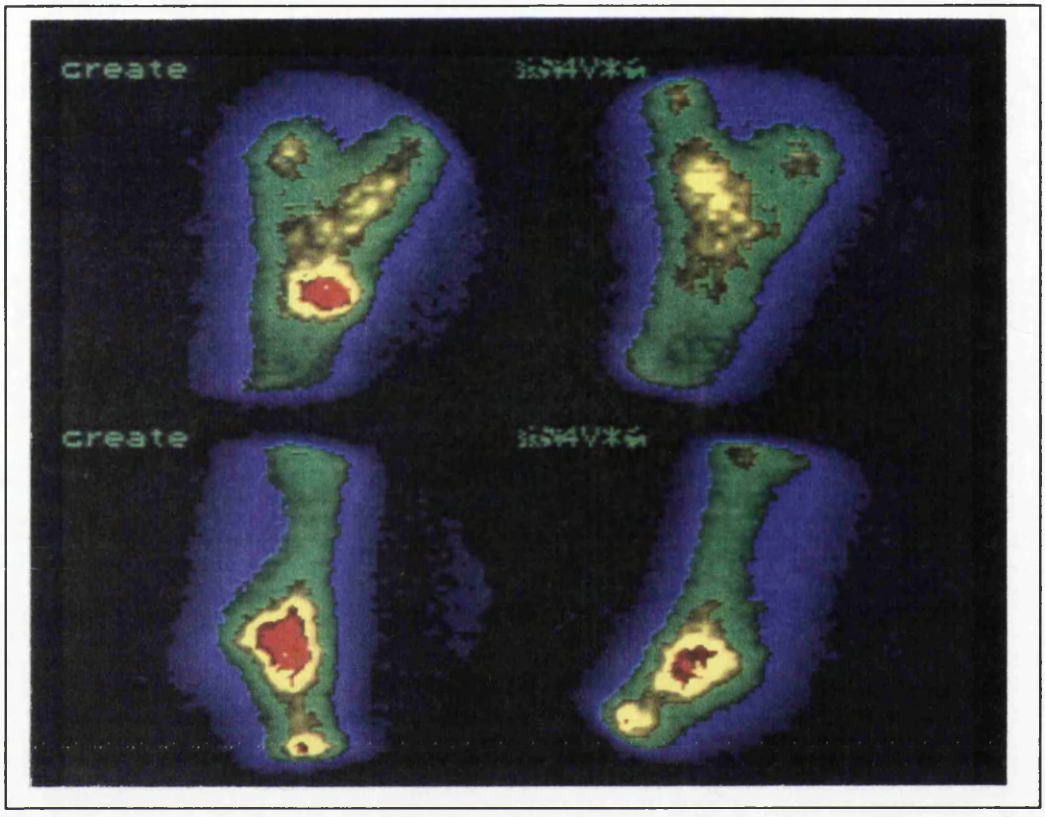


Figure 1.2. *Colour coded scintigraphic images of the two hocks and two hind fetlocks of a horse with bone spavin. Note the increase in tracer uptake in the left hock (superior left image).*

CHAPTER 2:

MATERIALS AND METHODS

2.1. Selection of Cases

The 17 cases included in this study were all admitted to the Equine Veterinary Hospital of the University of Glasgow during the period from November 1990 to March 1994. The majority of the cases (14) were referred to the University Hospital for lameness investigation, while in the remainder (3) a diagnosis of bone spavin had already been made and they were admitted and scanned only for inclusion in this study.

The criteria used for inclusion in the study were:

a) Horses that exhibited a hindlimb lameness and had their tarsi radiographed and scanned with a hand-held probe connected to a portable Scintillation Counter after injection of Tc 99m-MDP.

b) A diagnosis of bone spavin had been made by improvement of the lameness after intra-articular anaesthesia of the distal tarsal joints and/or by the presence of positive radiographic and scintigraphic findings.

One case was included where positive radiographic changes were the only criteria for inclusion, and in which the clinical significance of the changes was not known. In all other cases there was clinical evidence of bone spavin being the main or a contributory source of lameness. Thus, in this study spavin was considered a clinical as opposed to a radiological entity.

All cases received a comprehensive clinical orthopaedic examination, had both tarsi radiographed and their hindlimbs scanned. Post-mortem examination and pathology was carried out in one case.

2.2. Clinical Examination

A full clinical examination was carried out in all cases as part of the routine protocol to which patients admitted to the Veterinary Hospital for lameness investigation are submitted. This included:

2.2.1. Patient History

In each case a full history was taken. The breed, age, sex and use of the animal were recorded. Details were taken of the time and type of onset, duration and

severity of the lameness or complaint; any history of previous accident or injury and previous diagnosis, treatment and subsequent response.

2.2.2. Examination at Rest

This consisted of examining the animal standing on a flat, level surface for assessment of any visual or palpable abnormalities. The shape and balance of the feet were noted, as well as the type of shoeing and any abnormalities in the shoe wear. The conformation of the limbs and back, and any postural abnormalities were recorded. The limbs, and especially the tarsus, were viewed from all angles to identify any abnormal swellings. The hindquarters were viewed from behind with the animal standing in a squared position, and the presence of gluteal atrophy and/or pelvic asymmetry was recorded.

A thorough palpation of the limbs, back and pelvis was carried out subsequently. Special emphasis was placed on joint and synovial distension and on the presence of bony swelling or fibrous thickening of the medial aspect of the distal part of the hock. Any increase in skin temperature was noted. Passive flexion of the individual joints was carried out and resentment was noted.

In cases of reported or suspected back problems examination of the back was also carried out, which included palpation of the spinous processes and longissimus dorsi muscles, and manipulative tests of the spine as described in the standard texts (Stashak 1987). Palpation and manipulation of pelvis, especially tuber coxae and tuber sacrale was carried out when indicated. Faradic stimulation of the spinal and pelvic muscles was carried out in 4 cases.

2.2.3. Examination at Exercise

The horses were observed at the walk and at the trot in a straight line on a flat concrete surface and any gait abnormalities were noted. The degree of lameness at the walk and at the trot was recorded using a 0 to 5 grading system, where 0 represents no lameness and 5 represents non weight bearing lameness. The foot-flight arc of the hindfeet, the site of landing and breakover, the degree of flexion of the hocks and symmetry of gluteal rise were recorded.

Flexion tests were carried out in all joints of the lame and unaffected limbs. This consisted of holding the limb with the relevant joint flexed for one minute and observing the horse trot away from the observer a distance of 30 metres and back immediately afterwards (Taylor 1977; Stashak 1987). The inducement or exacerbation of lameness for more than four or five strides was considered positive

and was recorded. Of special interest was the response to the "Spavin Test" (flexion of the tarsus). Finally, the horse was lunged on a sand surface in a 20 metre circle and was observed for the presence of lameness at the trot on both reins and ,when necessary, at the canter. In selected cases observation of the horse on ridden exercise was carried out. In some cases clinical examination alone provided enough evidence to suggest the involvement of the tarsus; in other situations complementary diagnostic techniques were needed.

2.2.4. Regional and Intra-articular Anaesthesia

When a consistent hindlimb lameness was present and there was no obvious gross abnormality on examination, isolation of the source of lameness was carried out by diagnostic regional anaesthesia, starting at the lower limb and sequentially ascending towards the upper limb. This usually included Abaxial-sesamoid and "Four-point" blocks of the plantar and plantar metatarsal nerves. Desensitization of the tarsus and the structures distal to it was carried out by infiltration of local anaesthetic around the Tibial, superficial and deep Peroneal nerves as described in the standard texts (Stashak 1987). The horses were boxed for 10 min. after the local anaesthetic injection and subsequently troted up for lameness evaluation.

Confirmation of the involvement of the distal joints of the tarsus was achieved by intra-articular anaesthesia of the distal-intertarsal and tarsometatarsal joints. The distal-intertarsal joint was approached from the medial aspect of the hock. After clipping and aseptic preparation of the site, a 1-inch 20-gauge needle was placed in the gap between the central tarsal bone, T2 and T3 and was advanced almost to the hub (Sack and Orsini 1981; Stashak 1987). When synovial fluid appeared in the hub 5 to 7 ml. of 2% Mepivicaine hydrochloride (*Intra-Epicaine, Arnolds Veterinary Products, Romford, U.K.)* were injected until resistance occurred. The same protocol was followed for injection of the tarsometatarsal joint. The needle was placed in the plantaro-lateral aspect of the tarsus, between the fourth tarsal and fourth metatarsal bones, and was advanced in a dorso-distal direction (Sack and Orsini 1981; Stashak 1987; Dyson and Romero 1993). In most cases both joints were injected separately. In one occasion (case no. 5) only the TMT joint was injected. The horses were observed for the presence of lameness 5 an 15 min. after injection of the local anaesthetic drug.

Intra-articular anaesthesia of the tibiotarsal joint was carried out when there was suspicion of tibiotarsal or proximal-intertarsal joint involvement. This joint was approached through the medial aspect of the dorsal pouch of the tibiotarsal joint, distal to the medial malleolus and either plantar or dorsal to the saphenous

vein. Tibial-Peroneal regional anaesthesia was carried out in 9 cases and intra-articular anaesthesia of the DIT and TMT joints was carried out in 8 of the 17 cases.

2.3. Radiographic Examination

Radiographs of the tarsus were obtained from all cases included in this study. In most cases (12/17) both tarsi were radiographed because of the bilateral nature of the condition.

2.3.1 Radiographic Technique

Radiographs were obtained using a large overhead gantry radiographic unit *(Siemens RG125, Munchen, Germany)* or a portable unit *(Omnix N30, X-Ograph Ltd, Malmesbury, U.K.).* 24 x 30 cm. cassettes equipped with rare earth screens *(Cronex Quanta Fast Detail, Dupont Medical Imaging.)* or Ultra-violet emitting screens *(Ultra-Vision Rapid, Dupont.)* were used. The films used with each screen were *Cronex 10S (Dupont)* and *Ultra-Vision G (Dupont)* respectively.

Four standardised radiographic views of the tarsus were taken in every case: Lateromedial (LM), Dorsoplantar (DPl), 35° Dorsolateral-Plantaromedial Oblique (D35°L-PlMO) and 35° Plantarolateral-Dorsomedial Oblique (Pl35°L-DMO). In all projections the beam was centred at the distal-intertarsal joint. The lateromedial projection was taken with the beam angled 10° proximo-distally to avoid overlapping of the DIT and TMT joint spaces (Shelley and Dyson 1984; Butler *et al.* 1993). For the remainder of the projections the beam was directed horizontally.

2.3.2. Radiological Evaluation

The radiographs obtained were evaluated for signs of bone spavin and other pathological conditions. The radiological changes considered indicative of bone spavin were:

- Bone productive lesions including periarticular osteophytes, enthesiophytes and exostosis of the dorsal and dorsomedial cortices of the central and third tarsal bones and the proximal aspect of the third metatarsal bone.
- Lytic or resorptive lesions including joint margin irregularities, areas of subchondral bone lysis and small cyst-like lesions.
- Patterns of sclerosis in the subchondral and medullary bone of the central and third tarsal bones.

- Joint space narrowing and collapse.
- Joint ankylosis

In order to quantify the radiological findings and to be able to correlate them with the scintigraphic data at a later stage, a radiological scoring system was used. The system of scoring was adapted from the one developed by Kellgren and Lawrence for the grading of human osteoarthritis by radiological severity (Theiler *et al.* 1994) and is shown in ***Table 2.1:***

Grade		
0	None	No features of osteoarthritis.
1	Doubtful	Minute osteophyte, doubtful significance.
2	Minimal	Definite osteophyte, unimpaired joint space.
3	Moderate	Moderate diminution of joint space.
4	Severe	Joint space greatly impaired with sclerosis of the subchondral bone.

The criteria for grading was slightly modified from the original due to the unique characteristics of the radiographic changes of bone spavin. No distinction was made between bone productive and lytic radiographic changes when assigning the radiological scores. A single small osteophyte was considered of doubtful significance (grade 1), and so were slightly larger enthesiophytes found on the proximal border of the third metatarsal bone. The presence of lytic lesions in the subchondral bone was warranted a score of 3 or more. Partial or total obliteration of the joint space was given a score of 4.

A score from 0 to 4 was assigned to the individual PIT, DIT and TMT joints of every tarsus radiographed. Then a score for the whole tarsus was obtained by adding the scores of the three joints, and finally, a total score was obtained by adding the scores of both tarsi.

2.4. Gamma-Scintigraphic Examination

All horses in this study had their hindlimbs scanned with a hand-held probe connected to a scintillation counter as part of the diagnostic procedure. All horses were scanned after a full clinical examination had been completed. In 6 out of the 17 cases scintigraphy was carried out immediately after clinical examination and before a diagnosis had been reached. In the other 11 cases scintigraphy was carried out after clinical and radiographic examination suggested a diagnosis of bone spavin. When regional nerve blocks or intra-articular anaesthesia had been carried out the scintigraphy scan was postponed for a minimum of 10 days to avoid interference in the isotope distribution.

Bone phase scintigraphy was carried out in all (17) cases, while soft tissue phase scintigraphy was carried out in 9 cases. In all cases both entire hindlimbs were scanned. In 12 cases a detailed scan of the tarsi was carried out to complement the whole limb scan. In cases where pelvic or back problems were reported or suspected, pelvic and spinal scans were carried out in addition to the hindlimb scans. Eight horses included in this study received a pelvic scan, and the same number received a spinal scan. The forelimbs were scanned in 2 horses.

2.4.1. Equipment

The equipment used to carry out the procedure was a portable Scintillation Detector connected to a hand held probe (*Scaler-Ratemeter SR5, Nuclear Enterprises Ltd. Beenham, England*). The probe (Figs. 2.1. and 2.2.) consists of a sodium iodide (NaI) crystal of 1" in diameter and 1" thick connected to a photomultiplier tube. The crystal is collimated by a parallel hole lead collimator of 1" in diameter and 2" in length, which provides a considerably narrow collimation. The lead shield of the collimator is of approximately 0.5" thickness .

The probe is linked to the main electronics and display device (Fig. 2.1.) consisting of a high voltage generator, supplying power (0-2 KV.) to the photomultiplier tube, a linear pulse analyser with its own amplifier, a ratemeter and a scaler/timer. The ratemeter displays the counts/second rate (range 40 - 10^4 c.p.s.). The scaler or counter displays the total number of counts (scintillation events) registered during a preset time. The sample time range can be adjusted from 10 sec. to 10^5 sec.. The scintillation detector had to be calibrated to the photopeak period of the injected isotope before each scan.

Figure 2.1. *Portable Scintillation Detector and hand held probe used in this study.*

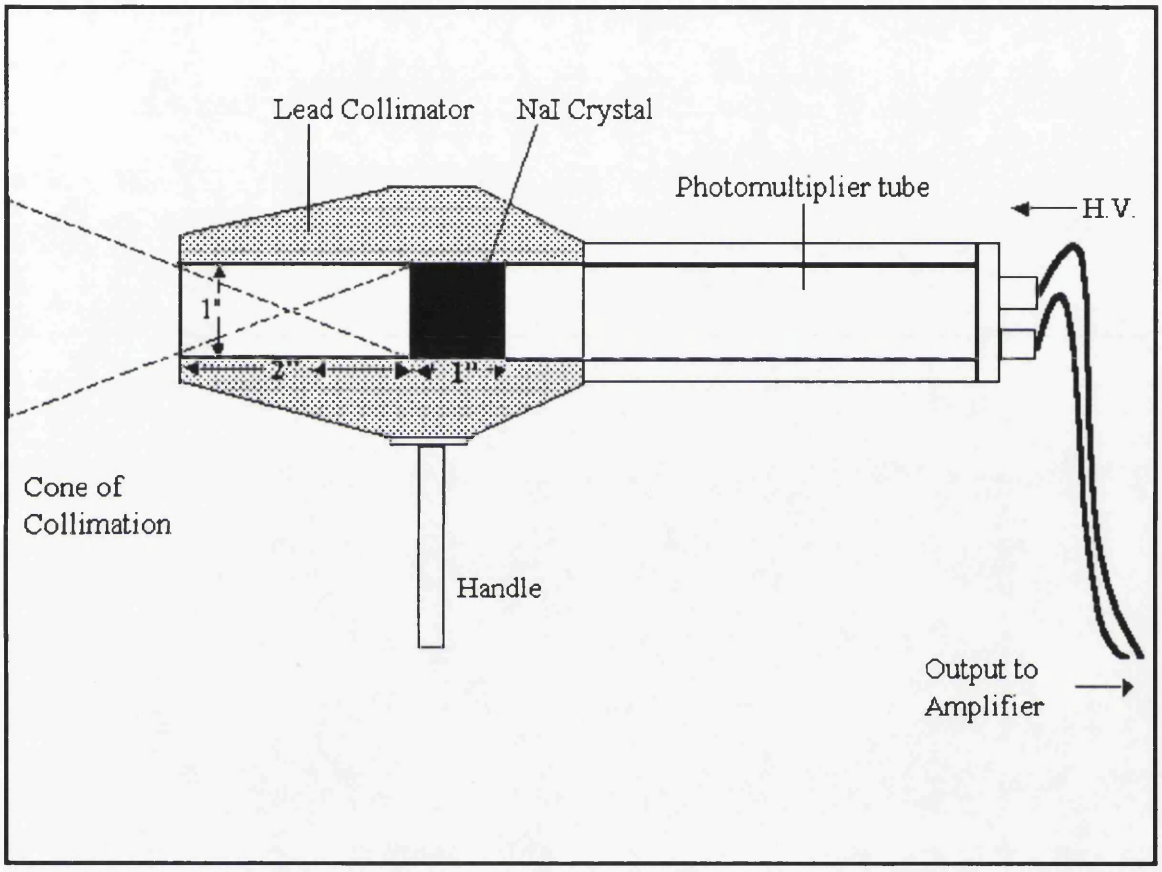


Figure 2.2. *Diagram of the hand held probe used in this study. Note the large collimator and the relatively tight collimation.*

2.4.2. Scanning Agent

The only scanning agent used was Technetium 99_m (Tc 99_m) labelled with methylene diphosphonate (MDP). The isotope was supplied by the *West of Scotland Radionuclide Dispensary* of the *Western Infirmary*, Glasgow, in the form of a 5 ml suspension. The isotope suspension was delivered to the Veterinary Hospital in a lead container, where it was stored for no more than 2 hours prior to injection. A dose of 2 Megabequerels per Kilogram (Mbq./kg.) and up to a maximum of 1000 Mbq. per animal was used.

2.4.3. Injection Technique

The animal receiving the isotope injection was confined in one of the two boxes designated for the purpose. A 14-gauge, 8 mm. teflon intravenous catheter *(Intraflon 2, Vygon, Ecouen, France)* was inserted in the jugular vein of the horse prior to injection. The isotope was drawn from the container in a 5 ml syringe covered by a tungsten shield *(Unilock, Bio-Nuclear Services Ltd., Stratton, U.K.)* and injected into the animal via the catheter.

When a pelvic scan had to be performed the animal was injected with a diuretic *(Lasix 5% solution, Hoechst Animal Health, Walton, U.K.)*. This was originally done at the time of isotope administration to prevent pooling of excreted $Tc99_m$-MDP in the bladder and the creation of artifacts (Pilsworth and Holmes 1992). Later the time of injection of the diuretic was postponed to just after the soft tissue scan to prevent the animal from emptying the bladder when the latter was being performed, and also because very low counts had been obtained on some occasions due to early diuresis and excretion of the isotope from the circulatory system. In some cases the feet of the horse were covered with polyurethane bags to avoid contamination with radioactive urine, which could give false positive results.

2.4.4. Scanning Technique

The scanning took place in the area adjacent to the designated box, which together with the box constituted the radiation controlled area. To facilitate the procedure and due to the relatively long counting time, the horse was mildly sedated unless very quiet. A combination of Detomidine *(Domosedan, SmithKline Beecham animal health, Tadworth, Surrey.)* at a dose rate of 10 µg./Kg. and Butorphanol *(Torbugesic, Willows Francis Veterinary, Crawley, West Sussex.)* at a dose rate of 0.025 mg./Kg. was used. The horse was then tied with a quick-release knot to a

loop of string on a wall ring located immediately outside the designated box. Horses of a fractious nature were held by an assistant during the procedure.

Scintigraphy Phases

In most cases the scintigraphic examination consisted of a Soft Tissue (Phase II) and a Bone Phase (Phase III) scan. Soft Tissue Phase Scans were carried out 25 min. post-injection (Mitsopoulos 1992), and delayed Bone Phase Scans 3 hours post-injection. In some instances a repeat Bone Scan was carried out 22 hours post-injection.

Scanning Protocol

A rigid scanning protocol was adopted to ensure consistent and repeatable results (Attenburrow *et al. 1984*; Pilsworth 1989; Pilsworth and Holmes 1982). The actual method of scanning consisted of placing the probe in contact with the skin on a series of predetermined points along both limbs of the horse and recording the amount of radiation emitted at each point before moving onto the next. The predetermined points were easily identifiable anatomical landmarks so that the exact location could be reproduced when sampling the contralateral limb. The probe was held perpendicular to the anatomical structure being sampled so that the area of interest was at the centre of the cone of collimation, and care was taken to reproduce the exact orientation of the probe as well as the position when sampling mirror points in both limbs. The sampling time was 10 seconds for soft tissue and bone phase scans and 30 seconds for scans carried out 22 hours post-injection.

When performing a soft tissue phase scan individual points were sampled alternately from one leg and the other before moving onto the next point. This was done to avoid causing a distortion of the results due to the time lag. If all the points were sampled in one leg first and then the other, the post-injection time difference would result in a net disparity between the counts of the two legs due to clearance of the isotope from the soft tissues and, to a lesser extent, isotope decay.

This procedure proved unnecessary for bone phase scans, where isotope concentration in bone tissue is much more constant. Nonetheless, the point sampling was alternated among the two legs at least once in the course of a bone scan.

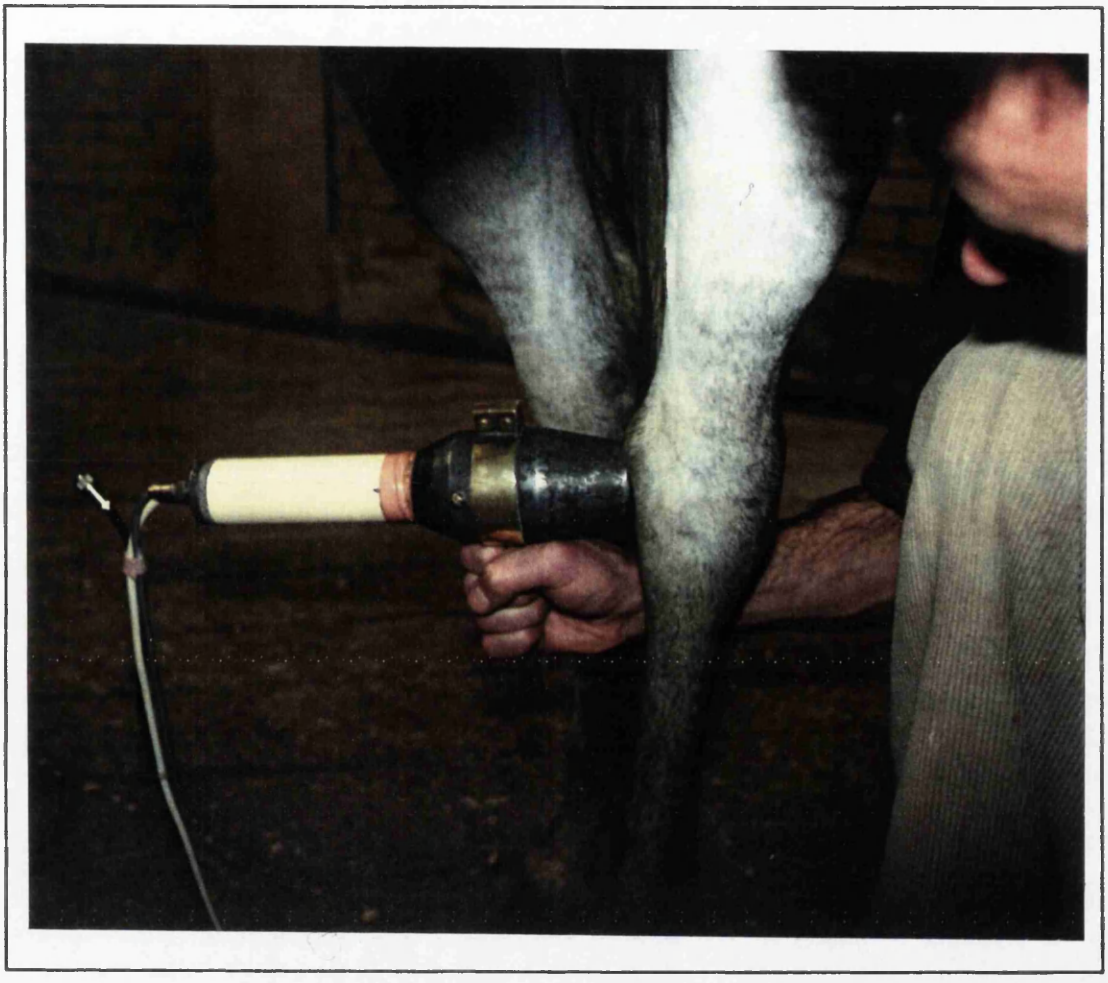


Figure 2.3. *Scanning the tarsus with the hand held probe.*

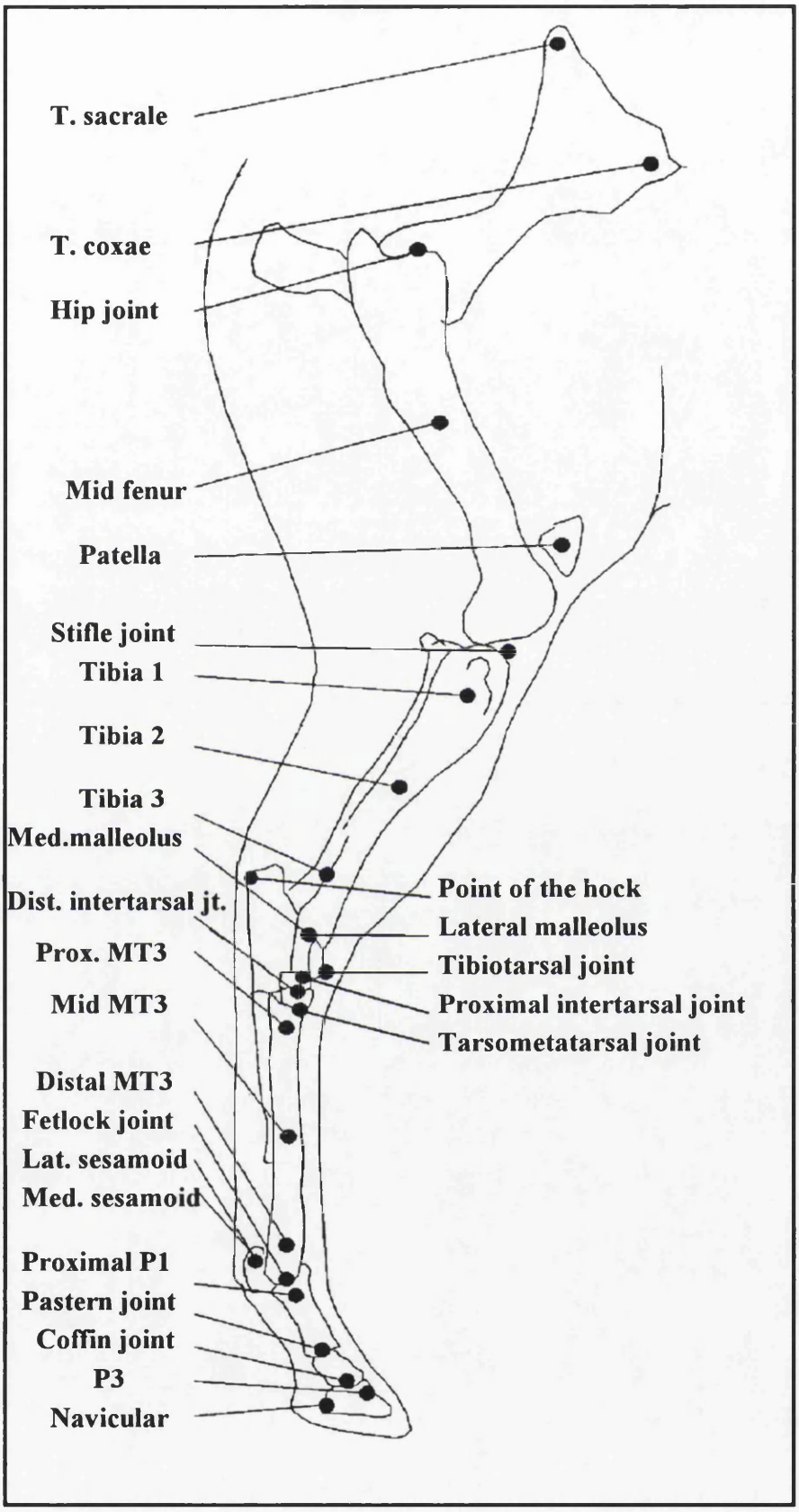


Figure 2.4. *Diagram showing the anatomical points sampled in a routine hind limb scan. The probe is held in contact with the skin and perpendicular to the structure being sampled for 10 seconds at each site.*

Reference Counts

A reference count from a pre-established neutral point was recorded prior to the skeletal scan in order to provide a means of standardisation of absolute counts, which could be then expressed as a percentage ratio of the reference count. The reference point was the wing of the atlas for the bone phase and the pectoral muscle for the soft tissue phase. These points were chosen because of their ease of accessibility and relatively infrequent involvement in musculo-skeletal disease.

Hindlimb Scans

The hindlimbs were scanned first in all cases presented with hindlimb lameness. The 27 anatomical points sampled in a routine hindlimb scan are shown in Fig 2.4. The points were slightly modified during the progress of the study until an optimal protocol was developed. Once that was achieved the protocol was repeated in every new case, allowing the author to become familiarised with it and to obtain more consistent results.

The position of the probe in every point was such that there was minimum amount of soft tissue between the bone and the collimator. In this way, tuber sacrale, tuber coxae and the hip joint were sampled at the sites where they were most readily palpable, and holding the probe perpendicular to the skin. The femur was sampled on the third trocanter, the points over the tibia were sampled medially and the points over the metatarsus, fetlock and phalanges were sampled dorsally. The stifle was sampled dorso-laterally - over the lateral femoral condyle, the PIT joint was sampled dorsally, the DIT joint medially and the TMT joint laterally. The proximal sesamoid bones were sampled abaxially and the navicular bone caudally.

Tarsal Scans

Once a hindlimb scan had been completed a more detailed scan of the tarsus could be carried out to complement it. The points of the tarsal scan are shown and described in Fig. 2.5. Note that this time all three distal tarsal joints were sampled medially, on the site of most probable pathology.

Pelvic, Spinal and Forelimb Scans

When the pelvis and spine were scanned a grid made out of masking tape was used to facilitate the location of the sampling points. The pelvic grid consisted of 110 or 70 points and the spinal grid of 39 points.

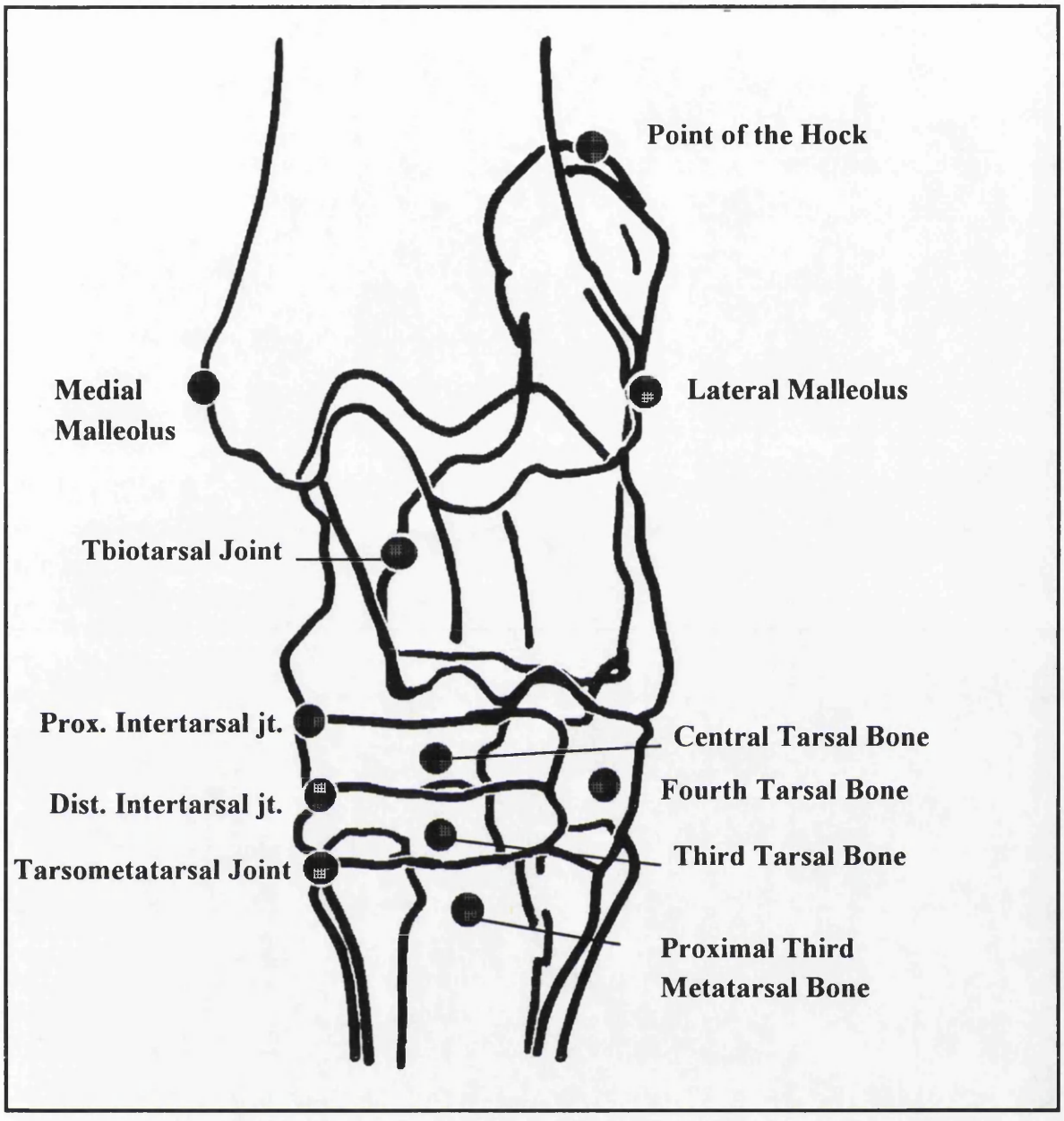


Figure 2.5. *Diagram showing the anatomical points in the tarsus where the probe is placed for radiation counting. The tibiotarsal joint is sampled on the medial trochlear ridge of the talus. The proximal-intertarsal, distal-intertarsal and tarsometatarsal joints are sampled on the medial aspect of the hock. The central and third tarsal bones are sampled dorsally and the fourth tarsal bone is sampled laterally.*

The scanning method for the pelvis and back used in the cases of this study has been described (Pilsworth and Holmes 1992; Mitsopoulos 1992; Pilsworth, Holmes and Shepherd 1993). The forelimbs were scanned in an identical manner as the hindlimbs.

2.4.5. Data Processing and Display

The basis of the data processing method adopted in this study was developed by Pilsworth and Holmes, and has been described (Pilsworth and Holmes 1992).

The counts registered at each point were recorded on a standard form, together with the reference count and patient details (Figs. 2.6. and 2.7.). There are no absolute values for the quantity of isotope uptake at a specific point of the skeleton, this being dependant on the dose, size of the horse, age, temperature and many other variables. This being the case, the raw data collected with such a method is quite meaningless and only very obvious focal increases can be recognised that way. The data needs to be manipulated to enable relative increases in isotope uptake to be detected. This was achieved firstly by calculating the ratio of the individual counts to the reference count (atlas or pectoral muscle) and expressing it as a percentage. These reference count ratios provide a rough means for comparison between different sites in one horse and between horses, although considerable differences may still exist. The second step was to calculate the differences between counts taken on pairs of sample points (one for each leg) and express them as a percentage increase over the normal side:

% (Abnormal side - Normal side) / Normal side

This allowed the author to localise the site of maximum relative increase in isotope concentration. When comparing the pairs of counts taken on each leg it was assumed that in the normal horse the radiotracer distribution is symmetrical and any unilateral relative increase is abnormal.

At the beginning of this study the data was processed manually. Later a commercial worksheet program (*EXCEL 4, Microsoft Corporation.)* on a personal computer *(IBM Personal System 2, Model 70-386)* was used to do the calculations and graphically display the results. For every region routinely scanned (hindlimbs, forelimbs, pelvis, back, tarsus...) a work-sheet was developed that would automatically make the calculations and produce a print out report.

Gamma-scintigraphy report. Hindlimbs

Name:
Case no.:
Reference counts: *Atlas:* *Date:*
Pectoral m.: *Soft / Bone tissue scan*

COUNTS	*SOFT TISSUE PHASE*		*BONE PHASE*	
	Left	*Right*	*Left*	*Right*
Tuber sacrale				
Tuber coxae				
Hip joint				
Mid femur				
Patella				
Stifle joint				
Tibia 1				
Tibia 2				
Tibia 3				
Med. malleolus				
Lat. malleolus				
Point of hock				
Tibiotarsal joint				
Prox. IT joint				
Distal IT joint				
TMT joint				
Prox. MT3				
Mid MT3				
Distal MT3				
Fetlock joint				
Med. sesamoid				
Lat. sesamoid				
Prox. P1				
Pastern joint				
Coffin joint				
P3				
Navicular				

Figure 2.6. *Form used to record the Gamma-Scintigraphy data of the hindlimbs.*

Gamma-scintigraphy report ***Tarsus***

Name:
Case no.:
Date:

Reference counts: *Atlas:*

Pectoral m.: *Soft / Bone tissue scan*

COUNTS	***SOFT TISSUE PHASE***		***BONE PHASE***	
	Left	*Right*	*Left*	*Right*
Med. malleolus				
Lat. malleolus				
Point of hock				
Tibiotarsal joint				
Prox. IT joint				
Central tarsal bone				
Distal IT joint				
3rd. tarsal bone				
4th. tarsal bone				
TMT joint				
Proximal MT3				

Figure 2.7. *Form used to record the Scintigraphy data of the Tarsus.*

The printed report consisted of two pages (see appendix A for examples) the first of which contained a table displaying: **(a)** the counts recorded at each point for each leg, **(b)** the reference count ratios (for each leg), and **(c)** the differences between pairs of points calculated over the right and left legs, all expressed as percentages. Of the last two sets of values only the one calculated over the normal leg, be it the right or the left, is relevant. Mean reference count ratio values for each leg (or tarsus in tarsal scans), mean increases of each leg over the contralateral leg and the mean difference between sample points were also calculated and displayed. The report displays the values of **(b)** (Page 1) and **(c)** (Page 2) as histogram charts that permit a rapid graphic visualisation of any asymmetric isotope distribution and its point of maximal increase (Page 2), and any abnormal bilateral distribution (Page 1).

2.4.6. Radiation Safety

The scanning procedures were carried out in accordance with The Ionising Radiations Regulations 1985 (Health and Safety at Work Act) and The Radioactive Substances Act; and the advise given by the University of Glasgow Radiation Protection Service was followed.

The isotope was delivered by a licensed driver and stored in a lead shielded container for a maximum of two hours before being used. All staff that carried out the scans or handled the horse wore lead aprons, whole body thermoluminescent dosimeters and on regular occasions finger film dosimeters. When handling the isotope, protective gloves and clothing was worn in addition. The maximum amount of radiation recorded on the dosimeters was of 0.1 mSv.

Horses injected with radioisotope were isolated into one of the two designated boxes, that had been modified to prevent spillage of contaminated urine outside the box. A radiation sign was placed on the box door and nobody was allowed in the controlled area, which constituted the box and and a 2 m. area around it, except at the time of scanning. The horse was kept in isolation for 72 hrs. post-injection. The contaminated bedding was allowed to decay for 7 days before it was disposed of in the usual way. All contaminated gloves, syringes and other material were stored in a lead lined container until the radioisotope had decayed.

A full record was kept of all isotope used and all scintigraphy scans carried out. No more than two scans per week were carried out on any occasion.

2.5. Pathology

A post-mortem and pathological examination was carried out in only one case (case no. 13), that was destroyed in the Veterinary Hospital at the owner's request due to the diagnosed pathology in the tarsal bones and other concomitant conditions. After euthanasia both tarsi were obtained by separating them from the leg at the level of the distal tibia and proximal metatarsus. The entire tarsus was then sawn in several slab sections of approximately 7 mm. in thickness in a dorsomedial to plantarocaudal direction. The sections were then examined macroscopically, microscopically, radiographed and observed for oxytetracycline fluorescence. Post-mortem examination of the rest of the carcass was also carried out.

2.5.1. Macrophotography

High magnification (x 6.3) photographs were taken of selected areas of the bone sections using a macrophotography camera *(Wild Photomakroscop M40)* and high detail 55 mm. black and white film *(Ilford FP 4 plus 125 ISO).*

2.5.2. Oxytetracycline Labelling and Fluorescence

Tetracyclines have the property of becoming bound to osteoblasts at sites of active bone production (MacCallum *et al.* 1971), and of producing a bright yellow fluorescence when viewed under ultra-violet light (Holmes 1963). Due to these two properties oxytetracycline has been extensively used as a marker in bone growth and pathology studies (Holmes 1963; MacCallum *et al.* 1971).

In this case oxytetracycline was used to try to mimic the distribution of the MDP-technetium in the affected tarsal bones, which had shown a significant isotope accumulation in the bone scan. The purpose of this was:

a) To prove that a high count detected on probe-point bone scintigraphy in a specific site is associated with an increased bone activity at that site.

b) To determine which are the sites of active bone remodeling and new bone formation in the tarsal bones when a high MDP-Technetium uptake is detected, especially, as in this case, when there is little change in the radiographic appearance of the affected bones.

The animal was injected with two doses of 15 mg./kg. of oxytetracycline hydrochloride *(Terramycin Q-100 injectable solution)* two and four days prior to

destruction. Once the sections of the right hock were obtained they were viewed under a 100 watt ultra-violet lamp (Wood's lamp) and oxytetracycline fluorescence was looked for.

The sections were photographed in a dark room under the sole illumination of the Wood's lamp. A conventional *reflex* camera fitted with a 50 mm. lens was used. The film used was a 35 mm. high-speed colour reversal film balanced for day light *(Kodak Ektachrome-X 400 ASA)*. To stop excess ultra-violet light reaching the film an ultra-violet light absorbing barrier filter *(Kodak Wratten filter No. 2A)* was mounted on the camera lens. No exciter filter was used.

2.5.3. High-Detail Radiography Sections

High detail radiographs of each section were taken using a portable radiographic unit *(Omnix N30, X-Ograph Ltd.)*. A combination of high-detail (mammography) screens and films *(Microvision TM, Dupont Medical Imaging)* were used.

2.5.4. Histology

The bone sections were decalcified in a 10 % formic acid solution. The areas of major interest, which were the dorso-medial aspect of the sectioned central tarsal, third tarsal and proximal end of the third metatarsal bones, were trimmed down to blocks of a small size, embedded in paraffin and sectioned at a thickness of 6 μm.

The histological sections were stained with safranin-O., cereus-red or hematoxylin-eosin, examined under the microscope and photographed.

2.6. Statistical Analysis

The data generated by the scintigraphy scans was correlated to the radiological scores of the tarsal joints and to the grade of lameness exhibited by the horse at examination.

The correlation between scintigraphy and radiography was estimated by calculating the correlation coefficient - **r** - (Sard 1987) between to sets of variables: the radiological score and the reference count ratio. A correlation coefficient was calculated separately for each of the PIT, DIT and TMT joints of each tarsus; for the whole left tarsus and the whole right tarsus. The coeficient of correlation of the whole tarsus was obtained by using the mean values (radiographic and scintigraphic) of the 3 joints. The correlation was calculated for both soft tissue phase and bone phase scintigraphy.

The correlation between scintigraphy and clinical signs (lameness) was estimated by calculating the correlation coefficient between the degree of lameness (graded from 1 to 5) and degeree of isotope uptake increase. To represent this parameter, the greatest difference between the counts of any pair of points in the tarsus over the normal count (value **[c]** in the scintigraphy report) was used. This correlation was also calculated for soft tissue phase and bone phase scintigraphy.

The correlation coefficient can range from -1 to +1. A correlation coeficient of $r > 0.7$ was considered good correlation, $0.4 < r < 0.7$ was considered moderate correlation and $r < 0.4$ was considered poor correlation. The calculations were made using a commercial computer software worksheet *(EXCEL 4, Microsoft Corporation).*

CHAPTER 3:

RESULTS.

3.1. Clinical Cases

Case no. 1.

A 12 year old Thoroughbred gelding formerly used for Show-jumping presented with an intermittent low-grade lameness of the right hind leg. This horse exhibited the typical clinical signs of bone spavin, with decreased flexion of the hocks, toe dragging and bringing the right hind leg across the midline of the track. Flexion tests were positive in both hindlimbs and there was a bony swelling at the "seat of spavin" of the right tarsus. Radiographically there were advanced osteoarthritic changes in the distal-intertarsal joints of both tarsi, with almost complete ankylosis, but with extensive areas of bone lysis still present. The TMT joints had early degenerative changes. The diagnosis of bone spavin was reached on a clinical and radiological basis only. The horse was subsequently scanned at 25 minutes, 3 and 22 hours post-injection of the radiotracer and significant increases of isotope uptake were detected in the right tarsus.

Follow up included two clinical and radiological examinations 6 and 12 months later and a second bone scan at 6 months. There was little improvement of the clinical symptoms and minimal progression of the radiographic changes. On the other hand, a slight decrease in isotope uptake was noticed on the second scan when compared with the first.

The results of the soft tissue scan of the tarsus and a print of a 35°DL-PlMO radiograph of the right tarsus are included in appendixes A and B respectively.

Case no. 2.

A 7 year old Irish Draft mare used for general riding presented with a sudden onset right hind leg lameness. The lameness improved after both Tibial-Peroneal nerve block and intra-articular anaesthesia of the right TMT and DIT joints. Radiography of both hocks revealed early changes only in the TMT and DIT joints of both tarsi. Scintigraphy was performed one week after the nerve blocks and revealed a very high concentration of radiotracer in the right TMT joint. This confirmed the diagnosis of bone spavin. The mare was retired.

The results of the bone scan of the tarsus and a print of a 35°DL-PlMO radiograph of the right hock are included in appendixes A and B.

Case no. 3.

A 7 year old Thoroughbred mare used for dressage and show-jumping presented with lameness involving the fore and hindlimbs. This horse had previously been diagnosed as having pelvic and cervical vertebral problems and had received osteopathic treatment. The forelimb lameness improved after a low four point nerve block of the left fore leg. The right hind leg lameness improved after a Tibial-Peroneal nerve block and again after intra-articular anaesthesia of the DIT and TMT joints. Radiography demonstrated periarticular spurs in the DIT and TMT joints of the right hind leg and degenerative changes in the left fore fetlock.

Scintigraphy demonstrated significant increases in isotope concentration in the left fore fetlock and right hind distal tarsus. Scintigraphy of the back and pelvis revealed no abnormalities. A diagnosis of osteoarthritis of the left fore fetlock and right hind bone spavin was reached and the mare was retired to stud.

Case no. 4.

A 9 year old Thoroughbred Show-jumper presented with a complaint of decrease in performance and refusal to jump. The referring Veterinarian had diagnosed a lumbar spine problem and the horse had been treated with rest and back manipulation prior to admission.

On examination the horse was found to be 1/5 lame on the right hind leg at the trot. Regional (Tibial-Peroneal) and intra-articular (DIT and TMT joints) anaesthesia was carried out and localized the source of lameness in the distal tarsal joints. On radiography there was only early degenerative changes in the right distal tarsus, with sclerosis and mild irregularities in the subchondral bone plate of the central tarsal bone, slight lipping of the DIT joint and enthesiophyte formation in the proximal MT3.

Scintigraphy performed on the back, pelvis and hindlimbs revealed a significant isotope concentration in the right distal tarsal joints. No abnormalities were found in the back or pelvis.

The horse was put on a controlled exercise programme and shod with lateral extension shoes in the right hind. It was re-examined 5 and 9 months later, during which time little progress had been made either clinically or radiographically. At this stage surgical arthrodesis of the affected joints was undertaken. The horse became reasonably sound after 1 year post-operatively.

Case no. 5.

A 7 year old Thoroughbred gelding used for eventing was presented with a history of hindlimb gait abnormalities following a fall at a cross country event. On the first examination the horse was 1/5 lame in the left hind leg at the walk. At the trot it exhibited a short and stiff stride on both hindlimbs, with a reluctance to bend the back and a rolling pelvis. On the lunge there was a slight right hind lameness in the right rein and possibly a left hind lameness on the left rein. At the canter the horse exhibited a disunited gait and a stiff back.

Due to the suspicion of a pelvic and/or spinal problem and the difficult temperament of the horse, no nerve blocks were carried out. The horse had soft and bone tissue scintigraphy performed on the back, pelvis and hindlimbs. The results showed a mild increase in Tc 99 uptake in the left sacroiliac area. There was also a "hot" area in the right distal tarsus. On radiography of the tarsus the presence of changes consistent with spavin was doubtful. At this stage the diagnosis was of a left sacroiliac strain and a clinically silent right hind spavin.

The horse was re-examined 5 months later. At this point it exhibited a 1/5 right hind leg lameness at the trot which improved after intra-articular anaesthesia of the TMT joint. The left hind lameness had disappeared. This case exemplifies the usefulness of scintigraphy in the detection of early or pre-clinical bone spavin. It also demonstrates the possible relationship between bone spavin and pelvic-spinal problems. The horse was re-scanned 10 months later to monitor the progress of the condition. Although the results were difficult to interpret due to a generalised increase in uptake in the entire left hind leg, there was still comparatively higher than normal activity in the right hock.

Case no. 6.

A 10 year old Arab cross gelding formerly used as a hack and retired since the onset of the problem about 5 months previously, presented with a 2/5 left hind leg lameness at the trot and an obvious palpable and visible swelling over the "seat of spavin" of the right hind leg.

Radiographs demonstrated advanced degenerative changes in the DIT and TMT joints of the right tarsus. Scintigraphy confirmed the high degree of bone activity in this joints, the left DIT joint being the most active.

Case no. 7.

A 7 year old Thoroughbred cross gelding used for dressage was presented with a long standing history of stiffness of the left hind leg and changes in hindlimb gait and flexibility of the back. The horse had previously been diagnosed as having suffered a sacroiliac strain and had received physiotherapy. On examination there was a slightly asymmetric pelvis with the right tuber sacrale higher than the left and some degree of left sided gluteal atrophy. There was a very slight left hind lameness and stiffness at the walk and at the trot. There was a positive response on flexion of the left hind fetlock. When the horse was ridden, a lack of impulsion, disunited gait and dropping of the left side of the pelvis were noted.

Bone and soft tissue scintigraphy of the back, pelvis and hindlimbs was carried out. The results showed an asymmetrical isotope distribution in the sacroiliac region and high increases in the left hind fetlock and right hind DIT joint. Radiography of both hocks and hind leg fetlocks revealed osteoarthritis of the left fetlock joint and spavin changes in the right DIT and to a lesser extent the TMT joints. Intra-articular anaesthesia of the left hind fetlock decreased the lameness but did not alter the other gait abnormalities. The diagnosis was of sacroiliac instability, lumbar pain, osteoarthritis of the left hind fetlock and a clinically silent bone spavin in the right hock.

Following a 2 month period of rest and physiotherapy the horse was represented for examination. At that time the left hind lameness and the lumbar pain had improved but a right hindlimb lameness with the characteristics of a classical spavin gait had appeared. The horse was re-introduced to a graduated exercise programme and shod with a lateral extension shoe on the right hind foot. On consecutive examinations over the period of one year the radiographic changes in both hocks progressed considerably to almost complete obliteration of the DIT joint spaces.

Case no. 8.

A 10 year old Connemara X Welsh pony used for pony club activities, including jumping, presented with a right hind lameness of 5 months duration. The gait characteristics were typical of a unilateral bone spavin, and there was a large, hard swelling on the dorso-medial aspect of the right hock. A Tibial-Peroneal nerve block and intra-articular anaesthesia of the DIT and TMT joints reduced the lameness considerably. On the radiographs of the right hock there were large

exostoses bridging the TMT joint and extensive areas of lysis in the subchondral bone of the DIT joint.

Scintigraphy was carried out after the diagnosis of bone spavin had been achieved by conventional means, and showed a marked increase in isotope concentration peaking in the right TMT joint. Follow up examinations 4 and 8 months later revealed a slight progression in the radiographic appearance, mainly consisting of increased bone lysis. There was no improvement of the lameness.

Case no. 9.

A 9 year old Show jumper with a history of breaking out of canter when on the right rein and stiffness in the right hind leg was referred for scintigraphic examination of the back, pelvis and hindlimbs. A full clinical examination was not carried out. The referring veterinarian had found pain on palpation of the lumbar area, and the horse had received physiotherapy on the back.

Bone scintigraphy revealed a moderate increase in Tc 99 uptake centred in the 5th. lumbar vertebrae and a more significant increase centred in the right DIT joint. Radiography of the back revealed fusion of the spinous processes of L5 and L6. Radiography of the right tarsus demonstrated only doubtful signs of osteoarthritis in the DIT joint. In this case the diagnosis of bone spavin was achieved on the basis of the scintigraphic findings.

Case no. 10.

A 14 year old riding pony presented with a history of intermittent right hind leg lameness of 3 months duration. The lameness improved after a Tibial-Peroneal nerve block. Radiography of the right tarsus showed mild changes in the TMT and DIT joints consistent with early bone spavin.

Scintigraphy was carried out twice, the first time having to be abandoned because of a generalised increase in the contralateral limb masking the results. The second bone scan carried out 4 months later showed a significant increase of Tc 99 concentration in the medial and dorsal distal left tarsus.

Case no. 11.

A 12 year old Thoroughbred X Arab mare used for general riding presented with a bilateral stiffness in the hindlimbs. The mare also had shown sensitivity over the lumbar area for the past two years. On examination the mare was slightly lame on both hind legs but mainly (1/5) on the right.

In view of the history and clinical signs scintigraphy was carried out on the back, pelvis and hindlimbs. The results of the pelvic scan were within normal limits. On the hindlimb scan there was a "hot spot" in the right proximal metatarsus and an area of similarly increased uptake in the distal left tarsus.

The right hind lameness did not improve after a Tibial-Peroneal nerve block, but was abolished after a subtarsal nerve block, leaving a residual left hind lameness that was too mild to attempt to block. Radiography and ultrasonography of the right proximal MT3 and adjacent structures revealed no abnormalities. There were, however, very early osteoarthritic changes in the DIT joints of both hind legs and in the left TMT joint. A provisional diagnosis of injury to the proximal cannon region of the right hind leg and early left hind leg spavin was made. Follow up of the mare was lost.

Case no. 12.

A 17 year old thoroughbred cross gelding presented with history of a possible "back problem" of 8 week's duration. On examination it was noted that the horse was clearly lame on the right hind leg and exhibited the typical characteristics of a bone spavin lameness. There was a moderate thickening of spavin region on the right hind leg.

Radiography revealed advanced osteoarthritic changes in both tarsi, with partial loss of joint space and large exoxtoses. Scintigraphy showed large concentrations of radiotracer in both tarsi, the right TMT joint being the highest (200% of the atlas count).

Case no. 13.

An 8 year old Thoroughbred cross mare used for hunting after having abandoned an eventing career due to navicular disease, was presented with a right hind leg lameness of 3 months duration. The lameness appeared after hunting and was severe initially. At the time of presentation the mare was only 0.5/5 lame at the trot, but very uncomfortable at the canter, constantly changing lead, "bunny hopping" and breaking out of canter. A mild pelvic asymmetry was also noted.

A complete scintigraphic investigation of the pelvis, spine and hindlimbs was carried out. The results showed a diffuse area of increased isotope uptake in the sacroiliac region, a mild focal increase in the lumbar spine and a very marked increase in right hock, centred in the DIT joint. Radiography of the hock revealed small cystic lesions and discrete periarticular new bone formation in the DIT joint.

Due to the concurrence of this pathology with previously diagnosed problems (navicular disease, malignant melanomas in perineal region) the mare was destroyed. Necropsy revealed a fused 4th. and 5th. lumbar vertebrae and a non displaced incomplete fracture of the central tarsal bone with secondary changes in the DIT joint. A complete description of the pathological findings is given in a different section, and the scan reports of the hindlimbs, back and pelvis are included in appendix A.

Case no. 14.

A 29 year old Dales pony that had been used in the past to pull a cart was presented with a chronic intermittent lameness that have been present for 5 years and an obvious bony swelling on the medial right hock.

Radiographically there was almost complete fusion of the DIT and TMT joints and osteoarthritic changes in the PIT joint. Scintigraphy demonstrated a high degree of bone activity still present in the area.

Case no. 15.

A 10 year old Thoroughbred cross eventer was admitted to the Veterinary Hospital 1 month after having suffered a heavy fall at a cross-country event. The horse was very stiff and unwilling to move after the accident, and at the time of presentation it had severe bilateral muscle wastage and bilateral hindlimb lameness. On scintigraphy, several areas of increased isotope concentration were found in the back, ribs, left tibia and especially the right hip region. The whole left hind leg had a generalised increase in uptake, presumably due to increased weight bearing on that leg. No increased activity was detected in the hocks. Radiography revealed no abnormalities apart from moderate bone spavin changes in both hocks. The horse was eventually destroyed and at post-mortem examination a fractured greater trochanter was found in the right femur, accompanied by osteoarthritis of the right hip joint.

This case demonstrates how positive radiological evidence of bone spavin can be accompanied by negative clinical and scintigraphic findings.

Case no. 16.

An 11 year old mare used for show-jumping presented with a sudden onset of lameness in the right hind leg. By means of regional (Tibial-Peroneal) and intra-articular (DIT and TMT joints) anaesthesia, the source of lameness was located in

the DIT and TMT joints. Improvement of the right hind lameness revealed a left hind lameness that also improved after anaesthesia of the TMT joint. Radiography failed to reveal any significant pathology in the region. A soft tissue and bone scan performed two weeks later showed a normal bone activity pattern throughout both hind legs. The mare was retired and was not available for follow-up examinations.

Case no. 17.

A 6 year old Irish draft gelding used for eventing presented with a very slight right hind lameness, decreased hock flexion and toe dragging that improved after anaesthesia of the DIT and TMT joints. Soft tissue and bone scintigraphy did not reveal any abnormalities, but radiography of the hocks showed significant changes in the right distal tarsal joints. This is the second case with positive radiological and negative scintigraphic findings.

3.2. Clinical Features

3.2.1. Signalment and History

The signalment and history are recorded in tables 3.1 and 3.2 respectively.

A wide range of breeds were represented in this study, ranging from Thoroughbreds to Draft horses and Ponies. The greatest proportion (8/17) were Thoroughbred crosses. The mean age was 10.8 years, and the range was 6 to 29 years. Five of the 17 (30%) horses were 7 years old or less. The sex distribution was 12 geldings (70%) and 5 mares. Most of the horses (10/17) were, or had been, involved in competitive activities. Four horses were eventers and 6 were show-jumpers.

Nine of the 17 horses were referred because of an overt hindlimb lameness, the remaining complaints being: stiffness in the hind limbs (4 horses), back problems (4), toe dragging (1), and traumatic injury (1). A decrease in performance and/or refusal to jump was reported in 4 cases. In 7 cases (41.2%) the back was mentioned as possible (main or contributory) cause of the problem. Prior to referral, 2 horses had received physiotherapy and 3 horses had received osteopathic treatment for the suspected back problems.

In 8 of the 17 cases the onset of lameness was reported to have been insidious. The remainder of cases (9/17) were of sudden onset, in 2 of them being the result of a fall (cases no. 5 and 15). The duration of the complaint ranged from 3 weeks to 5 years, the mean being 9.2 months. In 12 cases (70%) the duration ranged from 1 to 6 months.

3.2.2. Clinical Signs / Lameness Assessment

The results of the clinical examination of the cases included in this study are summarized in table 3.3.

Defects in conformation (tarsal valgus) were noted in 2 horses. Palpable or visible swelling on the distal medial hock was noted in 5 horses. Another two horses developed fibrous thickening of the area during the course of several examinations. Distension of the tibiotarsal joint was rare, and was only noted in one horse. Asymmetry of the gluteal muscles was apparent in 7 cases, and in one case there was bilateral muscle atrophy (case no. 15). Pelvic asymmetry in the form of unlevel tuber sacrale or tuber coxae was noted in 4 horses. In 3 horses (cases no. 5, 7 and 9) a painful response was elicited on palpation, manipulation or

faradic stimulation of the lumbar muscles. In one case (no. 17) there was pain on palpation and on faradic stimulation of the semimebranosus and semitendinosus muscles.

Fifteen of the 17 horses were lame or stiff on one or both hindlimbs at the walk. The same number of horses were lame at the trot, which constitutes the total number of cases where assessment of the lameness at the trot was carried out. In the remaining two cases this was not done either because of physical impossibility (case no. 15), or because the horse was referred for scintigraphic examination alone (case no. 9). In 14 cases (82.4%), on the initial examination, the lameness affected exclusively or predominantly the right hind leg, while the left hind leg was principally affected in 3 cases (17.6%). In one case (no. 7) the hindlimb lameness switched from the left to the right leg on follow up examinations, making the total of lameness affecting the right leg 15/17 (88.2%). The hindlimb lameness was bilateral in 5 cases (23.5%). Two cases presented with concomitant forelimb lameness. Examination of the lameness on the lunge on both reins was carried out in 9 horses, resulting in an increased degree of lameness in 5 of them. "Spavin Tests" were carried out in 15 cases, and were positive in at least one leg on 11 occasions, on 4 occasions being bilaterally positive.

Except for one case of severe bilateral locomotor impairment (case no 15), the lameness was mild or moderate ($\leq$ 2/5). In 12 cases there was an obvious decrease in hock flexion, and in 5 of them there was dragging of the toe. Seven horses exhibited a plaiting gait, bringing the affected leg across the midline of the track of the forelimb and landing on the lateral aspect of the foot. Four horses (cases no. 5, 7, 9 and 13) exhibited gait abnormalities suggestive of back or pelvic injuries, including stiffness in the back (lack of bending), rolling of the pelvis, disunited canter and "bunny hopping" with the hindlimbs.

3.2.3. Regional and Intra-articular Anaesthesia

The results of the nerve blocks and anaesthesia of the DIT and TMT joints carried out are summarised in table 3.4.

Sequential diagnostic nerve blocks were carried out in 8 of the 17 cases. In all of them anaesthesia of the Tibial and Peroneal nerves was included in the procedure. This nerve block resulted in improvement of the lameness in 7 cases. In the remaining case (no. 11), the lameness was abolished after a subtarsal nerve block. The decrease in the degree of lameness after the Tibial-Peroneal nerve block was always partial, incomplete flexion of the hock and toe drag being often

present. A positive effect was noted from 10 to 30 minutes after injection of local anaesthetic.

Intra-articular anaesthesia of the DIT and TMT joints was carried out in 7/17 cases. In all but one case (no. 16) this procedure was carried out on the lame or lamest leg only. In case no. 16 the distal tarsal joints of both tarsi were anaesthetised due to the presence of an obvious bilateral lameness. A partial (60%) or almost total (90%) decrease in the degree of lameness occurred on all occasions. Improvement of the lameness occurred as soon as 5 minutes after intra-articular injection. Intra-articular anaesthesia of the tibiotarsal joint was carried out on one occasion (case no. 8) with no effect on the lameness.

3.2.4. Follow Up Examinations

Follow up examinations were possible in 7 cases, on most occasions being carried out 6 and 12 months after the initial examination. In case no. 4 follow up was carried out over a 2 ½ year period. In most cases a reasonable level of soundness was achieved with treatment. In spite of that, lameness persisted in most cases and no real improvement of the condition was observed. In cases no. 5 and 7 the clinically silent bone spavin diagnosed on scintigraphy on the first examination became apparent, while the other conditions diagnosed (osteoarthritis of the fetlocks, lumbar and sacroiliac pain) improved.

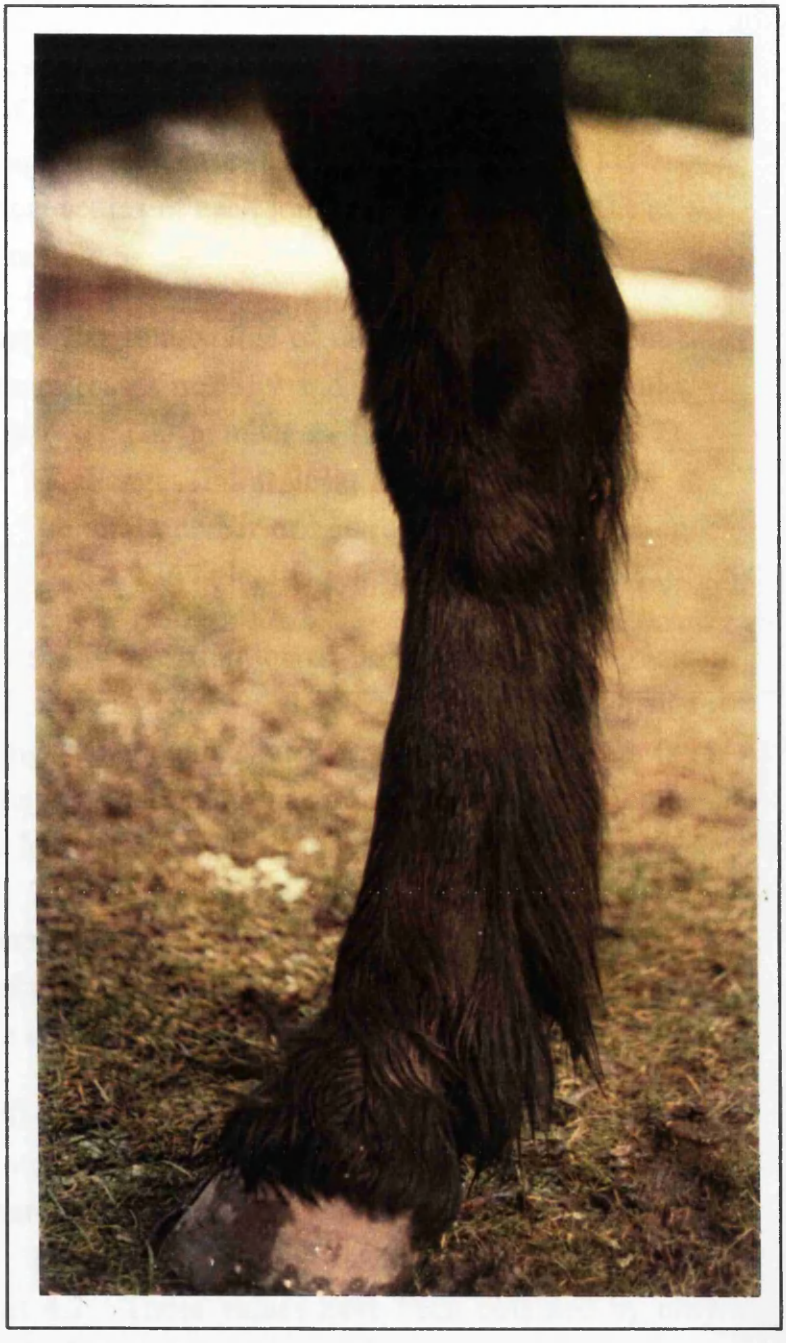


Figure 3.1. *Bony swelling on the medial aspect of the right hock of case no. 14.*

3.3. Radiography

A total of 29 tarsi were radiographed, this number includes bilateral tarsal radiographs of 12 cases and radiographs of only one tarsus of 5 cases. At least one tarsal radiograph of each case (usually a 35°DL-PlMO.) is included in appendix B. The radiological scores of each joint (PIT, DIT and TMT) of all tarsi radiographed are shown in table 3.5.

No horse was totally free of radiographic changes in all the joints (score = 0). Three horses (cases no. 5, 9 and 11) had only doubtful changes (score ≤1) in any of their joints. The number of horses with mild (≤ 2), moderate (≤ 3) and advanced (= 4) changes in at least one of their joints was 5 and 4 and 5 respectively. The total number of horses with positive radiographic findings (with a radiological score > 1 in at least 1 joint) was 14/17 (82.3%).

Looking at the distribution of the lesions by tarsi; 7 tarsi were affected by only doubtful changes (score ≤ 1), 10 tarsi had mild changes (≤ 2), 5 tarsi had moderate changes (≤ 3) and 7 tarsi had advanced changes (= 4) in at least one of the joints. The distribution of changes in the individual joints showed that the PIT joint was the least affected, with only mild changes on any occasion and a mean score = 0.9. The DIT joint was the most commonly and/or severely affected, showing severe changes in 7 occasions and a mean score = 2.4. The TMT joint had severe changes affecting it in one occasion and moderate changes in 6 occasions, the mean score being = 1.6.

The left-right tarsus distribution of the radiological changes showed that the right tarsus was more frequently affected by severe changes (4 occasions) and moderate changes (4 occasions) than the left tarsus (3 and 1 occasions respectively). The mean score of the right tarsus was 5.3 and the mean score of the left tarsus was 4.2. These values have been obtained by only taking in account cases that had both their tarsi radiographed.

The most frequently noted lesions were discrete joint margin irregularities in the form of lipping or osteophytes on the dorsal and dorso-medial aspects of the DIT and TMT joints. Discrete subchondral bone irregularities in the DIT joint were also common. Relatively large enthesiophytes on the dorsal aspect of MT3 were seen in 4 tarsi. New bone formation into the tarsal canal and in the non-articular space between the third and central tarsal bones ("synovial fossae") was the most significant lesion in 2 cases. Extensive bone production on the dorso-medial aspect of the tarsal and metatarsal bones was noted in 7 tarsi. Extensive

subchondral bone lysis was seen in 4 tarsi, and was usually accompanied by extensive bone production. These lesions were most common in the DIT joint. Lesions in the PIT joint were usually found in tarsi that had severe changes in the other joints. Narrowing of the joint space was noted in 2 tarsi, partial obliteration in 4 tarsi and total obliteration in 4 joints involving 3 tarsi (one tarsus had both DIT and TMT joints ankylosed).

Some types of lesions were commonly associated with the presence of lameness. This is the case for extensive subchondral bone lysis in the DIT joint and changes in the PIT joint. The presence of other, more benign types of lesion was noted in joints of both lame and sound legs. Thirteen of the 16 (81.2%) horses lame due to bone spavin had positive radiographic findings. In most cases the lesions were worse (the radiological scores were higher) in the lame or lamest leg. In only 1 case were the radiographic changes worse in the least lame leg, and in 3 cases the changes were of similar magnitude in both legs.

Follow up radiographs were taken 6 and 12 months after the initial examination in 6 cases and 5 cases respectively. During this period, with the exception of case no. 7, there was little progression of the changes in both mildly affected and severely affected joints. In case no. 7, collapse of the DIT joints of both tarsi progressed to partial obliteration in the period of one year. In case no. 8, the progression of the condition during 8 months affected only the extent of the lytic lesions, with no evidence of joint fusion. In case no. 5, joint fusion was achieved by surgical arthrodesis.

3.4. Scintigraphy

The print-outs of at least one scintigraphy scan (in most cases a bone phase hindlimb scan) of each case are included in appendix A. In tables 3.6. and 3.7. the summary data of the bone and soft tissue phase scans is recorded.

3.4.1. Bone Phase

The inerpretation of the results of the bone scans was greatly simplified by the use of the data processing programs and the graphic display of the readings. The reference count (atlas) ratios were useful in estimating the degree of bone activity in each tarsal joint, and were plotted in page 1 of the scintigraphy report. This plot was useful to detect bilateral increases in isotope uptake. The atlas count ratios varied greatly from one joint and one horse to another, ranging from 16% (left PIT joint of case no. 13) to 341 % (right TMT joint of case no. 14). In some cases there was poor MDP-Tc 99 labelling of the distal limb and low counts were recorded at all sites, while in other cases, especially in younger horses, the counts where high in relation to the atlas count throughout the limb. These two situations, however, did not preclude detection of abnormal localised increases.

In some cases, a generalised unilateral increase in radiotracer uptake was recorded. In the difference plot, this artifact often presented the shape of an inverted parabola, the difference between pairs of counts being greater as one moved distally along the limb. This was supposedly due to increased weight bearing in the non-affected limb (case no. 15) or to a "recrutation" phenomenon of bone capillary vessels (Ueltschi 1987). Increases in the tarsal joints due to bone spavin usually presented as sharp focal increases often involving only two or three sampling points. In some cases, though, they presented as more generalised increase throughout the tarsus. In those cases the difference plot was useful for indicating the site where the peak in increase uptake was located.

Looking at the values of the atlas count ratios of individual joints, the right DIT and the right TMT joints had the highest ratios (mean values of 90% and 89% respectively); followed by the left TMT, the left DIT and the left PIT joints (mean values of 67% and 66% and 65% respectively). The right PIT had the lowest atlas ratios (mean value of 62%). In general the TMT and DIT joints had higher values than the PIT joint.

On average, higher counts were recorded in the right tarsus than in the left tarsus. This is in agreement with the clinical signs and the radiological findings.

The mean values of the atlas ratios for the whole tarsi were 70% for the right and 61% for the left tarsus. These values were obtained by averaging the ratios of all the sample points in the tarsus, not only the ratios of the PIT, DIT and TMT joints.

The most useful parameter for indicating increased uptake in the tarsus was the greatest difference between pairs of sample points over the "normal" count, expressed as a percentage. This value was clearly visible in the difference plot histogram (page 2) of the scintigraphy report. A value of 40% increase or more over the contralateral limb was considered significant. This value is similar to the 30% reported by other clinicians (Pilsworth and Webbon 1988), but differs from the 15% value advocated by Attenburrow *et al.*(1984).

The value of the greatest difference between sample points in the tarsus ranged from +278% (right DIT joint, case no. 2) to +29% (case no. 17). In all but 2 cases (no. 16 and 17) the value was higher than 40%, that is, it was significantly increased. In case no. 15, although significantly increased (+75% in the right tibiotarsal joint)), this value was not higher than the mean increase in the whole leg (+84%). Thus, the number of cases with significantly increased uptake difference in the distal tarsal joints (positive for bone spavin on scintigraphy) was 14/17 (82.3%). In 10 of these 14 cases the increase was located in the right tarsus.

3.4.2. Soft Tissue Phase

The results of soft tissue phase scintigraphy mirrored in great measure those of bone phase scintigraphy. The range of the pectoral muscle count ratios was from 16% to 194%. The joints with higher average ratios were the right DIT and TMT joints (98% and 86% of the pectoral count). In the soft tissue phase the mean reference count ratios of the right tarsus were also higher (79%) than those of the left tarsus (64%). The greatest difference between any pair of sample points ranged from +380% to +37%. In all but one (case no. 16) out of the 9 cases where soft tissue scintigraphy was carried out, the value was higher than 40% (considered significant).

Soft tissue scintigraphy did not provide much additional information to that collected by bone scintigraphy. In most cases, the results of the soft tissue and bone scans correlated well, but in some cases, increases in different parts of the limb other than the region affected were detected in the soft tissue phase. These increases often did not appear in the bone phase scan and were considered artifacts.

3.4.3. Follow Up Examinations

An insufficient number of cases was scanned more than once to be able to extract any conclusions about the monitoring of the progression of the spavin with scintigraphy. Three cases received follow up scintigraphy scans (cases no. 1, 5 and 10). Case no. 1 was scanned 6 months after the initial examination and this showed a slight decrease in isotope uptake. Case no. 5 was scanned 12 months after the initial examination, but changes in the activity of the spavin could not be determined accurately due to a whole-limb unilateral increase in activity. Case no. 10 received two bone scans 3 months apart, the first scan having to be abandoned for the same reason.

3.4.4. Correlation Scintigraphic - Radiographic Findings

In general, the correlation between radiographic and scintigraphic findings in this study was only moderate. The same number of horses (14/17 = 82.3%) had positive radiographic or positive scintigraphic findings, but these were not matched. The 3 horses (17.6%) that had negative scintigraphic findings showed positive (although mild) radiographic changes, and the same number showed the reverse situation. In only 11/17 (65%) horses, positive radiographic and positive scintigraphic findings were paired.

The correlation coefficients for each joint between the degree of radiological change and the degree of radioisotope uptake in bone phase scans were:

left PIT $r = 0.565$	right PIT $r = 0.099$
left DIT $r = 0.744$	right DIT $r = 0.561$
left TMT $r = 0.599$	right TMT $r = 0.536$
left tarsus $r = 0.564$	right tarsus $r = 0.454$

These values show good correlation between these parameters in the left DIT joint only. In the rest of the joints there was moderate correlation, except for the right PIT joint, which showed poor correlation between radiography and scintigraphy.

The correlation coefficients between the radiological scores and soft tissue phase scintigraphy results were calculated for the right tarsus only, due to the small number of cases in which these parameters were available for the left tarsus. These were:

right PIT $r = 0.242$

right DIT $r = 0.867$

right TMT $r = 0.574$

right tarsus $r = 0.820$

The values of the correlation coefficients are higher for soft tissue phase than for bone phase scintigraphy. This could be due to the smaller number of cases in which soft tissue phase scintigraphy was carried out. In fact, 4 of the 6 cases in which the presence of scintigraphic and radiographic findings was not matched, did not have soft tissue phase scintigraphy data available, and it is likely that this had an influence on the correlation coeficient.

3.4.5. Correlation Scintigraphy - Clinical Signs

Of all the horses (16) lame due to bone spavin, 14 (87.5%) had positive scintigraphic findings. In all cases but 1 (case no. 10), the difference between counts was positive for the lame or lamest leg. In another case (no. 12), although the sample point which showed the greatest difference between pairs of counts was in the least lame leg, the highest absolute count was recorded in the lame leg. This reflects good correlation between scintigraphic positive findings and the existence of lameness. On the other hand, the correlation coefficient between the degree of lameness (0-5) and the values of the greatest difference between pairs of counts was $r = 0.179$ for bone phase scintigraphy and $r = -0.398$ for soft tissue phase scintigraphy (these values have been calculated excluding the 2 cases mentioned above). This indicates poor correlation between the degree of lameness and the quantified degree of isotope uptake.

3.5. Pathology

Only the tarsus of case no. 13 was available for post-mortem and pathological examination.

3.5.1. Macroscopic Examination / Macrophotography

Examination of the sections of the right tarsus revealed a very compacted appearance of the central tarsal bone, with almost total absence of bone trabeculae. This pattern was seen in all sections. In one section, corresponding approximately to the middle part of the hock in a dorsolateral to plantaromedial direction, a discoloured area in the subchondral bone of the proximal aspect of the central tarsal bone was noted. From this area there appeared to begin a line of disrupted bone that advanced towards the distal articular surface (fig. 3.2.). There were fine, linear disruptions in the cartilage of both articular surfaces of the central tarsal bone. These lesions indicate a healing, non-displaced articular fracture of the central tarsal bone. The origin of the fracture line was on the medial cortex, but the exit could not be determined, suggesting that this was an incomplete fracture. Unfortunately, visualisation of the complete articular surfaces of the bone was not possible due to the fact that the bone had been sawn in several narrow sections. This fracture could not be demonstrated in the clinical radiographs of the tarsus.

In addition to this lesion, ankylosis of the 4th. and 5th. lumbar vertebrae was found. The vertebral bodies, the articular facets and one of the transverse processes of the vertebrae were fused. No abnormalities were found in the left sacroiliac joint. The right wing of the ilium had fractured through the right sacroiliac joint as a result of the impact with the ground following euthanasia of the animal.

3.5.2. Oxytetracycline Fluorescence

Viewed under ultra-violet light, the sections showed several areas of oxytetracycline fluorescence in the central tarsal bone. The most intense fluorescence was seen in the subchondral cystic lesion of the proximal aspect of the central tarsal bone (fig. 3.3.). There was some degree of fluorescence throughout the section of the bone, indicating bone remodelling activity in the cancellous bone. Areas of new bone formation (osteophytes) seen in the dorsomedial and plantar aspects of the bone were intensely fluorescent, indicating secondary osteoarthritis (fig. 3.4.). There was no fluorescence in the other bones of the tarsus.

3.5.3. High Detail Radiography

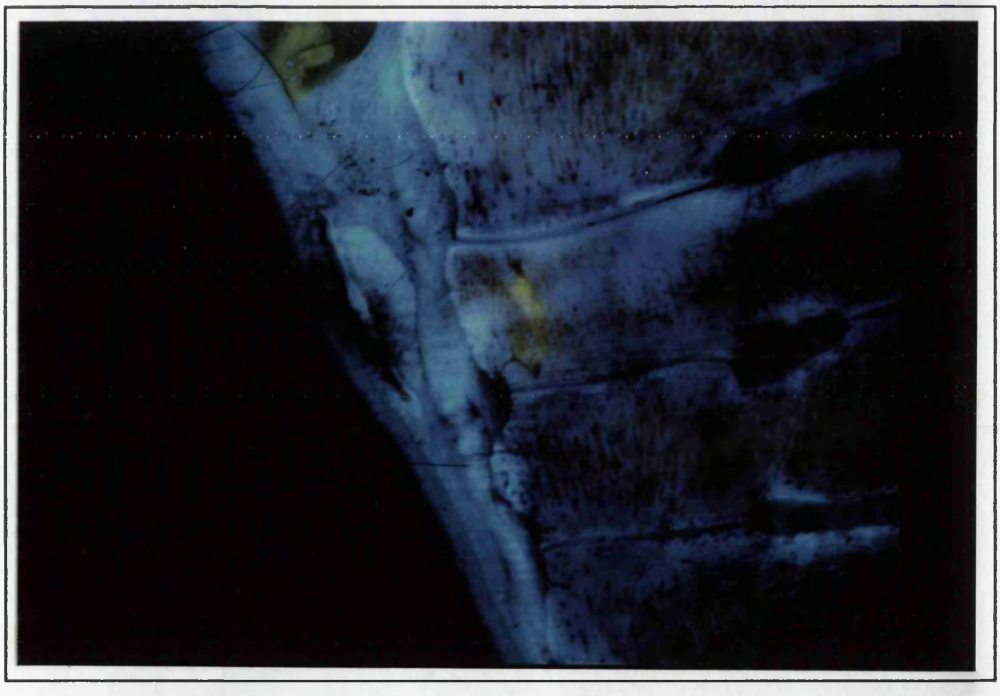
High detail radiographs of the sections revealed a substantial degree of sclerosis of the central tarsal bone. In one of the sections there was a lucent area in the subchondral bone of the proximal aspect of the central tarsal bone, which corresponded to the area of intense oxytetracycline fluorescence and the origin of the fracture line in the proximal articular surface (figs. 3.5. and 3.6.). A fracture line was not visible in the high detail radiographs. This could be due to the plane of the sections being almost parallel to the direction of the fracture. Osteophytes were seen in several sections, both in the dorso-medial and lateral aspects of the bone.

3.5.4. Histology

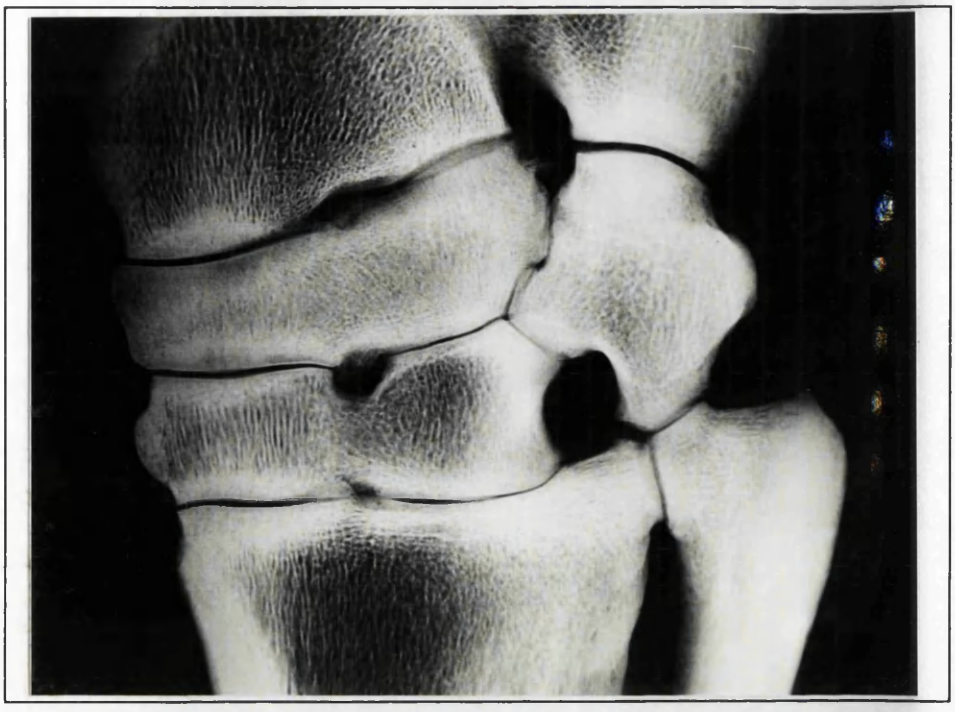
Histology of the sections of the central tarsal bone revealed a cystic lesion filled with fibrous and granulation tissue in the proximal joint surface, which corresponded to the lytic and fluorescing lesion described. Another disruption was seen in the distal articular surface, and an area of disrupted bone connected them. The cancellous bone had been intensely remodelled, and there were numerous secondary osteons. This gave the bone a very compacted appearance, resembling cortical bone (fig. 3.7.).

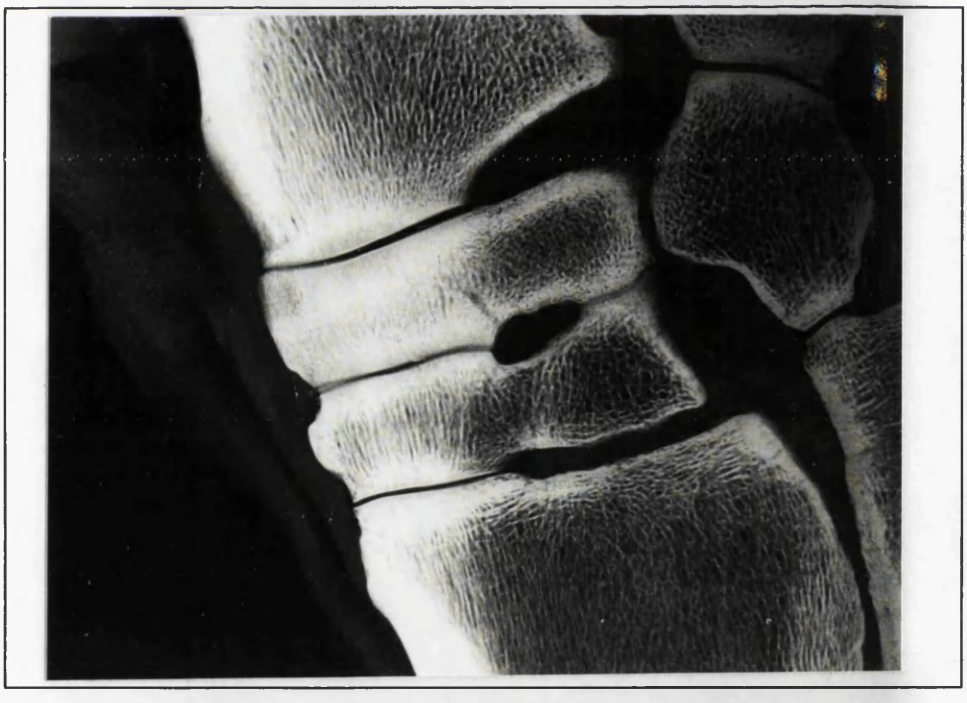
The articular cartilage of the proximal-intertarsal and the distal-intertarsal joints was largely unaffected. Apart from the discontinuity in the sites of the fracture, there were no other lesions. There were no erosions in the superficial layers and the chondrocyte population was healthy, apart from in the areas immediately adjacent to the fracture lines, where there was some chondrocyte necrosis. The safranin-O staining was good in almost all areas, which indicates normal levels of proteoglycans. These seems to indicate that the secondary changes of osteoarthritis were confined to the bone.

Figure 3.2. *Macrophotograph of a section of the central and third tarsal bones of the right tarsus of case no. 13. Note the cystic lesion in the proximal aspect of the central tarsal bone and the defect in the distal articular surface.*



Figures. 3.3. and 3.4. *Oxytetracycline fluorescence under ultra-violet light observed in the slab sections of the right tarsus of case no. 13. There is intense fluorescence of the cystic lesion, the areas of new bone formation and around the healing fracture line. There is slight fluorescence in areas of the cancellous bone.*





Figures 3.5. and 3.6. *High detail radiographs of the slab sections of the right tarsus of case no. 13. There is a lucent lesion on the proximal aspect of the central tarsal bone and osteophyte formation at various sites.*

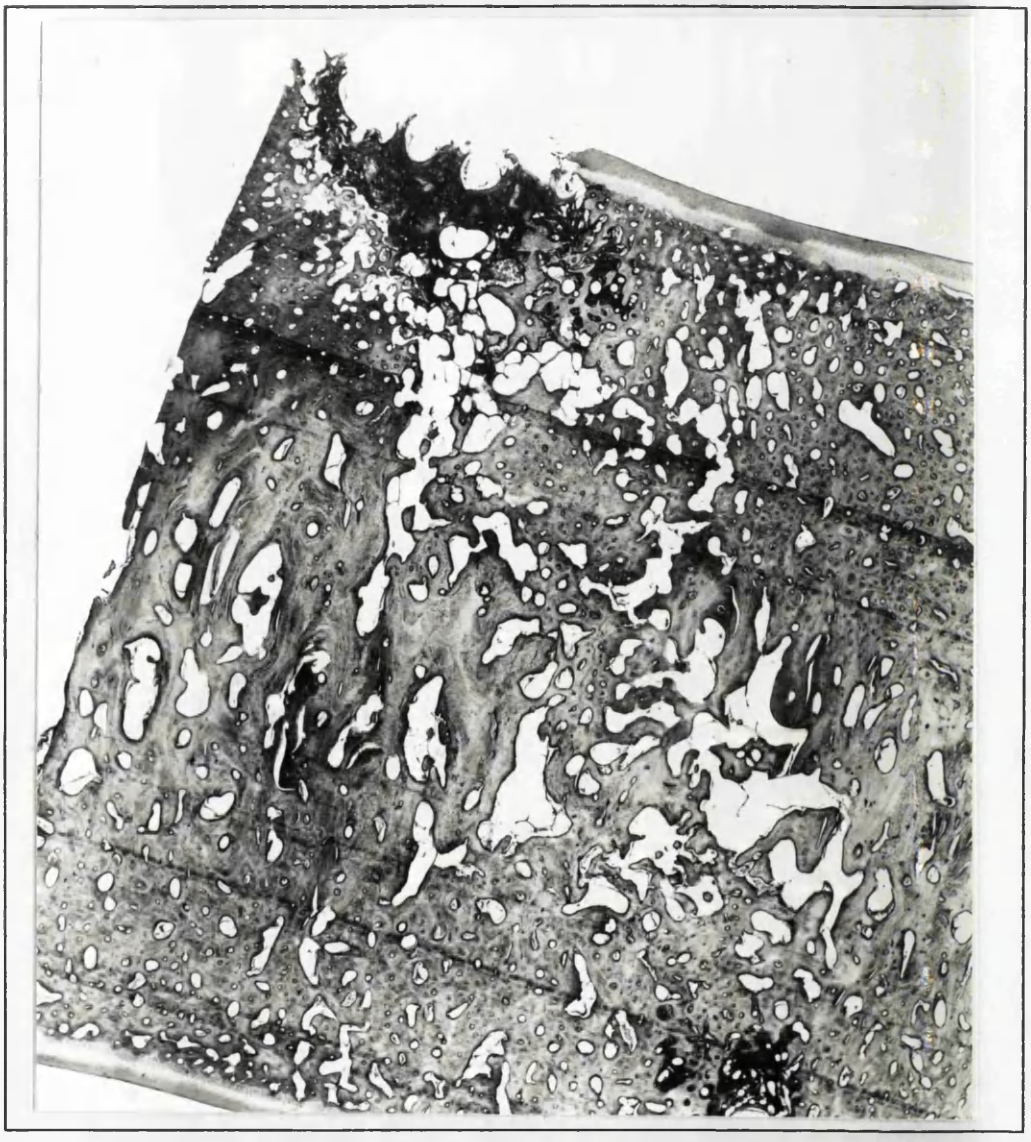


Figure 3.7. *Cereus-red stained section of a portion of the central tarsal bone of case no. 13. Note the cystic lesion in the proximal articular surface and the disruption of the cancellous and subchondral bone. The bone at either side of the disruption is very compacted.*

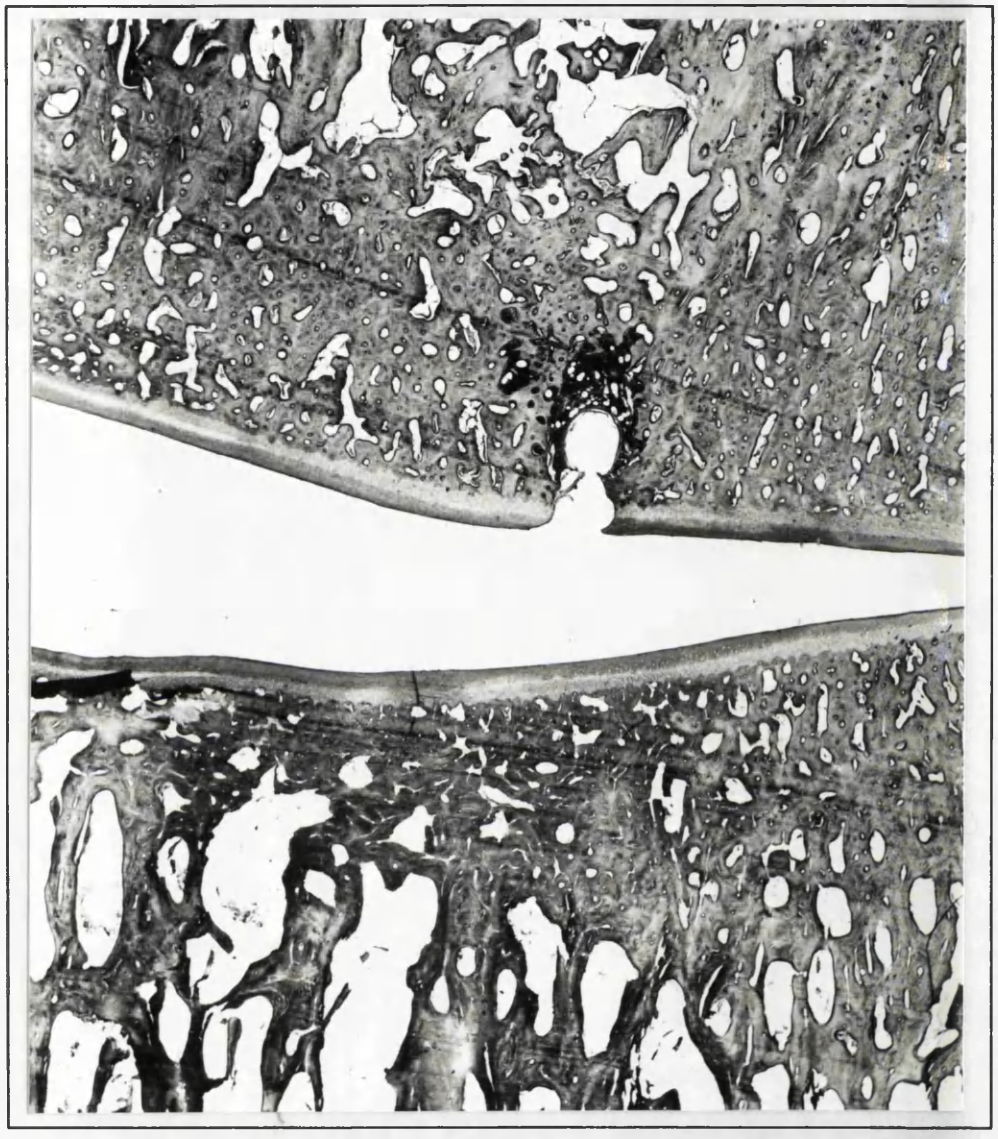


Figure 3.8. *A different section of the central tarsal bone of case no. 13. There is a defect in the distal aspect of the central tarsal bone. Note the difference in trabecular pattern between the central and third tarsal bones. The adjacent and opposing articular cartilage is undamaged.*

3.6. Final Diagnosis, Treatment and Outcome

The summary of the diagnosis, treatment and outcome of the cases included in this study is included in table 3.8.

Bone spavin was the final diagnosis in 16 cases. In one of these cases the main post-mortem diagnosis was of healing, incomplete fracture of the central tarsal bone, with secondary bone spavin. The condition was bilateral in 7 cases. Lumbar spine and/or sacroiliac disease was diagnosed as a concurrent condition in 4 cases. Other concomitant conditions include left hind fetlock osteoarthritis and unspecified injury to the proximal third metatarsal bone. One horse was diagnosed as having a fracture of the greater trochanter of the right femur and clinically and scintigraphically silent radiographic changes in the tarsus.

A combination of corrective shoeing with lateral extension shoes, gradual light exercise and low dose analgesics was the most commonly used form of treatment (7 cases). In two cases exercise was resumed without any other form of treatment and one case had surgical arthrodesis carried out.

Most cases were able to remain in light work, but the lameness usually persisted. The exceptions to this are case no. 4, which had surgical arthrodesis carried out, and possibly case no. 7, in which a certain degree of joint ankylosis was achieved. A temporary improvement was common, but the lameness was often fluctuating and reappeared in most cases, limiting the athletic capability of the horses. Five horses were retired and 2 were destroyed.

CHAPTER 4.

DISCUSSION

4.1. Clinical Features

The breed distribution in this study is unremarkable and reflects the type of horses that constitute the caseload of the Glasgow University Equine Veterinary Hospital. The sex distribution shows a preponderance of geldings over mares. A similar age distribution has been found in studies by Edwards (1982) and Wyn-Jones and May (1986), and is considered unremarkable taking into account the general use of the horses in the area and the caseload of the Hospital.

The wide range of ages recorded in this study is in accordance with the observations of other clinicians, that consider the condition to affect horses of all ages apart from the very young (Taylor 1977; Wyn-Jones 1988). Two main age groups can be identified in this study. The first group constitutes horses of 7 years or less that usually present with low grade insidious onset lameness, which is often bilateral, with no swelling in the medial hock and minimal radiographic changes. The second group of horses are older animals with obvious palpable and radiographic changes, often with a higher degree of lameness that can sometimes be unilateral. It is likely that the first group of animals represent the early stages of the condition, that can later develop into more advanced phases at a very variable rate.

The occupation of the horse has often been related to the development of Bone Spavin. Thoroughbreds, jumpers (Gabel 1980), trotters (Hartung 1983) and other types of horses have been implicated with a high incidence of the condition. Although the type of work and possibly the biomechanics affecting the tarsal joints in these horses are very different, the common factor is an increased amount of work, and thus, an increased level of stress placed on the joints. In the present study, a relatively high proportion of horses were, or had been, involved in different levels of competitive activities, especially eventing and show-jumping. While not challenging the view maintained by some (Wyn-Jones 1986) that spavin affects all types of horses, the results of this study seem to indicate that the incidence of the condition may be higher in horses subjected to increased levels of exercise. It is also apparent in this study that the competitive horses belong to the first age group, indicating an earlier onset of the condition. It is interesting to note that one case (no. 14) in this study spent many years of its life pulling a cart, a condition considered by Rooney (1969) to be highly predisposing to bone spavin.

Bad conformation is often mentioned as another predisposing cause of bone spavin (Stashak 1987). The results of this study are in contrast with this notion,

only two horses showing obvious conformational defects (tarsal valgus). While the number of horses in this study is too limited to disallow association between conformation and bone spavin, it would appear that, in many cases, bone spavin can occur in horses with a normal conformation.

The cases included in this study usually presented with a low grade or moderate lameness, that often did not totally preclude the animal from a moderate amount of work. This is in agreement with most other clinicians (Edwards 1982; Moyer *et al.* 1983). The most striking feature in the presentation of the cases in this study is the preponderance of right hindlimb lameness (82.4%) over left hindlimb lameness. This usually, but not always, correlated with the presence of more manifest radiological changes in the right tarsus. Other studies into the condition have reported a symmetrical distribution of the lameness (Moyer *et al.* 1983; Driesang and Böhm 1993), which seems a more logical situation. The reasons for the greater incidence of the condition in the right hindlimb in this study are not known. It is possible that the relatively small number of cases included here represent a skewed population and this is not a real deviation.

Clinical signs such as the presence of a palpable or visible swelling in the "spavin area", or the characteristic spavin gait (as it has been described earlier) were not a consistent feature in the cases of this study. Flexion tests, and regional and intra-articular analgesia techniques were useful diagnostic aids. The "Spavin Test" was positive in 73% of the cases. This figure is slightly lower than the 92% reported by Moyer *et al.* (1983), but still reflects the reliability of the test in confirmed cases of spavin. It is generally accepted that the test is not entirely specific for this condition (Wyn-Jones 1988).

Intra-articular anaesthesia of the distal-intertarsal and tarsometatarsal joints had an effect on the degree of lameness in cases where pathology was subsequently demonstrated. This technique, though, has some limitations and may not be as specific as it is believed. Sack and Orsini (1981) found that latex injected into those two joints in cadaver specimens permeated the fibres of the tibialis cranialis and peroneus tertius muscles in most cases, sometimes reaching as far proximal as the talus. Dyson and Romero (1993) reported the same finding after injecting the tarsometatarsal joint of live horses with contrast medium, and subsequently radiographing the limbs. Furthermore, they also found that contrast agent penetrated the tarsal sheath in 35% of the limbs and had diffused plantar and/or distal to the tarsometatarsal joint in 70% of them. Similarly, contrast agent injected in the plantar metatarsal area, as for a "subtarsal" nerve block, penetrated the tarsometatarsal joint in a small number of cases. Direct implications of these

findings are that, when carrying out anaesthesia of the tarsometatarsal joint, local anaesthetic diffusing into the dorsal and plantar aspects of the hock could desensitise the dorsal metatarsal nerves (Sack and Orsini 1981), and the plantar metatarsal nerves (Dyson and Romero 1993). Similarly, a subtarsal nerve block could desensitise the tarsometatarsal joint (Dyson and Romero 1993).

In case no 11, a right hindlimb lameness was improved after a subtarsal nerve block, but no radiographic changes were detected in the third metatarsal bone or adjacent soft tissue structures, and there was only evidence of an early bone spavin. There is a possibility that the subtarsal nerve block could have affected the tarsometatarsal joint. Scintigraphically, the increase of radioisotope concentration detected in the proximal third metatarsal bone could represent both a lesion in the proximal third metatarsal bone or osteoarthritis of the tarsometatarsal joint. A Gamma-camera would have been useful to differentiate between this two conditions.

In accordance with the experience of other clinicians (Gabel 1980; Wyn-Jones 1988), a relatively large number of cases (57%) were not presented or referred as lameness but as more non-specific problems. In many of these cases the owner, or the referring veterinarian, felt that the back was the possible cause of the problem. In some of these cases conventional lameness examination proved difficult, due to the subtle degree and bilateral character of the lameness. Under these circumstances, the gait abnormalities of the horse observed at the trot and on the lunge may resemble more stiffness of the back and poor impulsion of the hindquarters than a hindlimb lameness. Localisation of the source of pain by regional and intra-articular anaesthesia in these cases may be of limited value or lead to confusing results. To further complicate the picture, in some cases the pain and rigidity of the back may be a real symptom, but secondary to the lower limb lameness (Jeffcott 1980; Munroe 1993). The second situation can be relatively common. In a survey by Moyer *et al.* (1983), back pain was found in 60% of the horses diagnosed as having bone spavin. In this study only 3 horses were considered to show clear signs of back pain. The disparity in the figures indicates that evaluation of back pain in the horse remains a very subjective and controversial matter. Faradic stimulation proved to be useful in the detection of muscle pain in some of the cases in this study. Even in the presence of demonstrable back pain, appropriate diagnosis of the primary problem should remain the major goal. In the retrospective study by Moyer *et al.* (1983), in only 14% of the cases was this back pain considered to be more significant than the

spavin. In this study, bone spavin was considered to be the primary problem in all cases.

In another group of cases, which overlaps with the one described earlier, the presence of pelvic asymmetry and peculiar gait characteristics suggested a sacroiliac strain (Jeffcott 1980; Munroe 1993). The possibility to carry out a scintigraphic examination in these two groups of cases was of great value, and provided a means of examining the hindlimbs, back and pelvis for the presence of abnormal bone metabolism in a relatively quick and effective way.

4.2. Radiological Findings

The type, extent and distribution of the radiological findings in this study do not differ from the ones reported in other studies, with the only exception of the higher incidence of changes in the right tarsus. Lesions in the PIT joint were rare and, in accordance with the majority of clinicians (Butler *et al.* 1993; Edwards 1982) were considered significant. The results of this study show that the DIT joint is more commonly and severely affected than the TMT joint. Laverty *et al.* (1991) reported the same finding in a series of post-mortem specimens. They also concluded that changes in the DIT joint are likely to be more clinically significant than changes in the TMT joint. While this cannot be directly concluded from this case series, the presence of clear radiographic TMT joint lesions in two cases (no. 15 and 16) in the absence of, or with minimal clinical signs, may point towards this direction. Against this it can be argued that the lesions observed in these two cases were enthesiophytes, and thus not true articular lesions, a difference that was not taken in account in the series by Laverty *et al* (1991). The clinical significance of enthesiophytes in the dorso-proximal margin of the third metatarsal bone has been the object of much debate, having been recognised as not significant by some clinicians (Butler *et al.* 1993), and significant by others (Pilsworth 1992).

Radiography remains the gold standard in the assessment of joint damage in equine veterinary medicine. The sensitivity of the technique in detecting the presence of bone spavin in the present study was of 13/16 (81.2%). Three cases (no. 5, 9 and 11) had only doubtful radiographic changes in their tarsal joints according to the Kellgren-Lawrence scale (Theiler *et al* 1994). This supports the view that spavin can be clinically apparent with minimal or no radiographic changes, as proposed by Schmidt and Talazko (1978), Stashak (1987) and other clinicians; and is in opposition with the findings of Taylor (1977), who stated that all cases of spavin are accompanied by radiographic changes.

The question of the significance of radiographic lesions in apparently sound animals cannot be answered from the analysis of the cases included here, since one of the criteria for inclusion was the presence of lameness. In one case only (no. 15), positive radiographic findings were probably not associated with lameness. Although the animal had suffered a crippling injury and the contribution of the spavin to the lameness could not be determined, the fact that it was involved in high level eventing before the injury occurred suggests that the spavin changes may have been clinically silent. Other horses with positive radiographic changes that were not clinically significant were not seen by the author during the period of this study. Ueltschi (1977) reported massive radiological changes in sound and scintigraphically negative horses, but those consisted of ankylosed joints. Some authors have reported a large number of horses free of clinical signs with varying degrees of radiographic changes (Hartung *et al.* 1983) or post-mortem lesions in the tarsal joints (Wamberg 1953). In both occasions the horses involved were German trotters, which may indicate a special situation in this breed; and may not necessarily affect other types of horses in the same proportion. Hartung *et al.* (1983) considered these changes to be the result of developmental abnormalities, as they did not seem to be related to the time spent in training. Another relevant comment is that neither of the two authors defined the criteria for considering a horse sound. If the only criteria was the animal being maintained in training, this may have overlooked many cases of mild lameness.

Overall, and in agreement with the current literature, in this study there was little correlation between the degree of radiological change and the severity of the lameness. On the other hand, in most cases there was concurrence between the worst clinically affected leg and the presence of more advanced radiological changes in that tarsus.

The progression of the radiological changes during the follow up period was very modest. It has been stated that some cases of bone spavin may ankylose their joints in a 6 month to 1 year period (Edwards 1982; Stashak 1987). In view of the findings of this study, this seems an over optimistic statement. In none of the cases did the speed of progression of the changes lead to a degree of ankylosis that resulted in a genuine reduction in the lameness over the period of examination. This is particularly true of the cases diagnosed scintigraphically at a very early stage of the disease. Even in the cases where there was progressive loss of joint space and increasing bone production, leading to radiologically apparent partial ankylosis, there was little improvement of the clinical signs. In case no. 14 (an aged pony) the duration of the disease had been of more than 5 years and, although

radiologically there was fusion of the DIT and TMT joints, the horse remained lame and scintigraphy revealed a very high metabolic activity in the area. Wyn-Jones (1988) believed that the progression to total joint ankylosis and clinical improvement of the condition is a rare occurrence. Although the number of cases included in this study is limited, the results of consecutive radiographic (and scintigraphic) examinations appear to support this argument. Cases of asymptomatic horses with arthrodesed joints have often been reported in the past and current literature (Butler *et al.* 1993). Wyn-Jones (1988) speculated that these cases may represent a sequel to very early pathology (endochondral ossification abnormalities or third tarsal bone collapse) rather than to long standing disease.

The implications of this are that bone spavin (especially early bone spavin), in our opinion, may have a poorer prognosis for a return to soundness than some authors have led to believe (Taylor 1977; Edwards 1982; Stashak 1987). Taylor (1977) stated that the majority of cases with tarsal osteoarthritis return to usefulness. At present, the increasing level of competitiveness at all levels and a more critical attitude of the owners may be responsible for the diminished number of horses that are considered "sound" after conservative treatment, in comparison with the results of Taylor (1977). The overall good success rate obtained by surgical arthrodesis of the DIT and TMT joints (Edwards 1982; Wyn-Jones 1983; Stashak 1987; Schramme 1994) indicates that this technique should be considered a realistic alternative in all cases of bone spavin, and not a last resort technique.

4.3. Scintigraphy

4.3.1. Scanning Technique

The point-probe counting technique combined with the data processing and display system used in this study proved a very useful method for the detection of advanced and early cases of bone spavin. Several factors influenced the accuracy and reliability of the results obtained. These were: the adoption of a standardised scanning protocol, the accuracy in positioning and orientation of the probe, and the recognition of artefacts. The effects of the first two factors can be easily recognised by comparing the scan reports at the beginning and at the end of the study. More symmetrical and coherent scans were obtained as the protocol and skill of the operator improved. Different types of artefacts can alter the results or even make them non-interpretable, and their recognition is essential in the diagnostic procedure. It has been said that over-interpretation of false positive

scans is the most common mistake in the inexperienced clinician (Steckel 1991). The artefacts commonly seen in the course of this study were:

- Bladder artefact
- Urine contamination of the leg and foot
- Inaccurate positioning of the probe
- Generalised unilateral increase due to increased weight bearing in the non-affected leg
- "Vascular artefact"
- Regional nerve blocks and intra-articular anaesthesia
- Bandaging of the legs

As the isotope is excreted through urine, high concentration of isotope in the bladder may result in high counts in the pelvis and even in the upper hind limb. This can be seen in many of the scan reports included here. Injection of a diuretic drug or scanning after 22 hours post injection prevents this artefacts. Splashes of radioactive urine on the legs or soaking of the feet in a urine-wetted patch of bedding can result in increased counts in these areas. Mares can often splash their hocks when urinating. Washing of the legs and covering the feet with PVC bags should be carried out if possible before scanning begins.

Inaccurate positioning and/or direction of the probe can result in disparity of counts for the same point in different legs, and thus be interpreted as a pathological increase. The use of a relatively tightly collimated probe in this study, while increasing the spatial resolution, introduced a greater component of variability between counts due to probe positioning. A more symmetrical distribution of counts has been obtained by the author and other clinicians (Pilsworth 1992_a) using a more modern probe *(Cs mini-probe, Oakfield Instruments Ltd, Oxon).* This could be due, in our opinion, to the less tight collimation of the probe, which results in a reduction of error by positioning.

Generalised increases in radiotracer concentration in one of the limbs can be due to increased weight bearing of the non-affected leg - or disuse of the affected leg (Pilsworth and Webbon 1988; Milgrom *et al.* 1988). On other occasions, a massive unilateral increase may be detected that cannot be associated with this situation. It is possible that these abnormal isotope distributions are related to changes in the blood supply of the limb and not to pathological conditions. Ueltschi (1987) mentioned that the "recrutation" phenomenon of bone capillary vessels could change the accumulation ratio of radioisotope. In a normal situation only 70 - 75% of the osteons are connected to the blood circulation, and by

stimulating the parasympathetic system, resting osteons could be stimulated. In human medicine, the condition referred to as reflex sympathetic dystrophy consists of a similar generalised increase of a whole anatomical region (usually the hand) and is thought to be related to damage to the sympathetic innervation of the region (Holder *et al.* 1984).

Nerve blocks and bandaging of the limb prior to scanning can cause artefacts probably related to alterations to the blood supply to the area (Pilsworth 1989). There has been disagreement with regard to the effect of nerve blocks and intra-articular anaesthesia in the isotope distribution. Trout *et al.* (1991_a and 1991_b) reported that while soft tissue phase scintigraphy was affected by both regional and intra-articular anaesthesia performed 3 days previously, bone phase scintigraphy was not affected. Nonetheless, other clinicians have reported increased uptake in the bone phase associated with nerve blocks (Allhands *et al.* 1987), and during the course of this study similar situations were observed.

While the superior capabilities of a Gamma-camera in producing images where anatomical detail and patterns of isotope uptake can be recognised is not debated, point-probe counting has a few advantages over diagnostic imaging by gamma-camera:

- The amount of isotope, and therefore, the radiation risks are greatly reduced.
- The initial set up and maintenance costs are a fraction of those of a gamma-camera.
- This method provides an instant quantitative measurement of the given radiation at one site.

It has been stated that quantitative scintigraphy may have advantages over qualitative methods in the detection of abnormal metabolic ratios in the tarsal joints (Driesang and Böhm 1993). The scan reports permit instant visualisation of the counts of the whole limb permitting the clinician to readily detect unilateral whole limb increases. Those may be easily overlooked if one compares the scintigrams of two contralateral joints only. "Vascular artefacts" have been encountered by the author with relative frequency during the course of this study, and have been reported by others using this method (Pilsworth 1992_b). The fact that are not mentioned in many studies using a Gamma-camera suggests that may have been unrecognised in some occasions. This could lead to false positive results.

4.3.2. Soft Tissue and Bone Phase Scintigraphy

Gamma-camera three phase (nuclear angiogram, soft tissue and bone phase) scintigraphy has been used in human and veterinary medicine for the differentiation between soft tissue and bone injuries (Lamb *et al.* 1988). This technique has been reported to be able to discriminate between inflammatory arthritis and non inflammatory conditions (osteoarthritis). Holder (1990) stated that in osteoarthritis the first two phases should be normal. However, in an experimental study in dogs by Metcalf *et al.* (1985), differentiation between different degrees of induced inflammatory arthritis was not possible and soft tissue scans were positive even in the absence of soft tissue inflammation. In this study, soft tissue and bone phase scintigraphy were carried out in most cases. The results of soft tissue scintigraphy were very similar to the results of the bone phase scan, and differentiation between soft tissue and bone involvement was not possible. In addition, very often differences between counts at contralateral sites were detected in the soft tissue phase that could not be related to any pathological condition. The diffusion of the radiotracer in the soft tissues may be too fast and variable to permit comparison of two counts taken at slightly different times after injection. Bone phase scintigraphy proved to be superior to soft tissue scintigraphy in the detection of bone spavin, and additional information could not be gained from the soft tissue scans.

4.3.3. Differential Diagnoses

One of the limitations of probe scintigraphy is its limited specificity. Although the spatial resolution of the probe is good and different patterns of isotope distribution can be observed, complementation with other diagnostic techniques, especially radiography, is essential to reach an accurate diagnosis. In the course of this study, other conditions apart from bone spavin that resulted in high counts over the tarsus were diagnosed. Injuries to the proximal plantar aspect of the third metatarsal bone showed a peak of isotope uptake in that area, but not in the distal tarsal joints. Radiographic lesions in the plantar cortex of MT3 and lesions in the proximal suspensory ligament could not always be demonstrated in these cases. Horses with traumatic injury to the tarsus showed diffuse increases of isotope concentration throughout the tarsus and could be differentiated from bone spavin in that often the highest counts were recorded in the malleoli of the tibia or in the calcaneus. The high level of bone activity in these cases could be due to damage to the ligamentous insertions (enthesitis). Other conditions that could give high counts in the tarsus and should be considered as possible differential diagnoses are:

- Traumatic fractures of the tibial malleoli, talus, calcaneus and distal tarsal bones
- Avulsions of the tibial malleoli
- Complete or incomplete slab fractures of the third or central tarsal bones
- Incomplete fractures of the dorso-proximal cortex of MT3
- Fractures of the head of the fourth metatarsal bone
- Osteochondrosis of the tibiotarsal joint (talus and distal tibia)
- Osteoarthritis of the tibiotarsal joint or the talocalcaneal joint
- Lesions of the sustentaculum tali and/or mineralisation of the adjacent soft tissues
- Osteomyelitis or infectious arthritis
- Single cystic lesions in the talus, calcaneus or other tarsal bones

4.3.4. Correlation Scintigraphy - Radiography and Scintigraphy - Clinical Signs

This study shows that there is a moderate correlation between the degree of radiographic change and scintigraphic activity in cases of bone spavin. In a radiographic and scintigraphic study of 80 horses with bone spavin by Driesang and Böhm (1993), a high correlation was found between radiographic and scintigraphic positive findings, that is, the majority of horses that showed positive scans had positive radiographic changes. On the other hand, the authors did not think there was correlation between the degree of isotope uptake and the extent of the radiological changes, but this was not quantified. Similar studies have also shown that disagreement can exist between these two techniques (Ueltschi 1977 and 1994). In this study, positive radiographic and scintigraphic findings coincided in 65% of the horses. The statistically measured correlation between the metabolic activity as detected by scintigraphy and the extent of radiographic change was moderate for 4 of the 6 implicated joints, being good for the left DIT joint only, and poor for the right PIT joint. The results are not surprising considering that the two techniques measure two different events. Looking at the individual cases, one would have expected the correlation coefficients to be even lower. In many cases high counts were associated with only moderate radiographic changes, the most outstanding situation being the cases where relatively high counts were recorded in the total absence of radiographic changes. In the rest of the cases, the results indicate that there may be an association, however loose, between the progression of the radiographic changes and the increased metabolic activity as detected by scintigraphy. In fact, the highest counts were recorded in cases (no. 12 and 14) where there were severe radiographic changes and even joint arthrodesis. This is

in contrast with the observations of Ueltschi (1977), who suggested that the uptake of radiotracers decreased as the osteoarthritic process advanced. This fact may be true for horses with pain-free tarsi and totally arthrodesed joints, in which the metabolic activity of the tarsal bones has decreased due to the newly attained stability. However, this study shows that while the spavin is symptomatic, high bone metabolism continues, and may even increase, in cases of advanced osteoarthritis with radiographically apparent fusion of the joints. This seems to indicate that, in these cases, a functional ankylosis has not been achieved.

In this study, scintigraphy has proven useful in determining the clinical significance of both early and advanced radiographic signs of osteoarthritis.

The correlation between clinically positive and scintigraphically positive horses was excellent, but the degree of lameness did not correlate statistically to the degree of scintigraphic activity. The sensitivity of the technique for the detection of bone spavin was 14/16 (87%), which is higher than the sensitivity of radiography found in this study. This value has been obtained considering cases no. 16 and 17 to be affected by true bone spavin, a fact that could not be definitely established. The sensitivity of scintigraphy in confirmed cases of bone spavin was 100%. The limitations of the commonly used techniques in the diagnosis of bone spavin have been discussed. A positive bone scan provided unequivocal evidence of the clinical significance of the radiographic changes, as well as providing an estimate of the degree of activity. The significance of the positive radiographic changes of the three cases where the scans did not show increased activity is not known. In one of the cases (no. 15) the lameness did not originate from the tarsus. In the other two cases (no. 16 and 17) intra-articular anaesthesia localised the source of lameness in the distal tarsal joints. In both cases, the lameness and the radiographic signs were only mild (in case no.17 there was only slight toe drag), and the horses did not return for follow up examinations. One could speculate that the pain in these cases was related to a soft tissue injury and not to true bone spavin.

The most remarkable finding in this study is the demonstrated ability of scintigraphy to detect changes in bone metabolism before they become radiographically, or even clinically evident. In 3 cases (no. 5, 9 and 11) bone spavin was diagnosed scintigraphically in the total absence of radiographic changes. In 3 other cases (no. 5, 7 and 9) an increase of isotope concentration in the tarsal joints suggested early bone spavin when the clinical and the radiological signs pointed in a different direction. Follow up of these cases revealed that the

increased bony activity detected on scintigraphy was indeed an indication of incipient joint degeneration, as they became clinically symptomatic.

Unpublished data by Ueltschi (1994) revealed a similar situation, in which two thirds of a population of horses that showed scintigraphically positive but radiographically negative signs of bone spavin, developed radiographic changes in the course of successive follow up examinations. Recent reports in human medicine publications have demonstrated the predictive capability of scintigraphy in radiographic osteoarthritis of the human hand and knee (McCarthy *et al.* 1994). In these studies, initial radiographic and scintigraphic examinations of a large number of patients were compared to follow up radiographs taken during a 5 year period. They showed how radiographic changes of osteoarthritis detected on the second examination only, had been predicted by positive scintigraphic scans as early as 5 years before.

Neither of the studies by Ueltschi (1994) or McCarthy (1994) make reference to the clinical status of the patients scanned. An early report by the former author mentions that some of the scintigraphic positive and radiographic negative horses examined were not lame but showed a positive response to the flexion test. He interpreted this as a possible sign of early bone spavin, but no comment was made on the subsequent progression of the clinical signs (Ueltschi 1977). In contrast with the study by Ueltschi (1977), the cases in the present study that were radiographically negative for bone spavin and were subjected to follow up examinations, did not develop considerably more advanced radiographic changes in the course of 1 year. There is, however, a recognised poor correlation between the radiological and clinical signs of osteoarthritis, and the prediction of the development of clinical, rather than radiographic spavin (or osteoarthritis in general), unveils an even more significant and exciting situation.

The origin and significance of clinical and scintigraphic abnormalities in the back and pelvis detected on the initial examinations of the cases no. 5 , 7 and 9 are open to discussion. They may have been concomitant problems or they may represent conditions that developed secondary to subtle gait changes caused by an incipient, bilateral spavin. In any case, as the clinical manifestation of the bone spavin became more evident in successive examinations, these conditions became less important, and in some cases they positively improved.

The early detection by scintigraphy of osteoarthritis in the tarsal joints and at other sites has may implications. Gamma-scintigraphy provides a tool for resolving lameness and problems of poor performance that may otherwise remain

undiagnosed. In addition, it is attractive to think that the high sensitivity of scintigraphy for detecting early alterations of the subchondral bone before they become clinically or radiographically evident, may be used in adapting exercise regimes in athletic horses to the capability of their joints, and prevent progression of these alterations into clinically evident osteoarthritis. This would only be possible, of course, if these small changes in the subchondral bone are reversible and can be repaired without causing a permanent alteration of the joint, a hypothesis that has yet to be proved. The development of osteoarthritis may occur due to factors other than those detected by bone scintigraphy.

4.4. Pathology - Incomplete Fracture of the Central Tarsal Bone

Post-mortem examination of the right tarsus of case no. 13 revealed an unexpected healing fracture of the central tarsal bone and secondary osteoarthritis. The fracture was through both articular surfaces in the dorso-medial aspect of the central tarsal bone, but did not continue into the plantar or lateral cortices and was, therefore, an incomplete fracture. While complete slab fractures of the central tarsal bone have been reported (Linsday *et al.* 1982; Tulamo *et al.* 1983), a full description of one such incomplete fracture could not be found in the current literature. Stover *et al.* (1986) reported 3 cases of distal tarsal bone trauma diagnosed by scintigraphy, in 2 of which a fracture could not be demonstrated by radiography. These cases were thought to be either incomplete or complete non-displaced fractures, although this was not confirmed by post-mortem examination. Ueltschi (1994) mentioned that "bone stress cysts" and "microscopic fissures or fractures" can be found in the distal tarsal bones, but did not elaborate on any of these lesions. A similar type of fracture to the one described here has been reported by Pilsworth (1992_b). These fractures were detected by scintigraphy in racing thoroughbreds, and consisted of incomplete fractures of the dorsal aspect of the proximal cortex of the third metatarsal bone. Pilsworth postulated that these were "stress" fractures associated with repeated focal overloading of the affected articular area. In human medicine, complete and incomplete fractures of the tarsal navicular bone (equivalent to the central tarsal bone in equids) have been reported in runners (Goergen 1981). These were also considered stress fractures, and so are the third tarsal bone fractures observed so frequently in the racing greyhound (Wendelburg *et al.* 1988).

Stress fractures occur as a consequence of cyclical loading (Riggs and Evans 1990), which results in the accumulation of microdamage and eventual

failure of the bone. The increased rate of bone remodelling that results as a response to that microdamage is thought to contribute to the process in long bone stress fractures Increased bone resorption occurs at the beginning of the remodelling process, and results in greater porosity and weakening of the bone (Matin 1988; Riggs and Evans 1990). On the other hand, Pilsworth (1992_b) proposed that the stress fractures in the proximal MT3 that he described could be related to an increase in brittleness caused by the excess density of the affected bone, as observed in third carpal bone injury. This increase in density would also be a result of not coupled bone remodelling. The fracture observed in case no. 13 has the characteristics of a stress fracture. It is not possible to say if the high degree of compaction observed in the central tarsal bone preceded the fracture or occurred afterwards as a result of healing. An increased degree of sclerosis could have been a pre-existing and predisposing factor for the materialisation of the fracture. It is interesting to note that all the pathological changes seen in this case, including the cyst-like lesion and osteophytes due to "secondary" osteoarthritis, occurred in the bone, and the cartilage was largely undamaged.

The fracture described here was 3 months old and had been undiagnosed at the time of occurrence and subsequently at the examination on referral. The clinical signs of the horse at the time of referral were of only mild gait abnormalities. The clinical radiographs of the affected tarsus showed changes indistinguishable from those of bone spavin, and a fracture line could not be demonstrated in any of the views. The scan results showed a marked focal increase, but of no higher intensity than in other cases of bone spavin. The difficulty in diagnosing central and third tarsal bone fractures has been recognised (Tulamo *et al.* 1983). Gamma-camera scintigraphy carried out a short time after the injury has been useful in detecting these fractures. Stover *et al.* (1986) suggested that the scintigraphic appearance of these lesions was more intense and focal than in cases of tarsal osteoarthritis. An earlier clinical and scintigraphic examination of case no. 13 would have probably allowed an accurate diagnosis. Complete and incomplete central tarsal bone fractures should be in the list of differential diagnoses of causes of hindlimb lameness originating from the tarsus.

The clinical significance of the fused lumbar vertebrae (with associated high isotope uptake) and the increase in isotope concentration in the sacroiliac region seen in case no. 13 are not known, but the latter could represent an injury secondary to the fracture.

Figure 4.1. *Sections of specimens of the third and central tarsal bones, demonstrating the degree of compaction that can be attained in bone spavin.*

4.5. Considerations on the Aetiology of Bone Spavin and Osteoarthritis

Increased uptake of radiotracer in bone phase joint scintigraphy is mainly a reflection of changes in the metabolic activity of the subchondral bone (increased deposition and mobilisation of hydroxyapatite crystals), other factors being of minor significance (McCarthy *et al.* 1994). The detection, in this study and others, of radioisotope uptake increases in joints where there is no evidence of osteoarthritis, either radiographically or clinically; and the subsequent progression of these joints into the development of typical signs of osteoarthritis, suggests that the changes in bone activity detected take place very early in the process of osteoarthritis. There is experimental data that also supports the fact that bone changes are of early onset. Mc Devitt *et al.* (1977) found early formation of osteophytes only 3 days after an operation to induce osteoarthritis in dogs, which was as early as any cartilage change was detected. Studies using microfocal radiography in man have shown subtle changes in the subchondral bone before any changes in cartilage thickness are detected (Theiler *et al.* 1994).

The articular cartilage has received most of the attention in experimental and clinical studies designed to help our understanding of the aethiopathogenesis of osteoarthritis and the processes that govern its early stages. Damage to, or degeneration of the cartilage is generally thought to be the initiating process. There has been, however, a line of thought that has maintained that changes in the subchondral bone, especially stiffness, could be responsible for the destruction of the articular cartilage in primary osteoarthritis (Radin 1979). The results of the present, and similar studies, add weight to this argument.

While one should view osteoarthritis as the final common pathway of a multy-factorial process (Radin 1979), cyclical loading of the joints, affecting both the cartilage and the subchondral bone, seems the most likely mechanism to initiate such process. This may be especially true in high-load / low-motion joints such as the arthrodial joints of the tarsus. Joint motion opposed by the musculo-tendinous units is the main shock absorbing mechanism in locomotion. In the tarsal joints, the practical lack of any joint motion results in all the shock wave transmitted from the metatarsus being absorbed by the bone. The cancellous bone has the best shock absorbing properties (Radin 1979), but in the narrow third and central tarsal bones there is a limited amount of this bone. This may subject the subchondral bone of the tarsal joints to increased stresses that may result in microdamage. This microdamage is probably the basis of the increases in isotope uptake detected in

early positive scans. Microdamage in the form of trabecular "stress" fractures has been found in the human femoral head and proposed as the possible initial cause of pathology in that joint, including osteoarthritis and avascular necrosis (Todd *et al.* 1972). The accumulation of microdamage and healing of microfractures would result in a abnormal compaction of the bone, with even more reduced energy absorbing properties. This abnormally stiff subchondral bone would have a deleterious effect on the articular cartilage. Radin (1979) proposed that a gradient of stiffness underlying the articular cartilage would produce a shear stress that would destroy it. In addition, excessively compacted bone may impair the vascular supply to the osteochondral junction and limit the nutrient availability to the subchondral bone and articular cartilage. When the accumulation of microdamage is too great for the physiological bone repair mechanisms to counteract it, an area of subchondral bone lysis or a subchondral bone micro-cysts may form. The increased bone resorption seen at these sites may be part of the failing reparative process, as seen in long bone stress fractures (Riggs and Evans 1990).

Abnormal stiffness of the subchondral bone has been implicated in the development of incomplete intra-articular (stress) fractures of the dorso-proximal aspect of MT3 (Pilsworth 1992_b), and in the development of slab fractures and other bone pathology in the carpal bones (De Hann *et al.* 1987). It is also the possible cause of the incomplete fracture of the central tarsal bone described earlier. This shows a close association between osteoarthritis and more catastrophic joint pathology.

Other forces acting on the distal tarsal bones (torsional and tensile forces) may play a role in the process, causing what Rooney (1969) described as "asynchronous movements" of the tarsal bones, although this has not been demonstrated.

4.6. General Conclusion

The present study compares the clinical, radiographic and scintigraphic signs of 17 horses admitted for lameness examination to the Equine Veterinary Hospital of Glasgow University Veterinary School, and in which bone spavin was diagnosed as a main or contributory cause. The main conclusions to be drawn from it are:

- Bone spavin can present in a variety of clinical and radiographic manifestations. Scintigraphy provides an attractive alternative means of investigating the condition.

- The correlation between clinical and radiographic signs in bone spavin is not always good.
- The sensitivity of scintigraphy in the detection of clinical bone spavin is higher than that of radiography.
- There is a moderate correlation between the scintigraphic and radiographic signs of bone spavin.

Probably the most significant fact revealed by this study is the ability of Gamma-scintigraphy to detect subtle changes in the metabolic activity of the subchondral bone of the third tarsal, central tarsal and proximal MT3 bones principally, before, not only radiographic, but even distinct clinical signs of osteoarthritis become apparent. The implications of this are that scintigraphy can be used to resolve problem lameness with misleading clinical and radiographic signs, and that, more optimistically, it could be useful in monitoring subtle subchondral bone changes with a view to prevent the development of overt osteoarthritis (or other joint pathology such as articular "stress" fractures). Scintigraphy can also be useful in monitoring the effect of drugs and other treatment regimes in the treatment and/or prevention of osteoarthritis.

The limitations of this study are related to the difficulties in interpreting the results and reaching generalised conclusions over a relatively small number of cases. The horses in this study were patients of an equine hospital and were admitted for evaluation of a skeletal dysfunction. This study reflects, therefore, the findings on a population with specific clinical circumstances. A similar study with a larger and random population of horses would be more significant and would enable more weight to be given to the arguments exposed. Ideally, the correlation between clinical signs, radiography and scintigraphy should be assessed including both positive and negative cases of all three parameters, and the evaluation of each one of these parameters should be carried out by different clinicians, blinded to the findings of the other ones. Although point-probe scintigraphy has proved a useful and totally valid technique for the purpose of this study, modern Gamma-cameras with dedicated image and quantitative data processing computers offer obvious advantages in conveying information and diagnostic capability.

The monitoring with bone scintigraphy of normal joints, and joints showing early changes in bone activity, in horses on different exercise regimes during a period of time may give an insight into the factors influencing the development and progression of joint pathology and, specifically, osteoarthritis. The complementation of this technique with other "state of the art" imaging techniques such as MRI, which permits evaluation of the changes in the articular cartilage and

other soft tissue structures, as well as the subchondral bone, may, in the future, provide an answer to the role and interrelation of each one of those structures in the process of osteoarthritis.

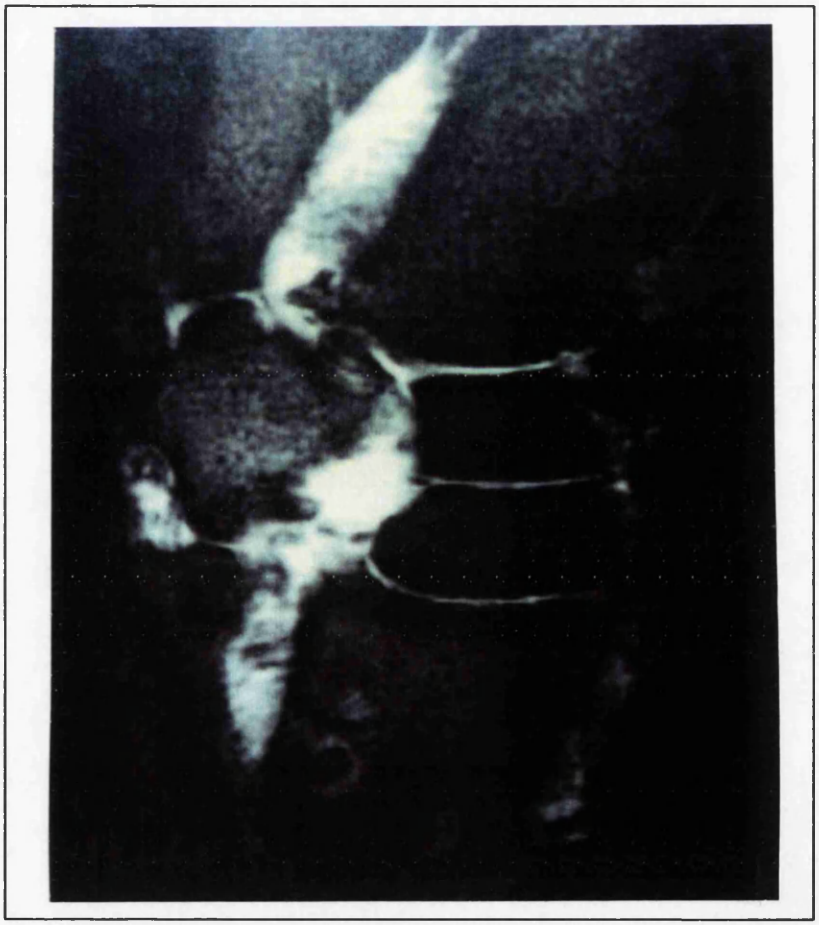


Figure 4.2. *MRI image of a specimen of equine tarsus.*

TABLES

Case	Breed	Age / sex	Use
1	Thoroughbred	12 y.o./ Gelding	Show-jumper
2	Irish draft	7 y.o./ Mare	General riding
3	Tb. X.	7 y.o./ Mare	Dressage / Show-jumping
4	Tb. X.	9 y.o./ Gelding	Show-jumper
5	Thoroughbred	7 y.o./ Gelding	Eventer
6	Arab X.	10 y.o./ Gelding	Light hacking
7	Tb. X.	7 y.o./ Gelding	Dressage
8	Connemara X.	10 y.o./ Gelding	Pony club Show-jumping
9	Tb. X.	9 y.o./ Gelding	Show-jumper
10	Welsh X Connemara	14 y.o./ Gelding	Riding pony
11	Tb. X Arab	12 y.o./ Mare	General riding (former Show-jumper)
12	Tb. X.	17 y.o./ Gelding	General riding
13	Tb. X.	8 y.o./ Mare	Hunter (former eventer)
14	Dales pony	29 y.o./ Gelding	In hand showing (former driving pony)
15	Tb. X.	10 y.o./ Gelding	Eventer
16	Connemara X.	11 y.o./ Mare	Show-jumper
17	Irish draft X.	6 y.o./ Gelding	Eventer

TABLE 3.1: Signalment of cases.
Key: (Tb.): Thoroughbred.

Case	Complaint	Onset	Duration
1	Lame R H	Sudden	10 moths
2	Lame R H	Sudden	2 months
3	Lame L F+ R H Pelvic + cervical problem	Insidious	1 year
4	Back problem, refusing to jump	Insidious	6 months
5	Back problem + poor hind limb action	Sudden	10 months
6	Lame L H	Insidious	5 months
7	Poor performance, stiff L H + back + disunited gait	Insidious	Several years
8	Lame R H	Insidious	5 months
9	Poor performance + stiff R H	Insidious	2 1/2 months
10	Lame R H	Insidious	3 months
11	Stiff on both hind legs (Previous back problem)	Sudden	1 month (back: 2 years)
12	Back problem / hind limb lameness	Sudden	2 months
13	Lame R H	Sudden	3 months
14	Lame R H	Insidious	5 years
15	Traumatic injury to pelvis + bilateral hindlimb lameness	Sudden (traumatic)	1 month
16	Lame R H	Sudden	3 weeks
17	Toe dragging R H	Sudden	4 months

TABLE 3.2: History.

Key: (RH): right hind, (LH): left hind

Case	Lameness at the walk	Lameness at the trot (0-5)	Lameness on the lunge L rein	Lameness on the lunge R rein	Flexion tests (spavin test)
1	Stiff RH	1/5 RH	N/P		(+) 1/5 LH (+ +) 3/5 RH
2	Stiff RH	1.5/5 RH	0.5/5 LH	1/5 RH	(-) LH (-) RH
3	Stiff RH	1/5 LF 0.5/5 RH	N/P		(+) 1/5 RH
4	1/5 RH	1/5 RH	1.5/5 RH	1/5 RH	(-) RH
5	1/5 LH Stiff LH + RH	Stiff RH > LH (later 1/5 RH)	sl. lame LH	1/5 RH	(-) LH (-) RH
6	Stiff LH	2/5 LH	N/P		(+ +) LH (-) RH
7	Stiff LH	0.5/5 LH (Later 0.5/5 RH)	_	0.5/5 LH	(-) LH (-) RH, later (+)
8	Stiff RH	1/5 RH	2/5 RH	2/5 RH	(+) RH
9	Stiff RH	N/A	N/P		N/P
10	N/A	1/5 RH	N/P		(+) RH
11	Stiff LH + RH sl. lame RH	1/5 RH	1/5 RH	1/5 RH	(+) LH (+) RH
12	0.5/5 RH	2/5 RH	N/P		(+ +) RH
13	sl. lame RH	0.5/5 RH	1/5 RH	0.5/5 RH	(-) RH (+) RH
14	NAD	1/5 RH	N/P		(+) LH (+ +) 3/5 RH
15	Severe bilateral lameness	N/P	N/P		N/P
16	Stiff LH + RH 1/5 RH	2/5 RH	2/5 RH	2.5/5 RH	(+) LH (+) RH
17	Stiff RH	sl. lame RH	sl. lame RH	sl. lame RH	(-) LH (-) RH

TABLE 3.3. a : Clinical signs - lameness assessment.

(RH): right hind, (LH): left hind, (N/P): not performed, (N/A): data not available, (sl.): slightly, (NAD) : no abnormalities detected.

Case	Plaiting gait	Decreased hock flexion	Toe drag	Gluteal atrophy	Bony swelling	Other gait abnormalities
1	(+) RH	(+) RH	(+) RH	sl.(+) RH	(+) RH	Mild hip hike RH
2	_	(+) RH	_	(+) RH	_	Falls inside the line on the right rein.
3	_	_	_	_	_	1/5 Lame LF
4	(+) RH	(+) RH	(+) RH	(+) RH	_	Marked hip hike RH
5	(+) RH	(+) LH (+) RH	_	_	_	Stiff back, rolling + hicking pelvis + disunited canter
6	(+) LH	(+) LH	_	_	(+) LH	_
7	(+) RH	(+) LH (+) RH	_	(+) LH	_	Rolling pelvis + dropping left side
8	(+) RH	(+) RH	(+) RH	(+) RH	(+) RH	_
9	_	(+) RH	_	_	_	Reluctance to canter on R rein
10	N/A	N/A	N/A	N/A	N/A	_
11	_	_	_	sl. (+) LH	_	_
12	(+) RH	(+) RH	_	_	sl.(+) RH	_
13	_	_	(+) RH	(+) RH	_	Uncomfortable + "bunny-hopping" at the canter
14	_	(+) RH	_	_	(++) RH	_
15	_	_	_	(+) LH (+) RH	_	Reluctance to walk / difficulty getting up
16	_	(+) LH (+) RH	_	_	_	_
17	_	(+) LH (+) RH	(+) RH	_	_	Occasional "bunny-hopping" at the canter

TABLE 3.3. b : Clinical signs (Continued).

Case	Tibial-Peroneal nerve block	Intra-articular anaesthesia (DIT + TMT joints)	Other observations
1	N/P	N/P	–
2	RH lameness improved	RH Improved (60%)	Four-point block RH: No change
3	RH Improved (70%)	RH lameness improved	Four-point block RH: No change
4	RH lameness improved	RH Improved (90%)	Four-point block RH: No change
5	N/P	RH Improved (TMT only)	–
6	N/P	N/P	–
7	N/P	N/P	LH fetlock joint block: Partial improvement
8	RH lameness improved	RH lameness improved	Four-point block RH: No change
9	N/P	N/P	–
10	RH lameness improved	N/P	Abaxial sesamoid block RH: No change
11	No change RH lameness	N/P	Subtarsal block : RH improved (lame LH)
12	N/P	N/P	–
13	N/P	N/P	–
14	N/P	N/P	–
15	N/P	N/P	–
16	RH lameness improved (lame LH)	RH and LH lameness improved	Four-point block RH: No change
17	RH lameness improved ?	RH lameness improved	–

TABLE 3.4: Regional and intra-articular anaesthesia results.

(DIT): Distal-Intertarsal, (TMT): Tarsometatarsal, (RH): right hind, (LH): left hind, (N/P) : not performed.

Case	Left PIT	Left DIT	Left TMT	Left tarsus	Right PIT	Right DIT	Right TMT	Right tarsus	Total score
1	1	4	2	7	1	4	3	8	15
2	0	0	2	2	1	1	1	3	5
3	N/A	N/A	N/A	_	2	3	3	8	_
4	N/A	N/A	N/A	_	1	2	2	5	_
5	N/A	N/A	N/A	_	0	1	1	2	_
6	1	4	3	8	0	2	0	2	10
7	0	3	2	5	1	3	3	7	12
8	1	2	1	4	2	4	2	8	12
9	0	1	0	1	0	1	0	1	2
10	N/A	N/A	N/A	_	1	2	2	5	_
11	0	1	0	1	0	1	0	1	2
12	1	4	3	8	2	4	2	8	16
13	N/A	N/A	N/A	_	1	2	0	3	_
14	1	2	1	4	2	4	4	10	14
15	1	2	1	4	1	3	1	5	9
16	0	2	1	3	0	2	1	3	6
17	1	1	1	3	2	2	3	7	10

TABLE 3.5: Radiological findings.

The numbers represent the radiological scores indicating the degree of osteoarthritis in each joint. (0): none, (1): doubtful, (2): mild, (3): moderate, (4): severe. (N/A) : data not available, (PIT): proximal-intertarsal joint, (DIT): distal-intertarsal joint, (TMT): tarsometatarsal joint.

Case	Regions scanned	"Hot" areas	A	B	C
1	B + T	RT + LT	+ 115% R TMT	N/A	N/A
2	HL	R T	+278% R DIT	+110% R T	N/A
3	FL+HL+B+P	RT + R Lateral sesamoid	+83% R TMT	+5% R T	-14% R leg
4	HL+B+P	R T	+214% R TT	+37% R T	N/A
5	HL+B+P	RT + Sacroiliac	+74% R PMT3	+24% R T	0%
6	H L	L T	+125% L TMT	+34% L T	+ 4% L leg
7	HL+B+P	RT+LT+Sacroil.	+48% R DIT	+10% R T	- 4% R leg
8	H L	R T	+106% R TMT	+20% R T	+10% R leg
9	HL+B+P	RT + Back	+92% R 4thTB	+38% R T	+9% R leg
10	H L	L T	+76% L PMT3	+33% L T	+3% L leg
11	HL + P	L T+R Prox.MT3	+63% L PIT	+6% L T	+9% L leg
12	H L	RT + LT	+81% L PIT	+14 % R T	+1% R leg
13	HL+B+P	RT+Back+Sacroil.	+200% R DIT	+71% R T	+17% R leg
14	H L	R T	+160% R CTB	+66% R T	+16% R leg
15	FL+HL+B+P	R Hip + L leg	+75% L TT	+60% L T	+84% L leg
16	H L	_	+33% L Medial Malleolus	+5% R T	+10% R leg
17	H L	_	+29% R Medial Malleolus	+5% R T	+7% R leg

TABLE 3.6: Scintigraphic findings - Bone Phase.

A: Greatest difference between counts of any pair of points in the tarsus over the "normal" count x100.

B: Mean difference between counts of the tarsus (over the "normal" count) x 100.

C: Mean difference between counts of whole leg over the sound leg x 100.

Key: (R): right, (L): left, (RT): right tarsus, (LT): left tarsus, (FL): forelimbs, (HL): hindlimbs, (B):back, (P): pelvis, (PIT): proximal-intertarsal joint, (DIT): distal intertarsal joint, (TMT): tarsometatarsal joint, (PMT3): proximal third metatarsal, (CTB): central tarsal bone, (4thTB): 4th tarsal bone, (TT): tibiotarsal joint, (N/A): data not available.

Case	A	B	C
1	+208% R DIT	+65% RT	N/A
2	N/A	N/A	N/A
3	N/A	N/A	N/A
4	+380 %R DIT	+96 %RT	N/A
5	+60 %R PMT3	+39% RT	N/A
6	+67% L DIT	+22% LT	-1% L leg
7	N/A	N/A	N/A
8	+116% R PMT3	+18% RT	+8% R leg
9	N/A	N/A	N/A
10	+147% L DIT	84% LT	+7% L leg
11	N/A	N/A	N/A
12	+56% R DIT	+11% RT	+3% R leg
13	N/A	N/A	N/A
14	+162% R DIT	+49% RT	+1% R leg
15	N/A	N/A	N/A
16	+37% R TT	+3% RT	+5% L leg
17	N/A	N/A	N/A

TABLE 3.7: Scintigraphic findings - Soft Tissue Phase.

(see table 3.6. for Key)

Case	Diagnosis	Treatment	Outcome
1	Bilateral Bone Spavin	Graduated exercise prog. + corrective shoeing	Working
2	Bilateral Bone Spavin	none	Retired
3	Bilateral Bone Spavin + DJD LF fetlock	none	Retired to stud
4	RH Bone Spavin	Surgical arthrodesis	In light work
5	RH Spavin, sacro-iliac strain + left lumbar pain	Rest initially, then exercise + corrective shoeing	In light work ("loss of use")
6	LH Bone Spavin	none	Retired
7	Bilateral Spavin, DJD LH fetlock, sacro-iliac + back	First rest + physiotherapy, then exercise + shoeing	In light work
8	RH Bone Spavin	Exercise + NSAIDS + lateral extension shoe	In light work
9	RH Bone Spavin + lumbar spine problem	Graduated exercise programme	"Loss of use"
10	RH Bone Spavin	none	Retired
11	LH Bone Spavin + injury proximal MT3 RH	Rest	N/A
12	RH Bone Spavin	Exercise + NSAIDS + lateral extension shoe	In light work
13	Incomplete # CT bone + 2ndary Bone Spavin RH	_	Destroyed
14	RH Bone Spavin	none	Retired (In hand showing)
15	# greater trocanter right femur + traumatic injuries	_	Destroyed
16	Bilateral tarsitis / Bone Spavin ?	Corrective shoeing + graduated exercise	Retired ?
17	Low grade RH Bone Spavin	Exercise	N/A

TABLE 3.8: Diagnosis, treatment and outcome.

(LF): left fore, (LH): left hind, (RH): right hind, (CT): central tarsal bone, (N/A): data not available

APPENDIX A:

SCINTIGRAPHY DATA

Gamma - scintigraphy report . Tarsus **Soft Tissue Phase**

Anderson 117889 **Date: 15/08/1991**

Lame RH

	L count	R count		L %	R %		(L-R)/R		(R-L)/L
med. mall.	-	-	med. mall.	43%	43%	med. mall.	0%	med. mall.	0%
lat. mall.	-	-	lat. mall.	74%	67%	lat. mall.	10%	lat. mall.	-9%
p. of hock	-	-	p. of hock	90%	150%	p. of hock	-40%	p. of hock	67%
tibio-tars. jt	-	-	tibio-tars. jt	91%	150%	tibio-tars. jt	-39%	tibio-tars. jt.	65%
prox. IT jt.	-	-	prox. IT jt.	170%	215%	prox. IT jt.	-21%	prox. IT jt.	26%
central tb.	-	-	central tb.	85%	180%	central tb.	-53%	central tb.	112%
dist. IT jt.	-	-	dist. IT jt.	65%	200%	dist. IT jt.	-68%	dist. IT jt.	208%
3rd. tb.	-	-	3rd. tb.	120%	215%	3rd. tb.	-44%	3rd. tb.	79%
4th. tb.	-	-	4th. tb.	-	-	4th. tb.	0%	4th. tb.	0%
TMT jt.	-	-	TMT jt.	40%	80%	TMT jt.	-50%	TMT jt.	100%
prox. MT3	-	-	prox. MT3	60%	80%	prox. MT3	-25%	prox. MT3	33%
Mean values :				84%	138%		-39%		65%
Mean difference between sample points							-33%		68%

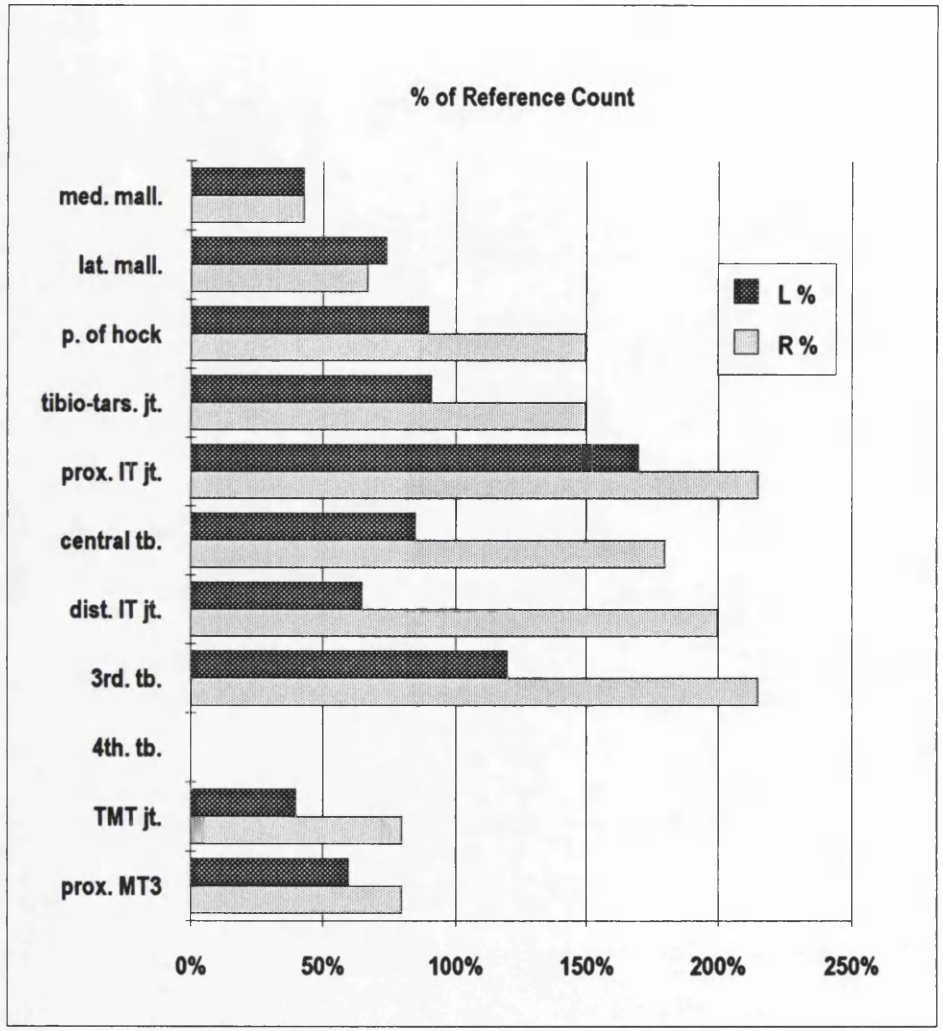


Fig. A.1.a Scintigraphy report of case no. 1. Page 1

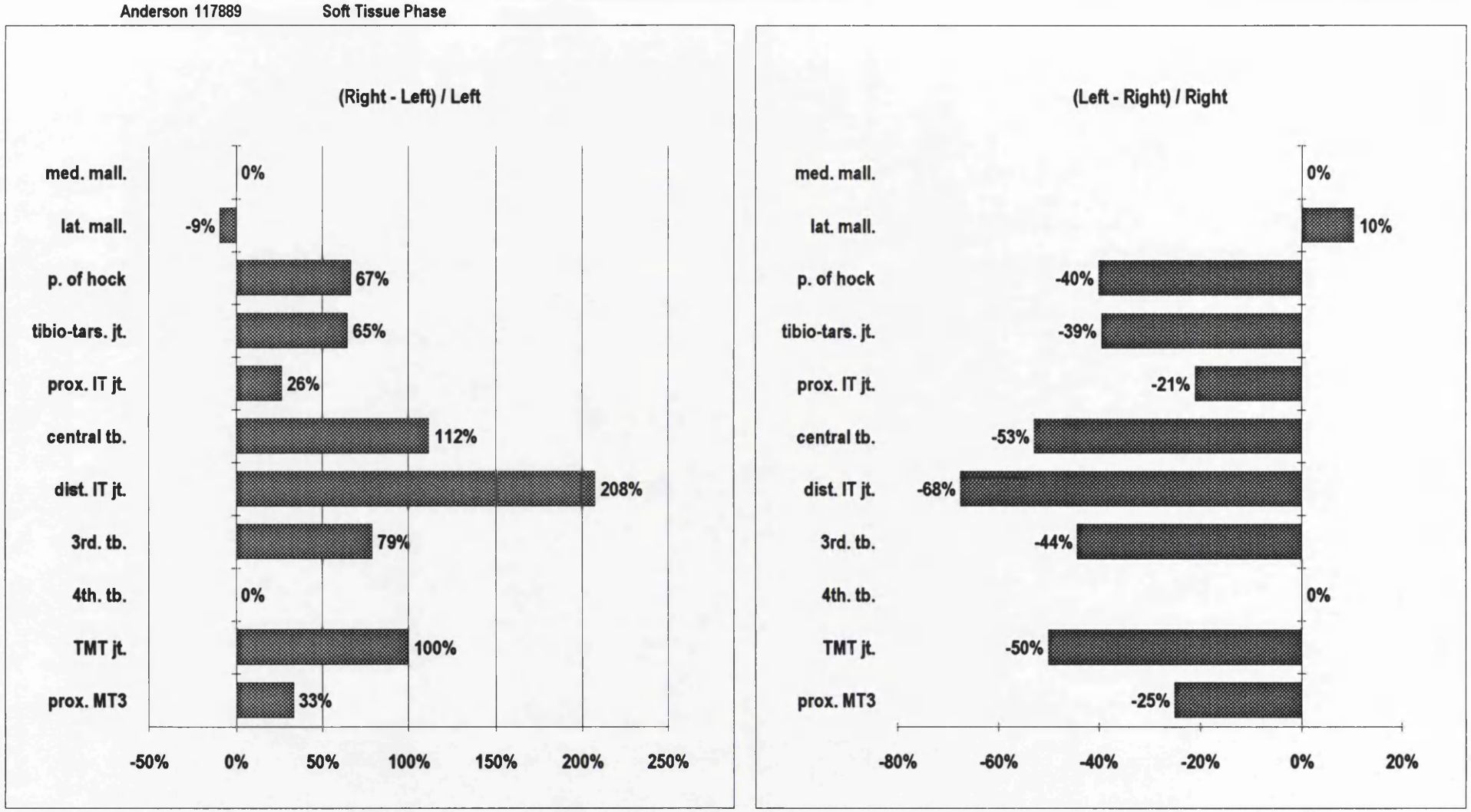


Fig. A.1.b Scintigraphy report of case no. 1. Page 2

Gamma - scintigraphy report . Tarsus **Bone Phase**

Wilson 114739 **Date: 5/11/90** **Atlas: 5074**

Lame RH

	L count	R count		L %	R %		(L-R)/R		(R-L)/L
med. mall.	1814	3267	med. mall.	36%	64%	med. mall.	-44%	med. mall.	80%
lat. mall.	1472	2088	lat. mall.	29%	41%	lat. mall.	-30%	lat. mall.	42%
p. of hock	1801	3121	p. of hock	35%	62%	p. of hock	-42%	p. of hock	73%
tibio-tars. jt	-	-	tibio-tars. jt	-	-	tibio-tars. jt	0%	tibio-tars. jt.	0%
prox. IT jt.	917	2494	prox. IT jt.	18%	49%	prox. IT jt.	-63%	prox. IT jt.	172%
central tb.	-	-	central tb.	-	-	central tb.	0%	central tb.	0%
dist. IT jt.	1121	4241	dist. IT jt.	22%	84%	dist. IT jt.	-74%	dist. IT jt.	278%
3rd. tb.	-	-	3rd. tb.	-	-	3rd. tb.	0%	3rd. tb.	0%
4th. tb.	-	-	4th. tb.	-	-	4th. tb.	0%	4th. tb.	0%
TMT jt.	1254	2322	TMT jt.	25%	46%	TMT jt.	-46%	TMT jt.	85%
prox. MT3	935	2037	prox. MT3	18%	40%	prox. MT3	-54%	prox. MT3	118%
Mean values :				26%	55%		-52%		110%
Mean difference between sample points							-50%		121%

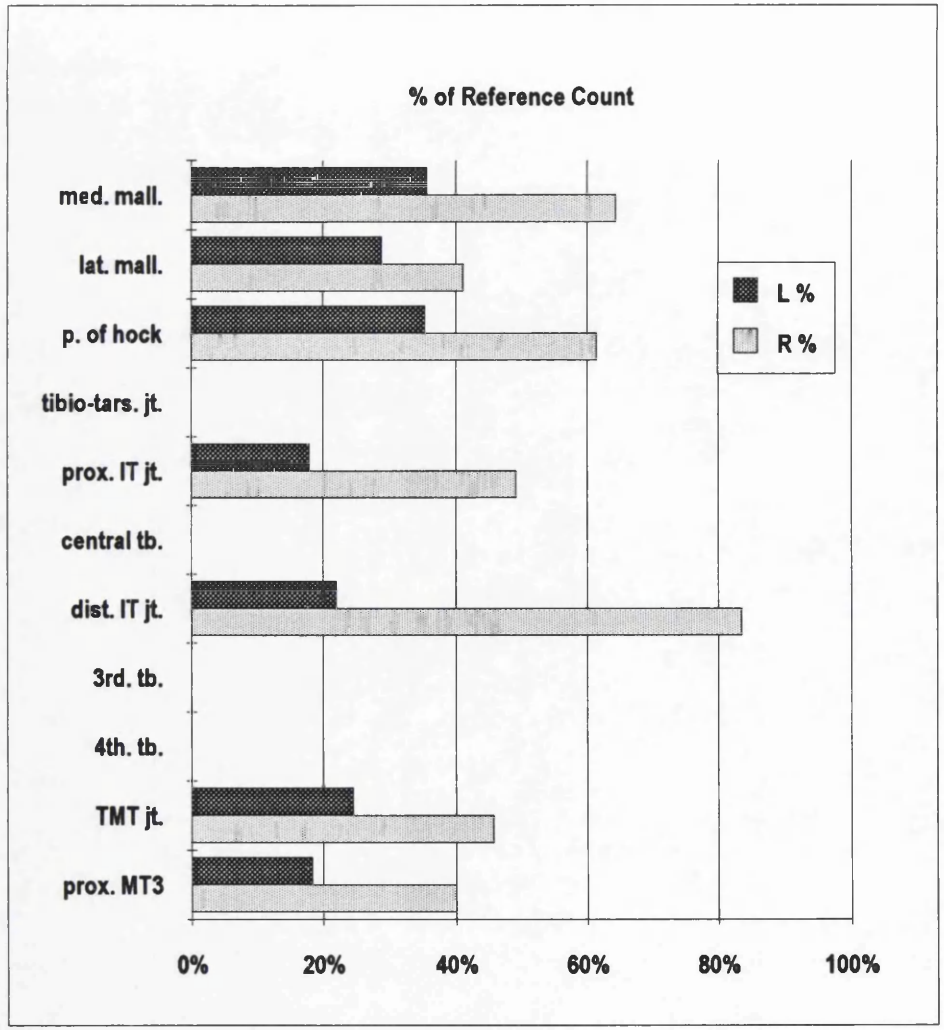


Figure. A.2.a Scintigraphy report of case no. 2

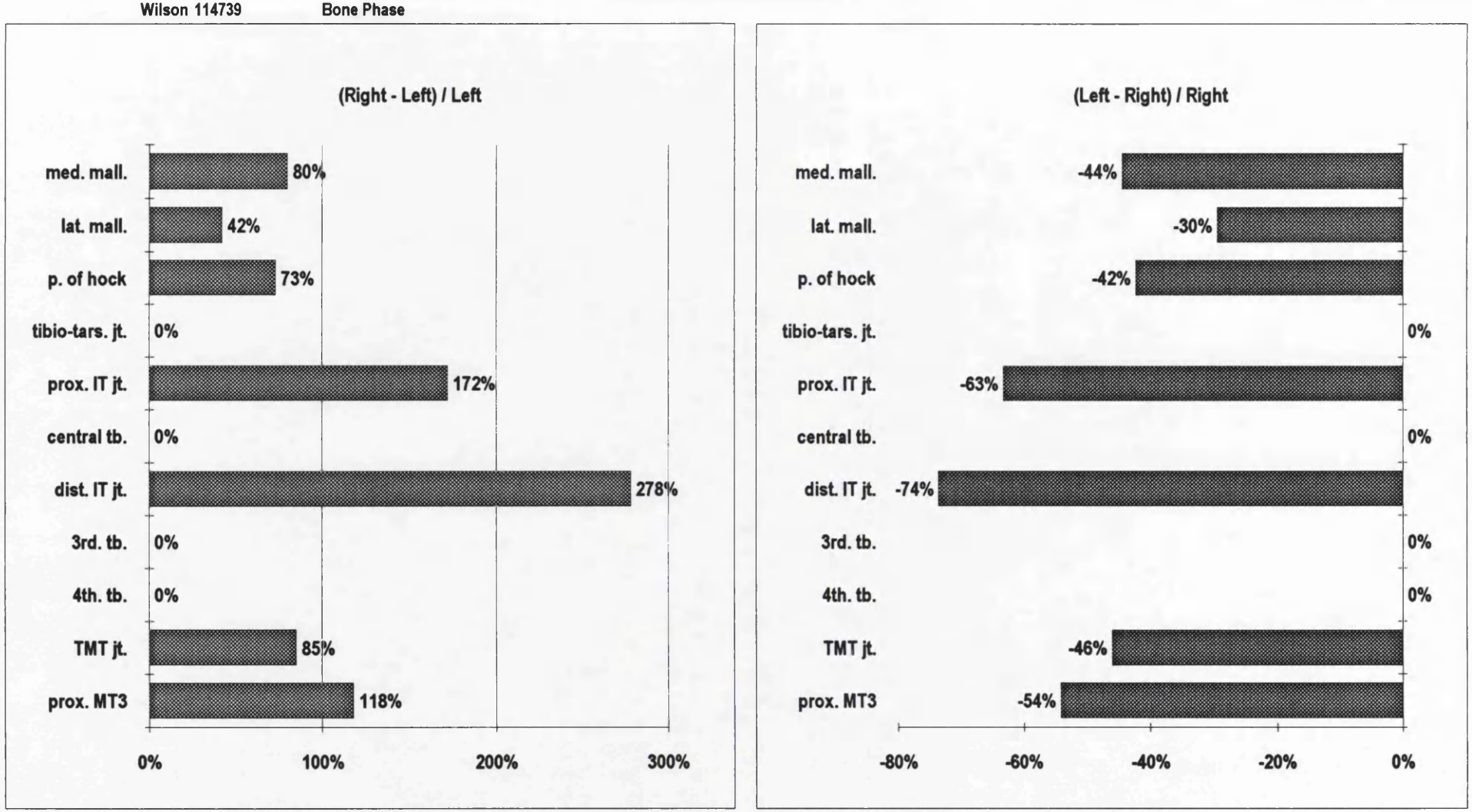


Figure. A.2.b. Scintigraphy report of case no. 2

Gamma - scintigraphy report **Hind limbs** Bone Phase

Tyrie 119435 Date: 05/03/92 Atlas: 3582

	L count	R count		L %	R %		(L-R)/R		Lame RH (R-L)/L
tub.sacr.	3676	3455	tub.sacr.	103%	96%	tub.sacr.	6%	tub.sacr.	-6%
tub.coxae	2129	1557	tub.coxae	59%	43%	tub.coxae	37%	tub.coxae	-27%
hip	3187	1636	hip	89%	46%	hip	95%	hip	-49%
mid femur	1554	1282	mid femur	43%	36%	mid femur	21%	mid femur	-18%
patella	3071	587	patella	86%	16%	patella	423%	patella	-81%
stifle	1660	565	stifle	46%	16%	stifle	194%	stifle	-66%
tibia 1	2785	1417	tibia 1	78%	40%	tibia 1	97%	tibia 1	-49%
tibia 2	3001	3081	tibia 2	84%	86%	tibia 2	-3%	tibia 2	3%
tibia 3	2150	2834	tibia 3	60%	79%	tibia 3	-24%	tibia 3	32%
med. mall.	1193	1346	med. mall.	33%	38%	med. mall.	-11%	med. mall.	13%
lat. mall.	979	1241	lat. mall.	27%	35%	lat. mall.	-21%	lat. mall.	27%
p. of hock	902	838	p. of hock	25%	23%	p. of hock	8%	p. of hock	-7%
tibio-tars. jt	1179	969	tibio-tars. jt	33%	27%	tibio-tars. jt	22%	tibio-tars. jt	-18%
prox. IT jt.	971	1083	prox. IT jt.	27%	30%	prox. IT jt.	-10%	prox. IT jt.	12%
dist. IT jt.	1153	1115	dist. IT jt.	32%	31%	dist. IT jt.	3%	dist. IT jt.	-3%
TMT jt.	825	1512	TMT jt.	23%	42%	TMT jt.	-45%	TMT jt.	83%
prox. MT3	702	579	prox. MT3	20%	16%	prox. MT3	21%	prox. MT3	-18%
mid MT3	454	524	mid MT3	13%	15%	mid MT3	-13%	mid MT3	15%
dist. MT3	431	699	dist. MT3	12%	20%	dist. MT3	-38%	dist. MT3	62%
fetlock jt.	440	556	fetlock jt.	12%	16%	fetlock jt.	-21%	fetlock jt.	26%
med. ses.	701	628	med. ses.	20%	18%	med. ses.	12%	med. ses.	-10%
lat. ses.	397	968	lat. ses.	11%	27%	lat. ses.	-59%	lat. ses.	144%
prox. P1	428	772	prox. P1	12%	22%	prox. P1	-45%	prox. P1	80%
pastern jt.	484	652	pastern jt.	14%	18%	pastern jt.	-26%	pastern jt.	35%
coffin jt.	834	765	coffin jt.	23%	21%	coffin jt.	9%	coffin jt.	-8%
P3	1015	732	P3	28%	20%	P3	39%	P3	-28%
navicular	817	522	navicular	23%	15%	navicular	57%	navicular	-36%
Mean whole limb counts :				38%	33%		16%		-14%
Mean difference between sample points :							27%		4%

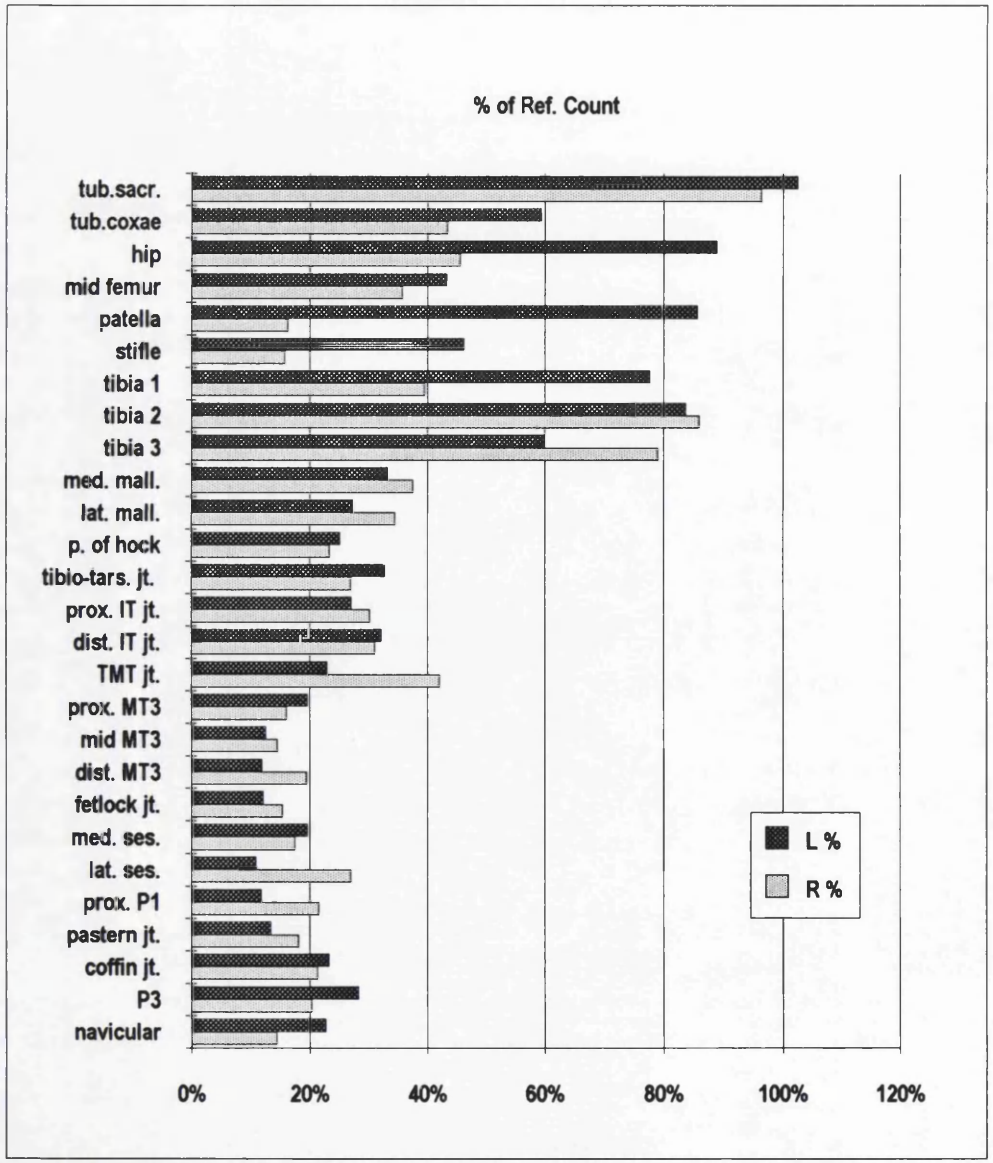
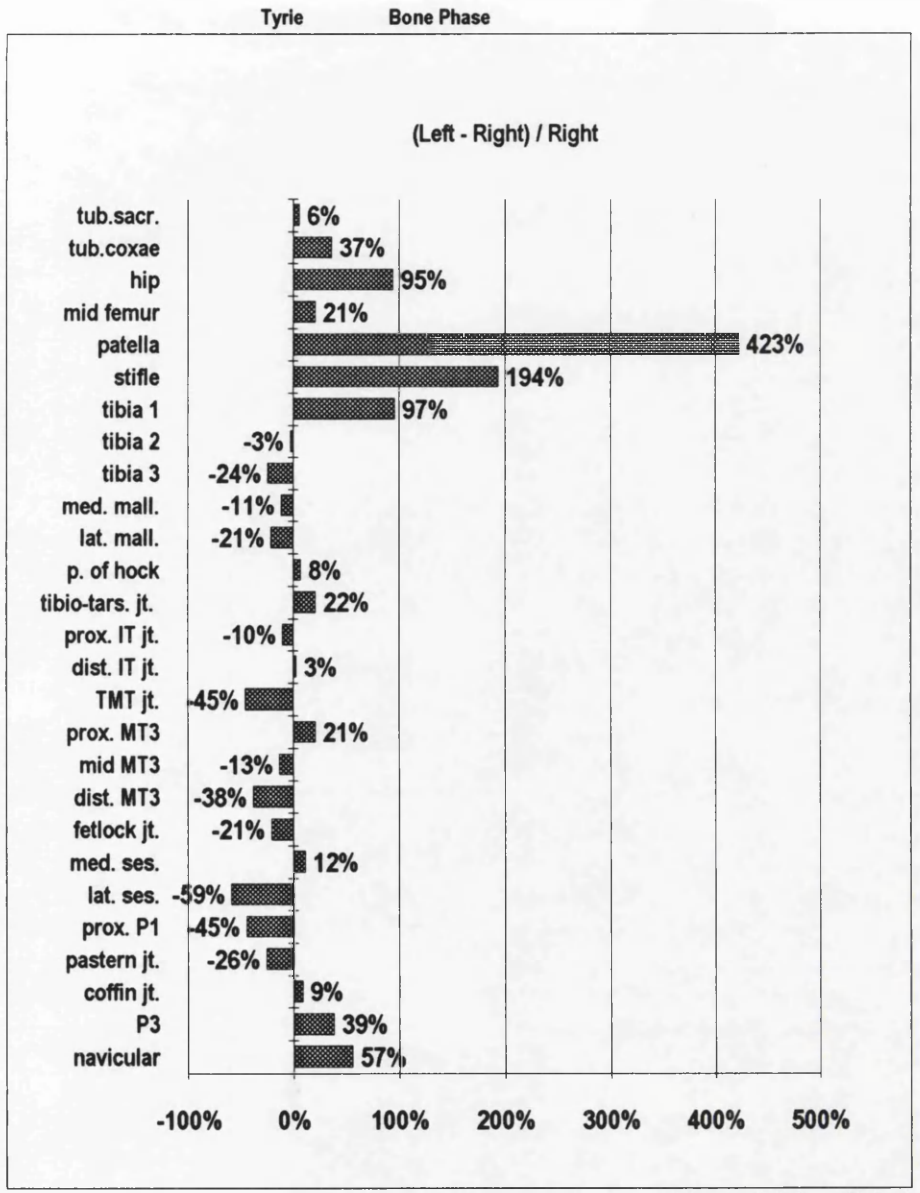


Figure A.3.a. Scintigraphy data of case no. 3. Page 1.



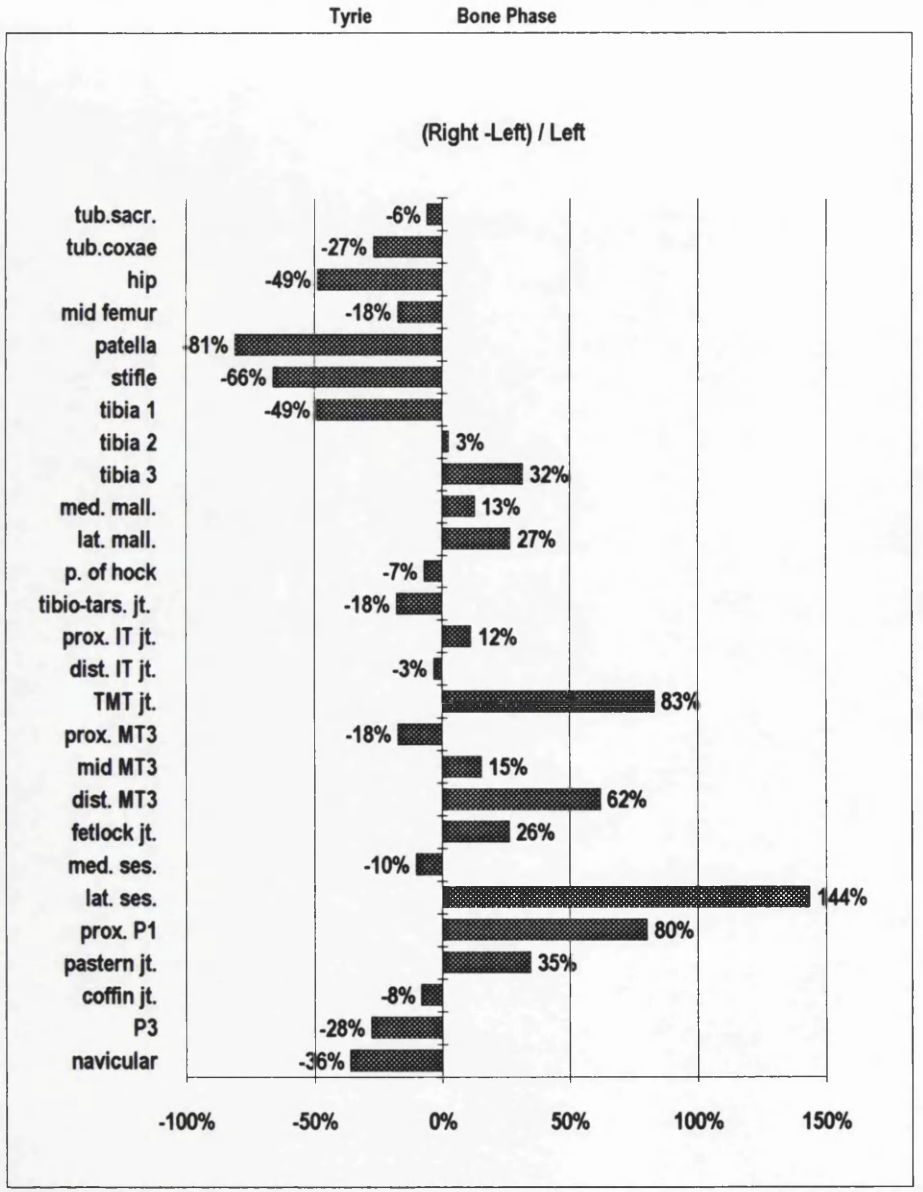


Figure A.3.b. Scintigraphy data of case no. 3. Page 2.

Gamma - scintigraphy report . Tarsus **Bone Phase**

Ridding 119095 **Date: 22/1/92** **Atlas: 1605**

	L count	R count		L %	R %		(L-R)/R		LameRH (R-L)/L
med. mall.	349	493	med. mall.	22%	31%	med. mall.	-29%	med. mall.	41%
lat. mall.	212	214	lat. mall.	13%	13%	lat. mall.	-1%	lat. mall.	1%
p. of hock	314	334	p. of hock	20%	21%	p. of hock	-6%	p. of hock	6%
tibio-tars. jt	362	1136	tibio-tars. jt	23%	71%	tibio-tars. jt	-68%	tibio-tars. jt.	214%
prox. ITT jt	576	301	prox. ITT jt	36%	19%	prox. ITT jt.	91%	prox. ITT jt.	-48%
central tb.	800	1066	central tb.	50%	66%	central tb.	-25%	central tb.	33%
dist. ITT jt.	218	350	dist. ITT jt.	14%	22%	dist. ITT jt.	-38%	dist. ITT jt.	61%
3rd. tb.	770	1036	3rd. tb.	48%	65%	3rd. tb.	-26%	3rd. tb.	35%
4th. tb.	0	0	4th. tb.	0%	0%	4th. tb.		4th. tb.	
TMT jt.	217	303	TMT jt.	14%	19%	TMT jt.	-28%	TMT jt.	40%
prox. MT3	0	0	prox. MT3	0%	0%	prox. MT3		prox. MT3	
Mean values :				26%	36%		-27%		37%
Mean difference between sample points							-14%		43%

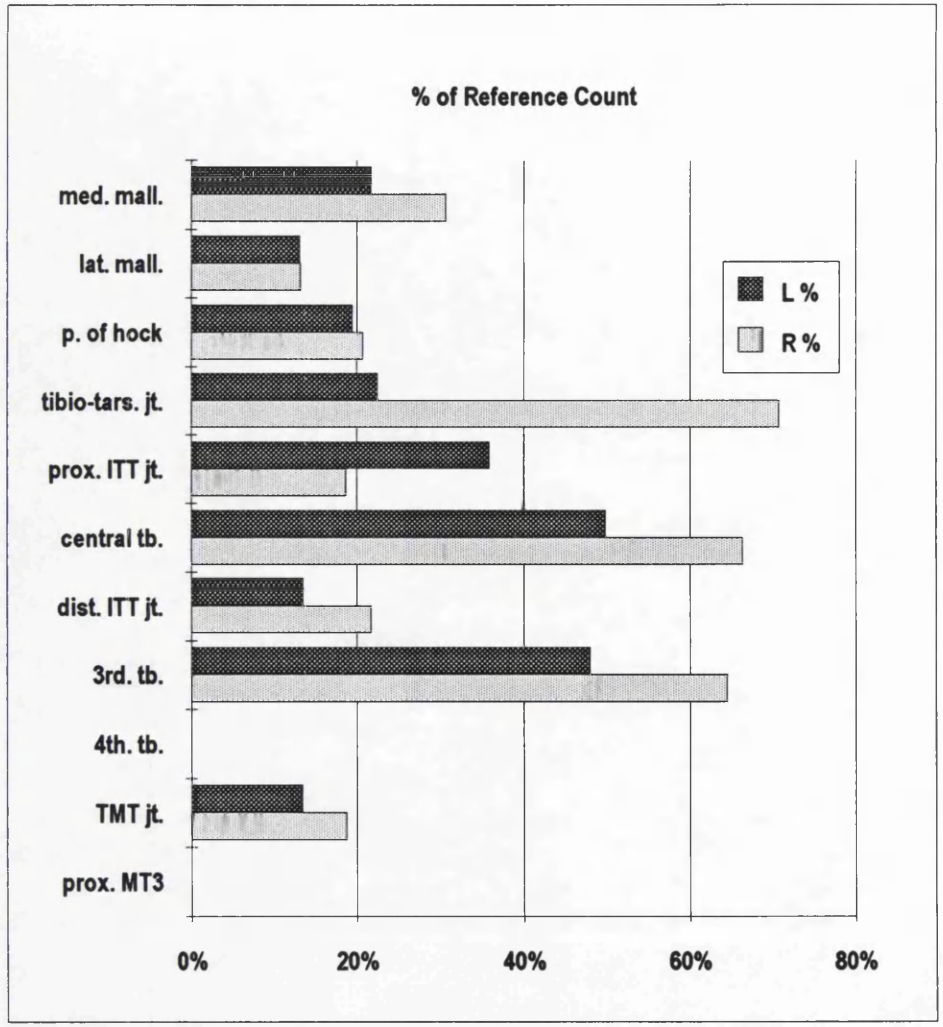
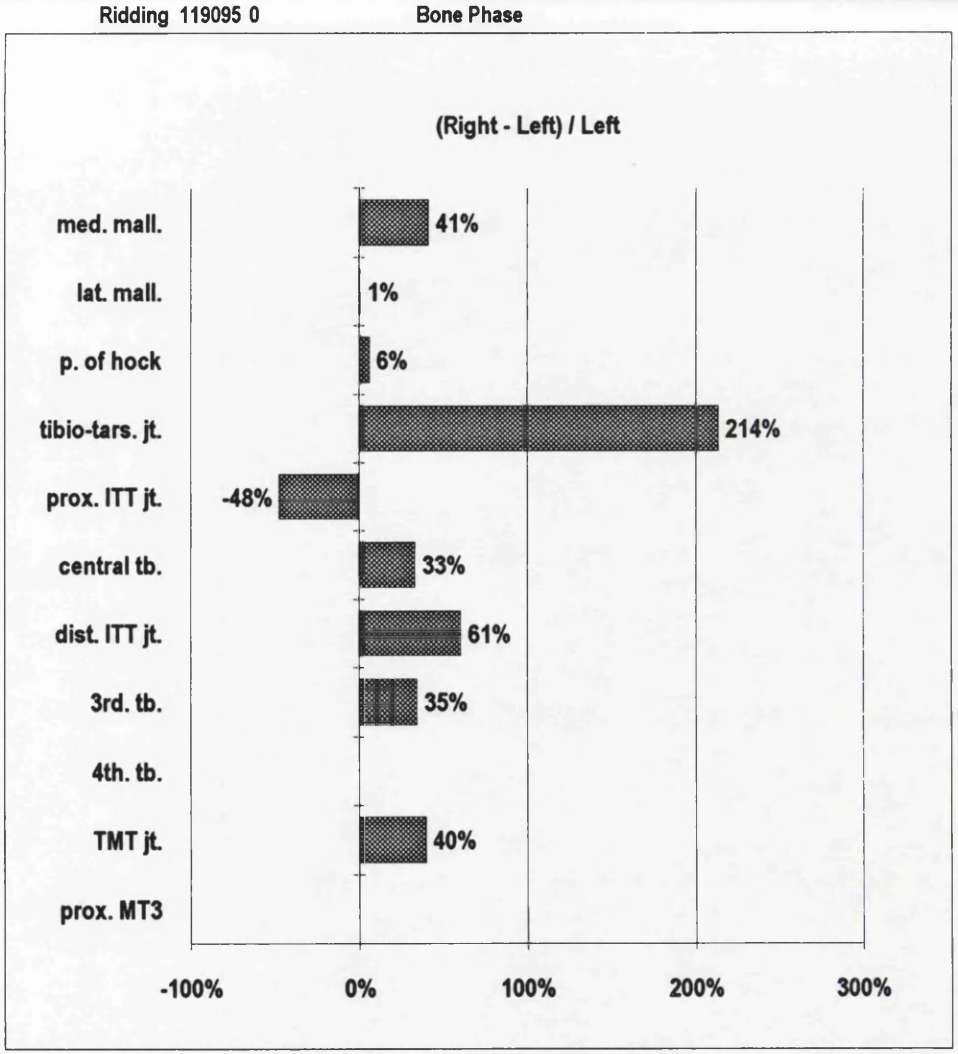


Figure A.4.a. Scintigraphy data of case no. 4. Page 1.



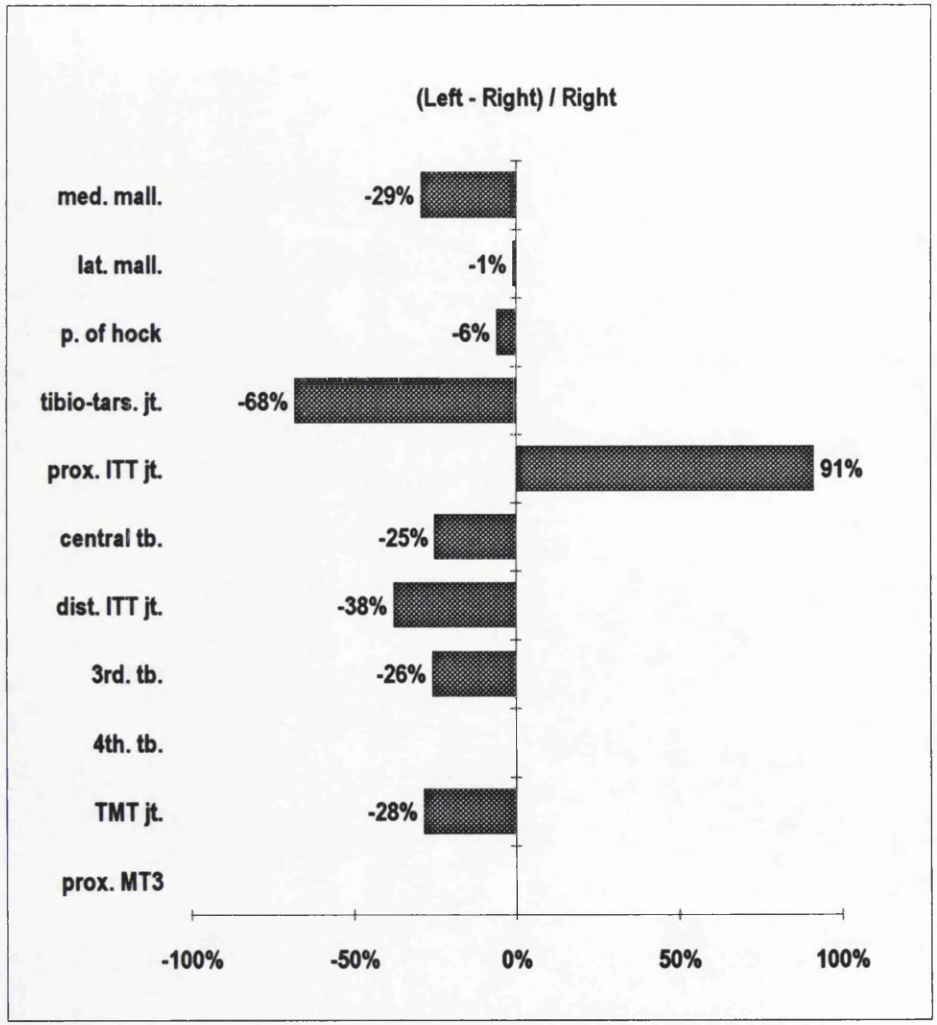


Figure A.4.b. Scintigraphy data of case no. 4. Page 2.

Gamma - scintigraphy report **Hind limbs** Bone Phase

Shaw 122032 Date: 05/05/93 Atlas: 292

	L count	R count		L %	R %		(L-R)/R		Lame RH (R-L)/L
tub.sacr.	355	307	tub.sacr.	122%	105%	tub.sacr.	16%	tub.sacr.	-14%
tub.coxae	464	336	tub.coxae	159%	115%	tub.coxae	38%	tub.coxae	-28%
hip	205	202	hip	70%	69%	hip	1%	hip	-1%
mid femur	60	61	mid femur	21%	21%	mid femur	-2%	mid femur	2%
patella	194	150	patella	66%	51%	patella	29%	patella	-23%
stifle	168	187	stifle	58%	64%	stifle	-10%	stifle	11%
tibia 1	200	145	tibia 1	68%	50%	tibia 1	38%	tibia 1	-28%
tibia 2	157	130	tibia 2	54%	45%	tibia 2	21%	tibia 2	-17%
tibia 3	99	135	tibia 3	34%	46%	tibia 3	-27%	tibia 3	36%
med. mall.	0	0	med. mall.	0%	0%	med. mall.		med. mall.	
lat. mall.	0	0	lat. mall.	0%	0%	lat. mall.		lat. mall.	
p. of hock	0	0	p. of hock	0%	0%	p. of hock		p. of hock	
tibio-tars. jt	176	220	tibio-tars. jt	60%	75%	tibio-tars. jt	-20%	tibio-tars. jt	25%
prox. IT jt.	163	152	prox. IT jt.	56%	52%	prox. IT jt.	7%	prox. IT jt.	-7%
dist. IT jt.	169	207	dist. IT jt.	58%	71%	dist. IT jt.	-18%	dist. IT jt.	22%
TMT jt.	114	154	TMT jt.	39%	53%	TMT jt.	-26%	TMT jt.	35%
prox. MT3	95	165	prox. MT3	33%	57%	prox. MT3	-42%	prox. MT3	74%
mid MT3	72	72	mid MT3	25%	25%	mid MT3	0%	mid MT3	0%
dist. MT3	103	105	dist. MT3	35%	36%	dist. MT3	-2%	dist. MT3	2%
fetlock jt.	267	280	fetlock jt.	91%	96%	fetlock jt.	-5%	fetlock jt.	5%
med. ses.	201	257	med. ses.	69%	88%	med. ses.	-22%	med. ses.	28%
lat. ses.	166	189	lat. ses.	57%	65%	lat. ses.	-12%	lat. ses.	14%
prox. P1	172	170	prox. P1	59%	58%	prox. P1	1%	prox. P1	-1%
pastern jt.	126	105	pastern jt.	43%	36%	pastern jt.	20%	pastern jt.	-17%
coffin jt.	158	144	coffin jt.	54%	49%	coffin jt.	10%	coffin jt.	-9%
P3	146	150	P3	50%	51%	P3	-3%	P3	3%
navicular	125	112	navicular	43%	38%	navicular	12%	navicular	-10%
Mean whole limb counts :				59%	59%		0%		0%
Mean difference between sample points :							0%		4%

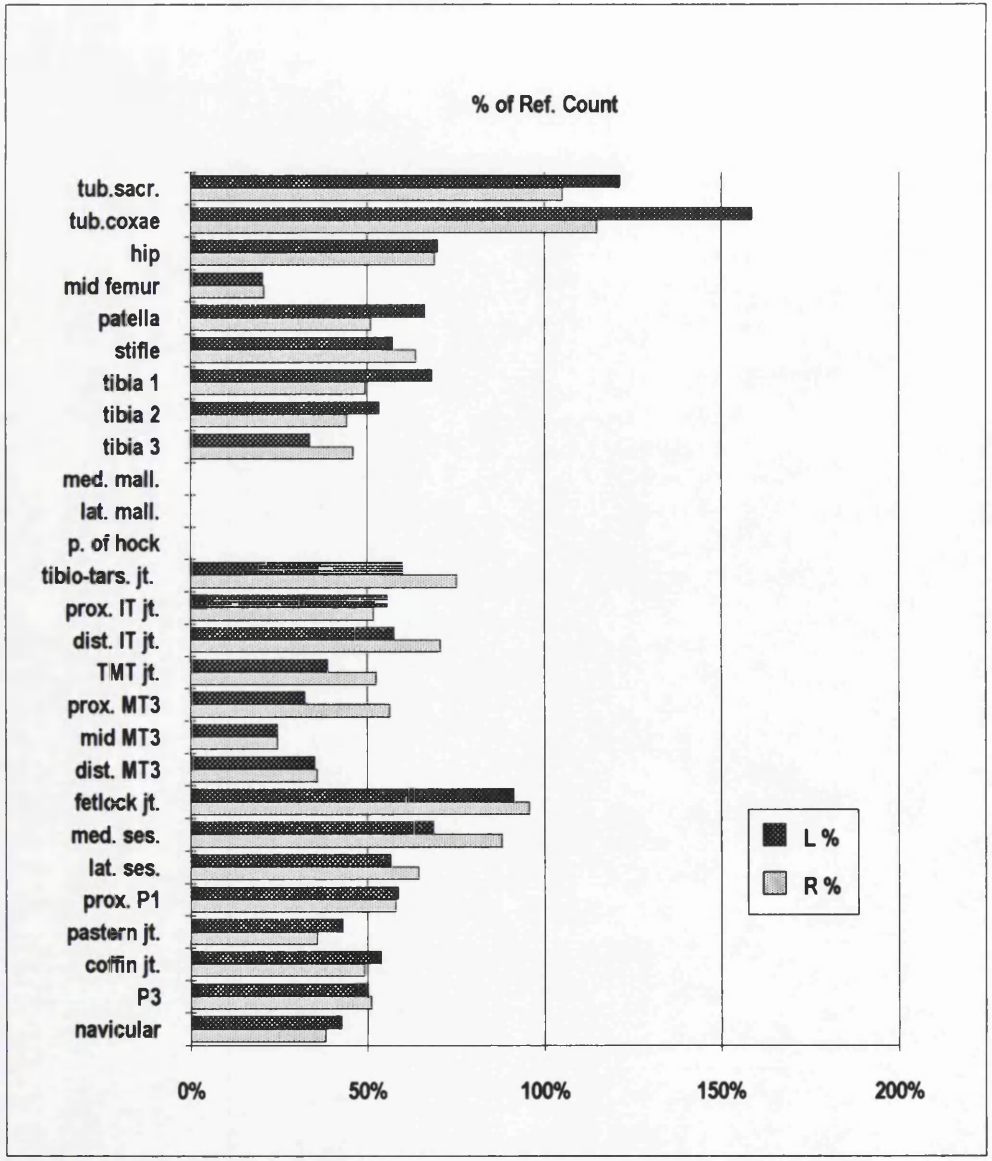
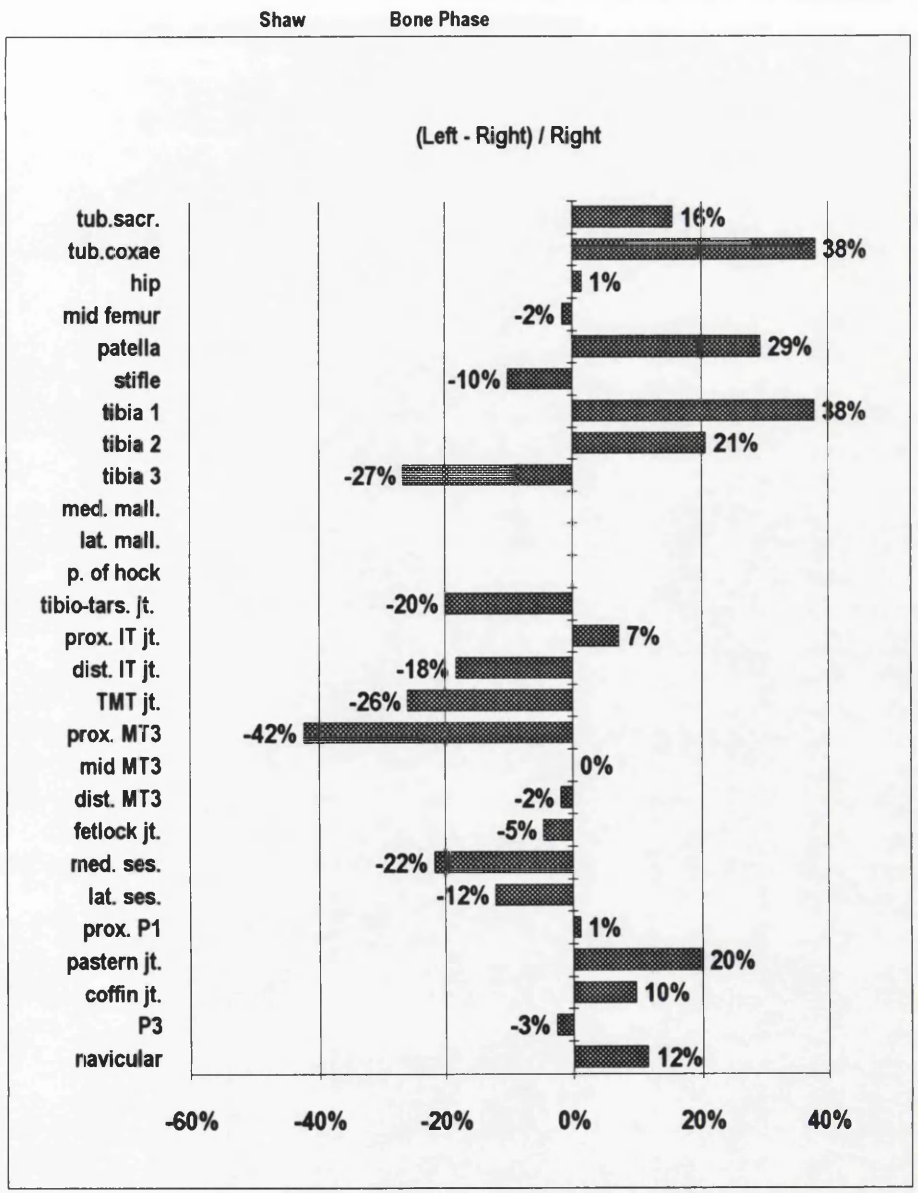


Figure A.5.a. . Scintigraphy data of case no. 5. Page 1.



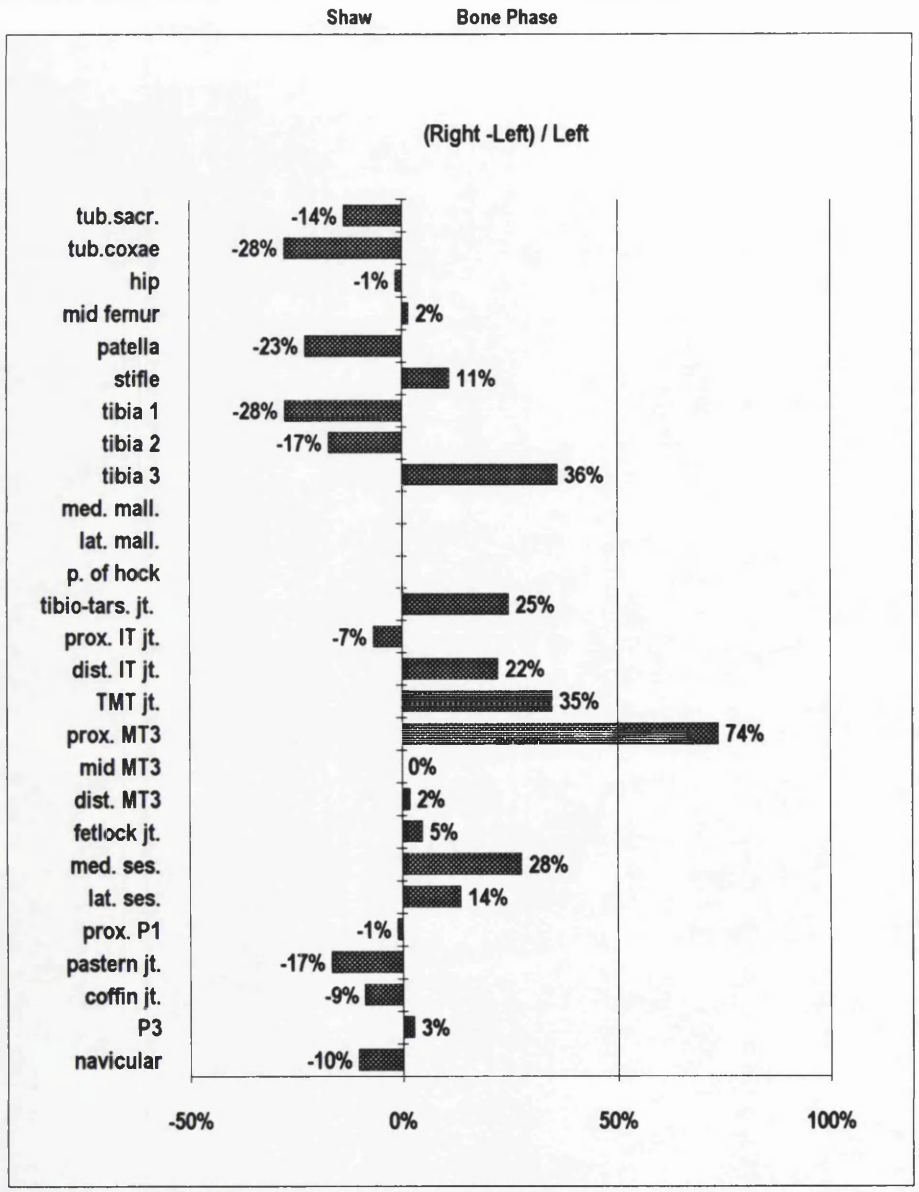


Figure A.5.b. Scintigraphy data of case no. 5. Page 2.

Gamma - scintigraphy report **Hind limbs**

Lucy 122085 **Bone phase** **Atlas : 354**

	L count	R count		L %	R %		Lame LH (L-R)/R		(R-L)/L
tub.sacr.	1116	1270	tub.sacr.	315%	359%	tub.sacr.	-12%	tub.sacr.	14%
tub.coxae	521	719	tub.coxae	147%	203%	tub.coxae	-28%	tub.coxae	38%
hip	2128	1906	hip	601%	538%	hip	12%	hip	-10%
mid femur	186	267	mid femur	53%	75%	mid femur	-30%	mid femur	44%
patella	385	346	patella	109%	98%	patella	11%	patella	-10%
stifle	306	324	stifle	86%	92%	stifle	-6%	stifle	6%
tibia 1	207	215	tibia 1	58%	61%	tibia 1	-4%	tibia 1	4%
tibia 2	162	157	tibia 2	46%	44%	tibia 2	3%	tibia 2	-3%
tibia 3	261	290	tibia 3	74%	82%	tibia 3	-10%	tibia 3	11%
med. mall.	0	0	med. mall.	0%	0%	med. mall.	0%	med. mall.	0%
lat. mall.	0	0	lat. mall.	0%	0%	lat. mall.	0%	lat. mall.	0%
p. of hock	0	0	p. of hock	0%	0%	p. of hock	0%	p. of hock	0%
tibio-tars. jt	314	300	tibio-tars. jt	89%	85%	tibio-tars. jt	5%	tibio-tars. jt	-4%
prox. IT jt.	279	299	prox. IT jt.	79%	84%	prox. IT jt.	-7%	prox. IT jt.	7%
dist. IT jt.	388	272	dist. IT jt.	110%	77%	dist. IT jt.	43%	dist. IT jt.	-30%
TMT jt.	628	279	TMT jt.	177%	79%	TMT jt.	125%	TMT jt.	-56%
prox. MT3	197	192	prox. MT3	56%	54%	prox. MT3	3%	prox. MT3	-3%
mid MT3	199	181	mid MT3	56%	51%	mid MT3	10%	mid MT3	-9%
dist. MT3	255	199	dist. MT3	72%	56%	dist. MT3	28%	dist. MT3	-22%
fetlock jt.	405	317	fetlock jt.	114%	90%	fetlock jt.	28%	fetlock jt.	-22%
med. ses.	300	254	med. ses.	85%	72%	med. ses.	18%	med. ses.	-15%
lat. ses.	265	277	lat. ses.	75%	78%	lat. ses.	-4%	lat. ses.	5%
prox. P1	293	252	prox. P1	83%	71%	prox. P1	16%	prox. P1	-14%
pastern jt.	290	263	pastern jt.	82%	74%	pastern jt.	10%	pastern jt.	-9%
coffin jt.	323	359	coffin jt.	91%	101%	coffin jt.	-10%	coffin jt.	11%
P3	401	361	P3	113%	102%	P3	11%	P3	-10%
navicular	149	258	navicular	42%	73%	navicular	-42%	navicular	73%
Mean whole limb counts :				117%	112%		4%		-4%
Mean difference between sample points :							7%		0%

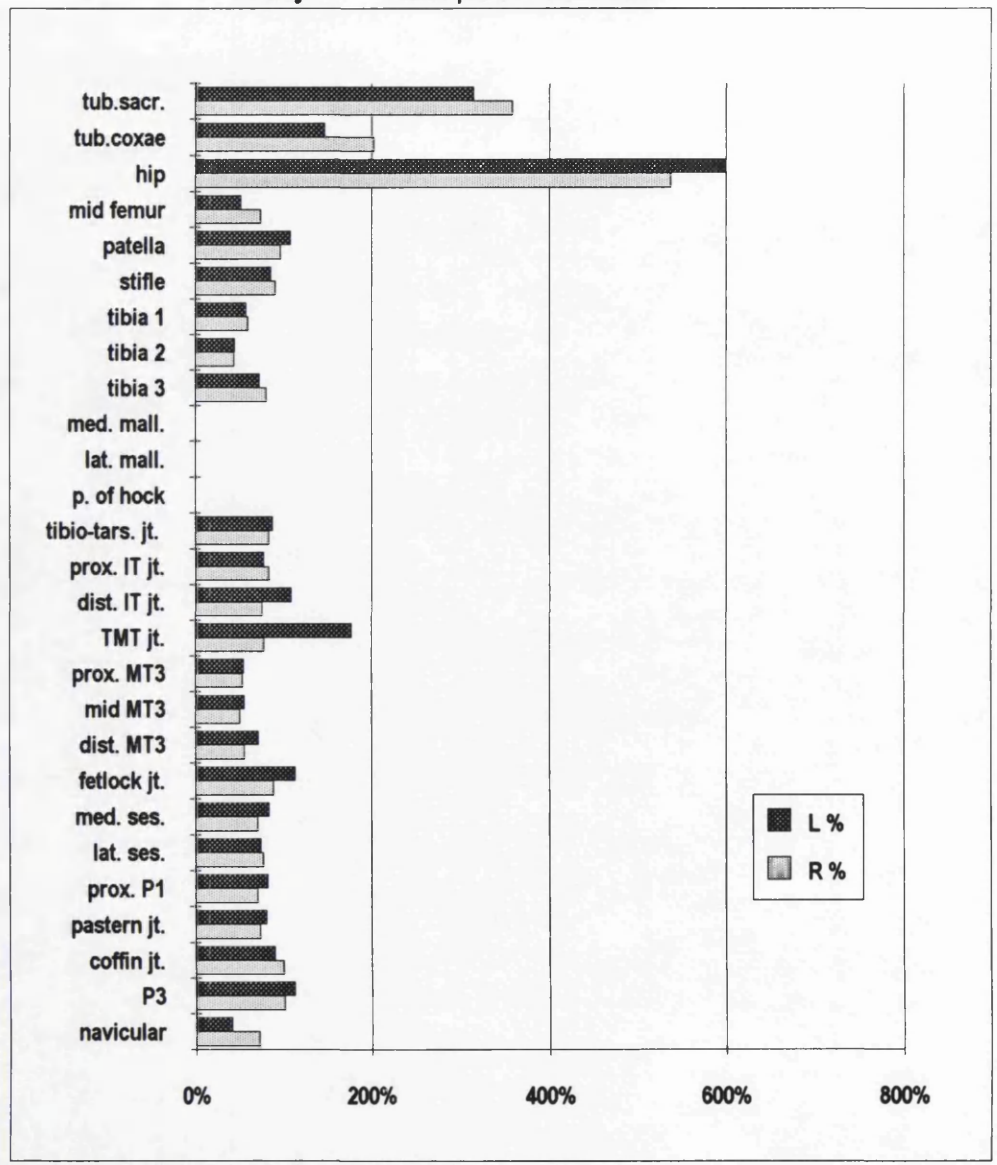
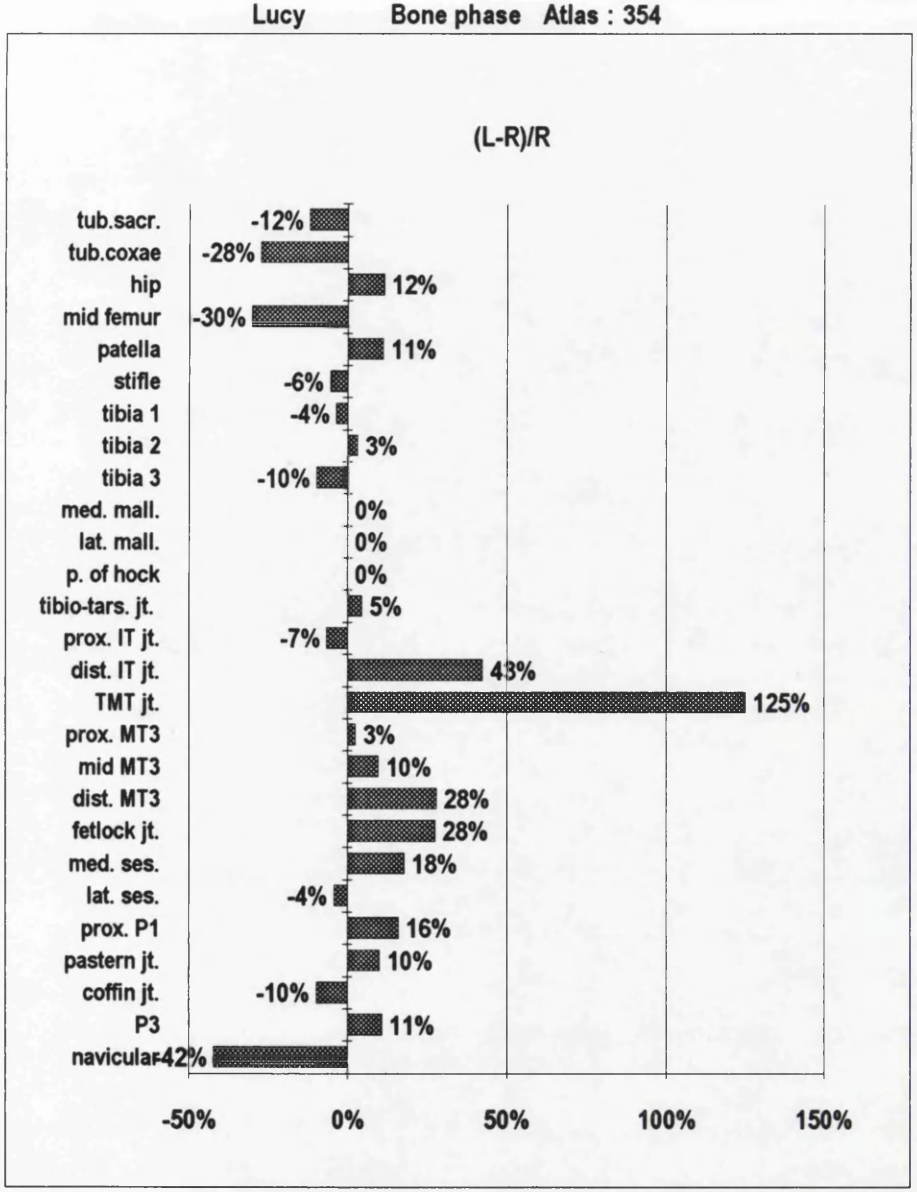


Figure A.6.a. Scintigraphy data of case no. 6. Page 1.



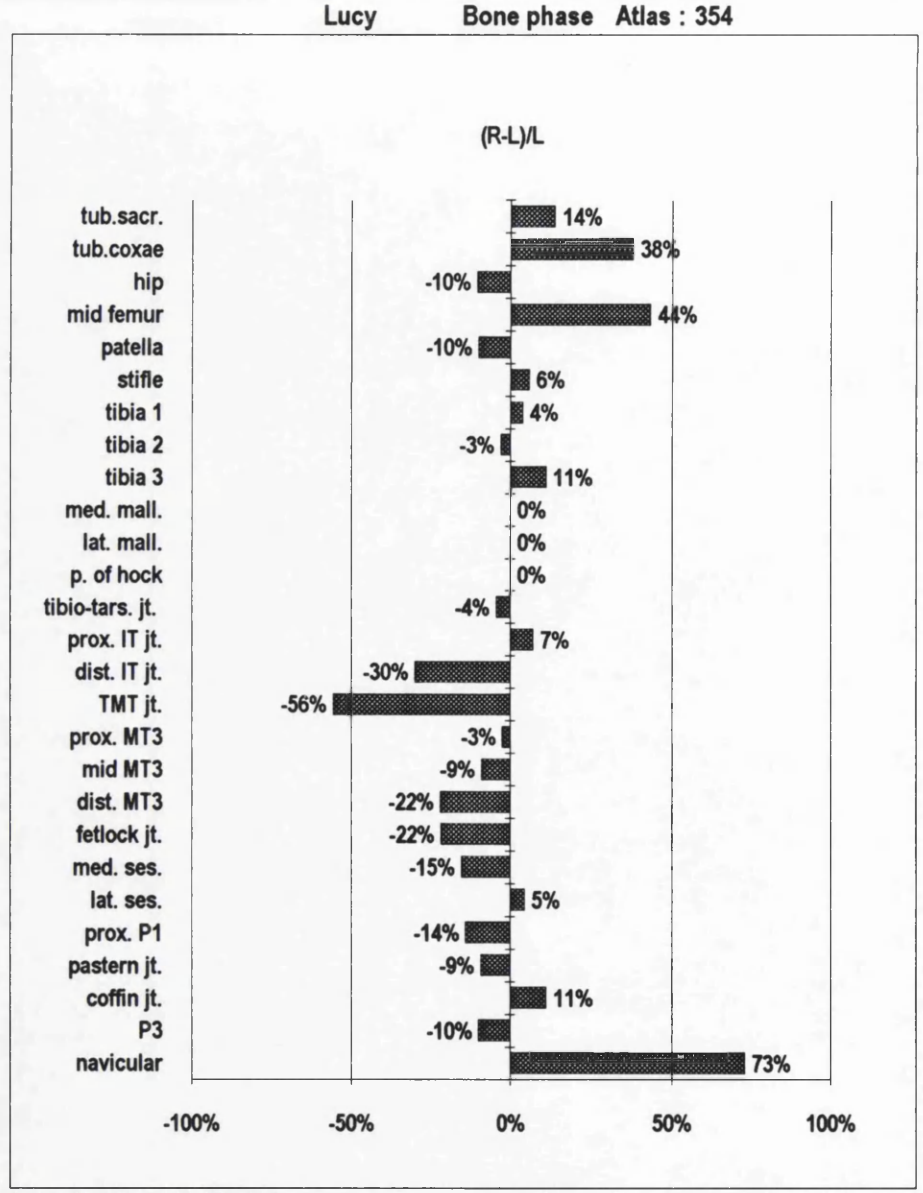


Figure A.6.b. Scintigraphy data of case no. 6. Page 2.

Gamma - scintigraphy report **Hind limbs**

Renilson 122406 **Bone phase** **Atlas : 1698**

	L count	R count		L %	R %		(L-R)/R		Lame RH (R-L)/L
tub.sacr.	2611	2517	tub.sacr.	154%	148%	tub.sacr.	4%	tub.sacr.	-4%
tub.coxae	2210	2420	tub.coxae	130%	143%	tub.coxae	-9%	tub.coxae	10%
hip	906	675	hip	53%	40%	hip	34%	hip	-25%
mid femur	854	663	mid femur	50%	39%	mid femur	29%	mid femur	-22%
patella	2460	2105	patella	145%	124%	patella	17%	patella	-14%
stifle	2611	2721	stifle	154%	160%	stifle	-4%	stifle	4%
tibia 1	3081	3054	tibia 1	181%	180%	tibia 1	1%	tibia 1	-1%
tibia 2	947	1193	tibia 2	56%	70%	tibia 2	-21%	tibia 2	26%
tibia 3	1732	1828	tibia 3	102%	108%	tibia 3	-5%	tibia 3	6%
med. mall.	0	0	med. mall.	0%	0%	med. mall.	0%	med. mall.	0%
lat. mall.	0	0	lat. mall.	0%	0%	lat. mall.	0%	lat. mall.	0%
p. of hock	0	0	p. of hock	0%	0%	p. of hock	0%	p. of hock	0%
tibio-tars. jt	1250	870	tibio-tars. jt	74%	51%	tibio-tars. jt	44%	tibio-tars. jt	-30%
prox. IT jt.	1396	1426	prox. IT jt.	82%	84%	prox. IT jt.	-2%	prox. IT jt.	2%
dist. IT jt.	1701	2512	dist. IT jt.	100%	148%	dist. IT jt.	-32%	dist. IT jt.	48%
TMT jt.	1442	1704	TMT jt.	85%	100%	TMT jt.	-15%	TMT jt.	18%
prox. MT3	885	877	prox. MT3	52%	52%	prox. MT3	1%	prox. MT3	-1%
mid MT3	650	459	mid MT3	38%	27%	mid MT3	42%	mid MT3	-29%
dist. MT3	1017	797	dist. MT3	60%	47%	dist. MT3	28%	dist. MT3	-22%
fetlock jt.	1364	915	fetlock jt.	80%	54%	fetlock jt.	49%	fetlock jt.	-33%
med. ses.	1033	1059	med. ses.	61%	62%	med. ses.	-2%	med. ses.	3%
lat. ses.	997	824	lat. ses.	59%	49%	lat. ses.	21%	lat. ses.	-17%
prox. P1	1098	737	prox. P1	65%	43%	prox. P1	49%	prox. P1	-33%
pastern jt.	1029	891	pastern jt.	61%	52%	pastern jt.	15%	pastern jt.	-13%
coffin jt.	895	624	coffin jt.	53%	37%	coffin jt.	43%	coffin jt.	-30%
P3	635	533	P3	37%	31%	P3	19%	P3	-16%
navicular	347	367	navicular	20%	22%	navicular	-5%	navicular	6%
Mean whole limb counts :				81%	78%		4%		-4%
Mean difference between sample points :							12%		-7%

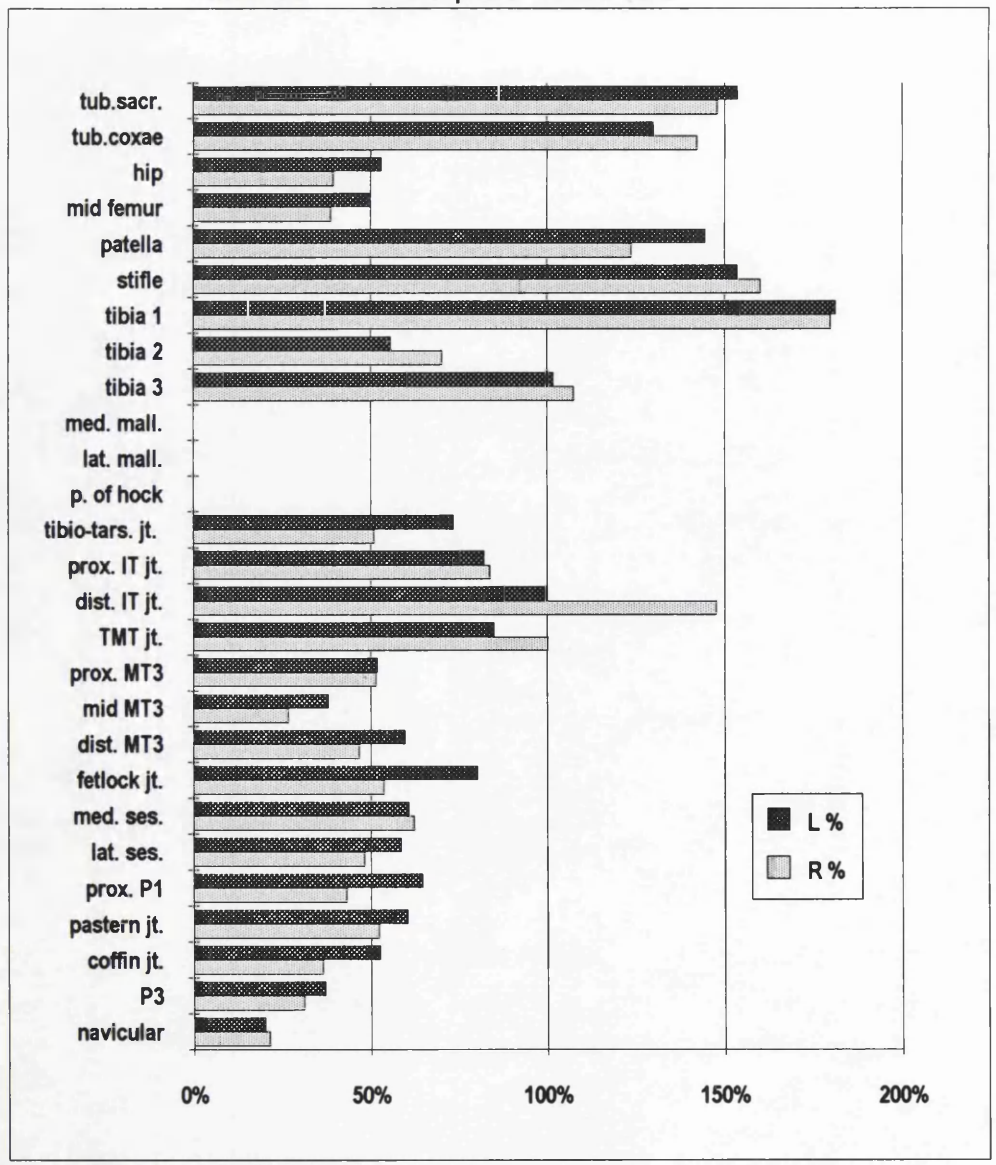
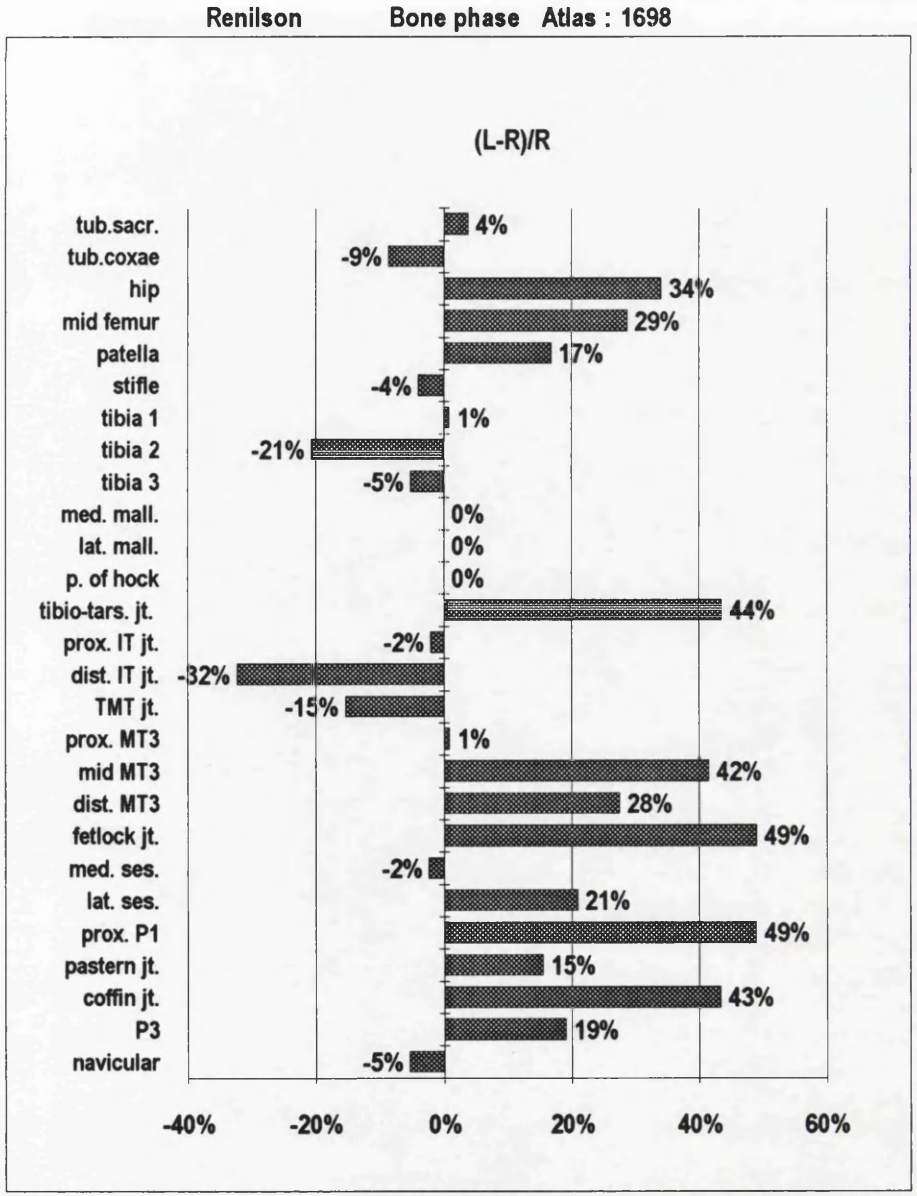


Figure A.7.a. Scintigraphy data of case no. 7. Page 1.



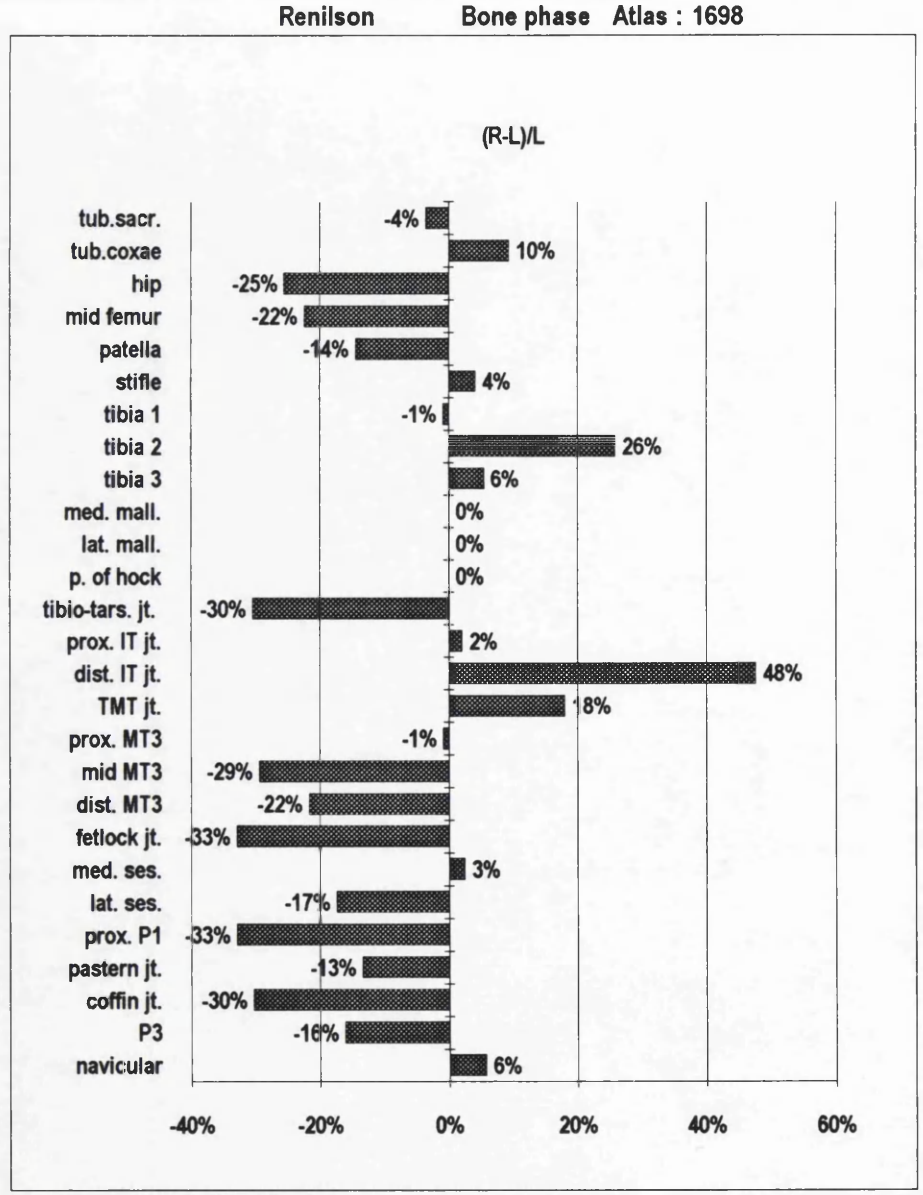


Figure A.7.b. Scintigraphy data of case no. 7. Page 2.

Gamma - scintigraphy report **Hind limbs**

Laing 122497 **Bone phase** **Atlas : 1916**

	L count	R count		L %	R %		(L-R)/R		Lame RH (R-L)/L
tub.sacr.	3161	3061	tub.sacr.	165%	160%	tub.sacr.	3%	tub.sacr.	-3%
tub.coxae	2716	2518	tub.coxae	142%	131%	tub.coxae	8%	tub.coxae	-7%
hip	2034	3451	hip	106%	180%	hip	-41%	hip	70%
mid femur	867	1240	mid femur	45%	65%	mid femur	-30%	mid femur	43%
patella	1606	1609	patella	84%	84%	patella	0%	patella	0%
stifle	1602	1404	stifle	84%	73%	stifle	14%	stifle	-12%
tibia 1	1290	1075	tibia 1	67%	56%	tibia 1	20%	tibia 1	-17%
tibia 2	1071	981	tibia 2	56%	51%	tibia 2	9%	tibia 2	-8%
tibia 3	1227	1342	tibia 3	64%	70%	tibia 3	-9%	tibia 3	9%
med. mall.	2273	2278	med. mall.	119%	119%	med. mall.	0%	med. mall.	0%
lat. mall.	1916	1779	lat. mall.	100%	93%	lat. mall.	8%	lat. mall.	-7%
p. of hock	1691	1649	p. of hock	88%	86%	p. of hock	3%	p. of hock	-2%
tibio-tars. jt	1728	1748	tibio-tars. jt	90%	91%	tibio-tars. jt	-1%	tibio-tars. jt	1%
prox. IT jt.	1653	1518	prox. IT jt.	86%	79%	prox. IT jt.	9%	prox. IT jt.	-8%
dist. IT jt.	1710	2220	dist. IT jt.	89%	116%	dist. IT jt.	-23%	dist. IT jt.	30%
TMT jt.	1649	3402	TMT jt.	86%	178%	TMT jt.	-52%	TMT jt.	106%
prox. MT3	1204	1758	prox. MT3	63%	92%	prox. MT3	-32%	prox. MT3	46%
mid MT3	951	1108	mid MT3	50%	58%	mid MT3	-14%	mid MT3	17%
dist. MT3	1214	1284	dist. MT3	63%	67%	dist. MT3	-5%	dist. MT3	6%
fetlock jt.	1789	1859	fetlock jt.	93%	97%	fetlock jt.	-4%	fetlock jt.	4%
med. ses.	1413	1497	med. ses.	74%	78%	med. ses.	-6%	med. ses.	6%
lat. ses.	1503	1838	lat. ses.	78%	96%	lat. ses.	-18%	lat. ses.	22%
prox. P1	1493	1425	prox. P1	78%	74%	prox. P1	5%	prox. P1	-5%
pastern jt.	1479	1555	pastern jt.	77%	81%	pastern jt.	-5%	pastern jt.	5%
coffin jt.	1573	1557	coffin jt.	82%	81%	coffin jt.	1%	coffin jt.	-1%
P3	1328	1281	P3	69%	67%	P3	4%	P3	-4%
navicular	1205	1430	navicular	63%	75%	navicular	-16%	navicular	19%
Mean whole limb counts :				84%	93%		-9%		10%
Mean difference between sample points :							-6%		11%

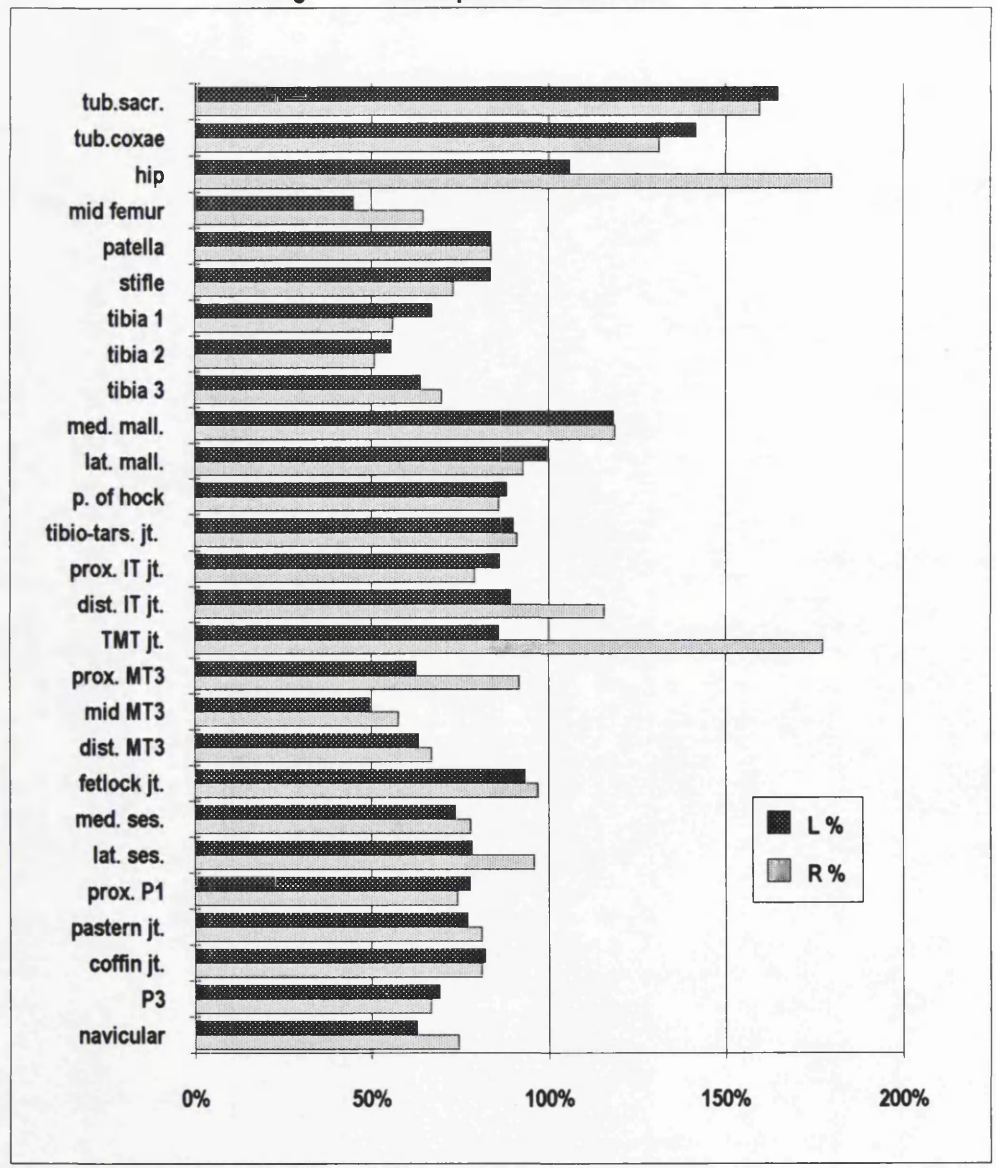
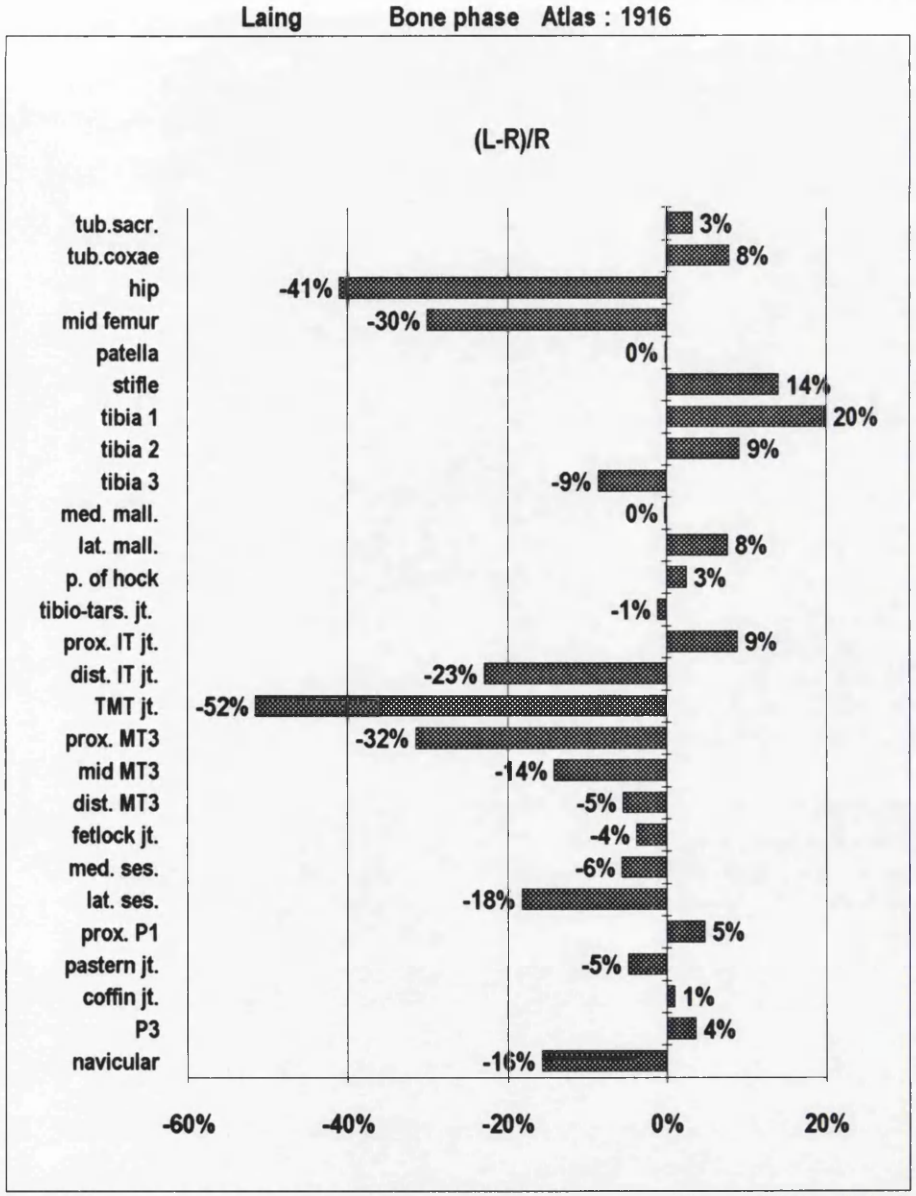


Figure A.8.a. Scintigraphy data of case no. 8. Page 1.



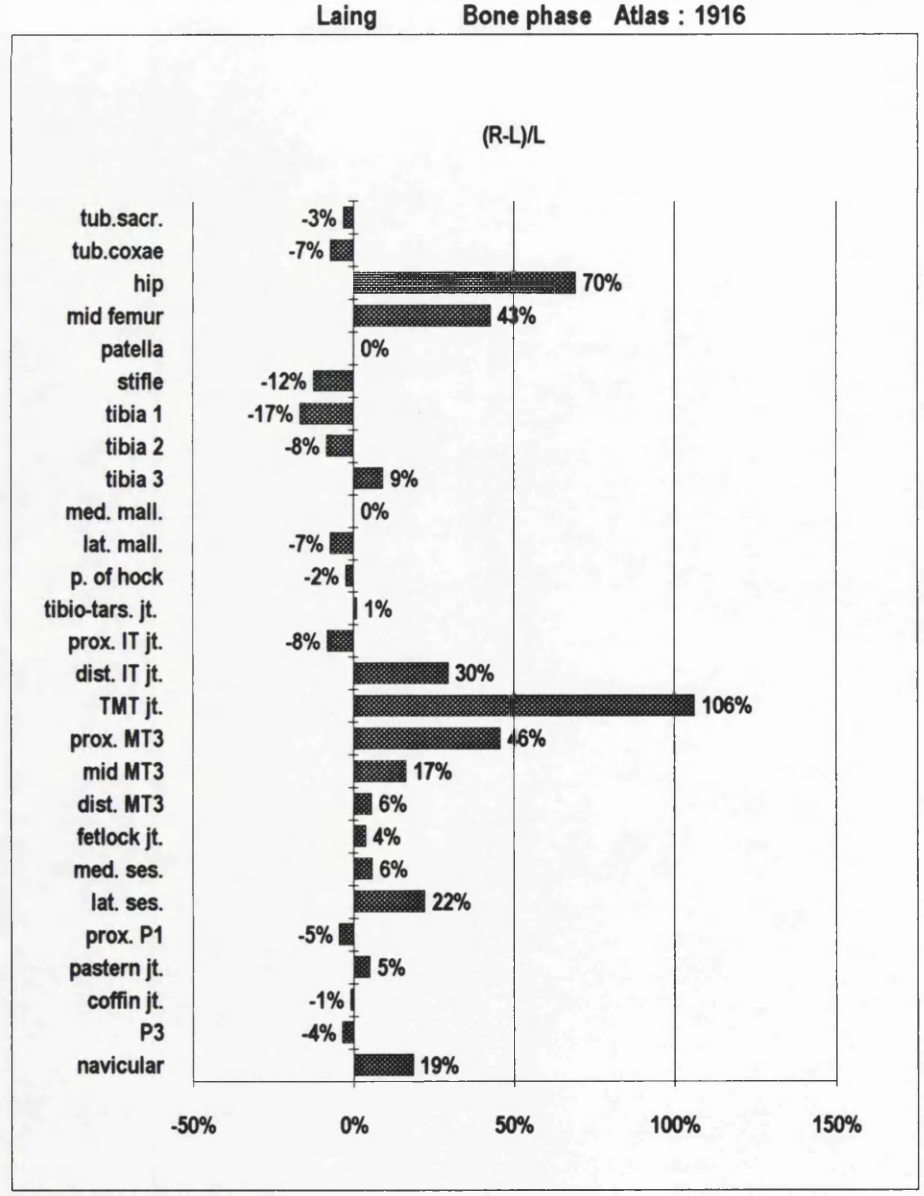


Figure A.8.b. Scintigraphy data of case no. 8. Page 2.

Gamma - scintigraphy report **Hind limbs**

Dillon 122646 **Bone phase** **Atlas : 1487**

	L count	R count		L %	R %		(L-R)/R		Lame RH (R-L)/L
tub.sacr.	2965	3084	tub.sacr.	199%	207%	tub.sacr.	-4%	tub.sacr.	4%
tub.coxae	3598	2841	tub.coxae	242%	191%	tub.coxae	27%	tub.coxae	-21%
hip	2952	2134	hip	199%	144%	hip	38%	hip	-28%
mid femur	952	1412	mid femur	64%	95%	mid femur	-33%	mid femur	48%
patella	2156	1505	patella	145%	101%	patella	43%	patella	-30%
stifle	1760	1828	stifle	118%	123%	stifle	-4%	stifle	4%
tibia 1	2469	2156	tibia 1	166%	145%	tibia 1	15%	tibia 1	-13%
tibia 2	1792	1580	tibia 2	121%	106%	tibia 2	13%	tibia 2	-12%
tibia 3	2132	1334	tibia 3	143%	90%	tibia 3	60%	tibia 3	-37%
med. mall.	1760	2180	med. mall.	118%	147%	med. mall.	-19%	med. mall.	24%
lat. mall.	1316	1913	lat. mall.	89%	129%	lat. mall.	-31%	lat. mall.	45%
p. of hock	2707	2881	p. of hock	182%	194%	p. of hock	-6%	p. of hock	6%
tibio-tars. jt	1189	1694	tibio-tars. jt	80%	114%	tibio-tars. jt	-30%	tibio-tars. jt	42%
prox. IT jt.	1030	1498	prox. IT jt.	69%	101%	prox. IT jt.	-31%	prox. IT jt.	45%
dist. IT jt.	789	1289	dist. IT jt.	53%	87%	dist. IT jt.	-39%	dist. IT jt.	63%
TMT jt.	807	1152	TMT jt.	54%	77%	TMT jt.	-30%	TMT jt.	43%
prox. MT3	444	561	prox. MT3	30%	38%	prox. MT3	-21%	prox. MT3	26%
mid MT3	335	331	mid MT3	23%	22%	mid MT3	1%	mid MT3	-1%
dist. MT3	368	411	dist. MT3	25%	28%	dist. MT3	-10%	dist. MT3	12%
fetlock jt.	375	418	fetlock jt.	25%	28%	fetlock jt.	-10%	fetlock jt.	11%
med. ses.	324	344	med. ses.	22%	23%	med. ses.	-6%	med. ses.	6%
lat. ses.	342	377	lat. ses.	23%	25%	lat. ses.	-9%	lat. ses.	10%
prox. P1	399	417	prox. P1	27%	28%	prox. P1	-4%	prox. P1	5%
pastern jt.	454	426	pastern jt.	31%	29%	pastern jt.	7%	pastern jt.	-6%
coffin jt.	701	665	coffin jt.	47%	45%	coffin jt.	5%	coffin jt.	-5%
P3	761	621	P3	51%	42%	P3	23%	P3	-18%
navicular	369	451	navicular	25%	30%	navicular	-18%	navicular	22%
Mean whole limb counts :				88%	88%		-1%		1%
Mean difference between sample points :							-3%		9%

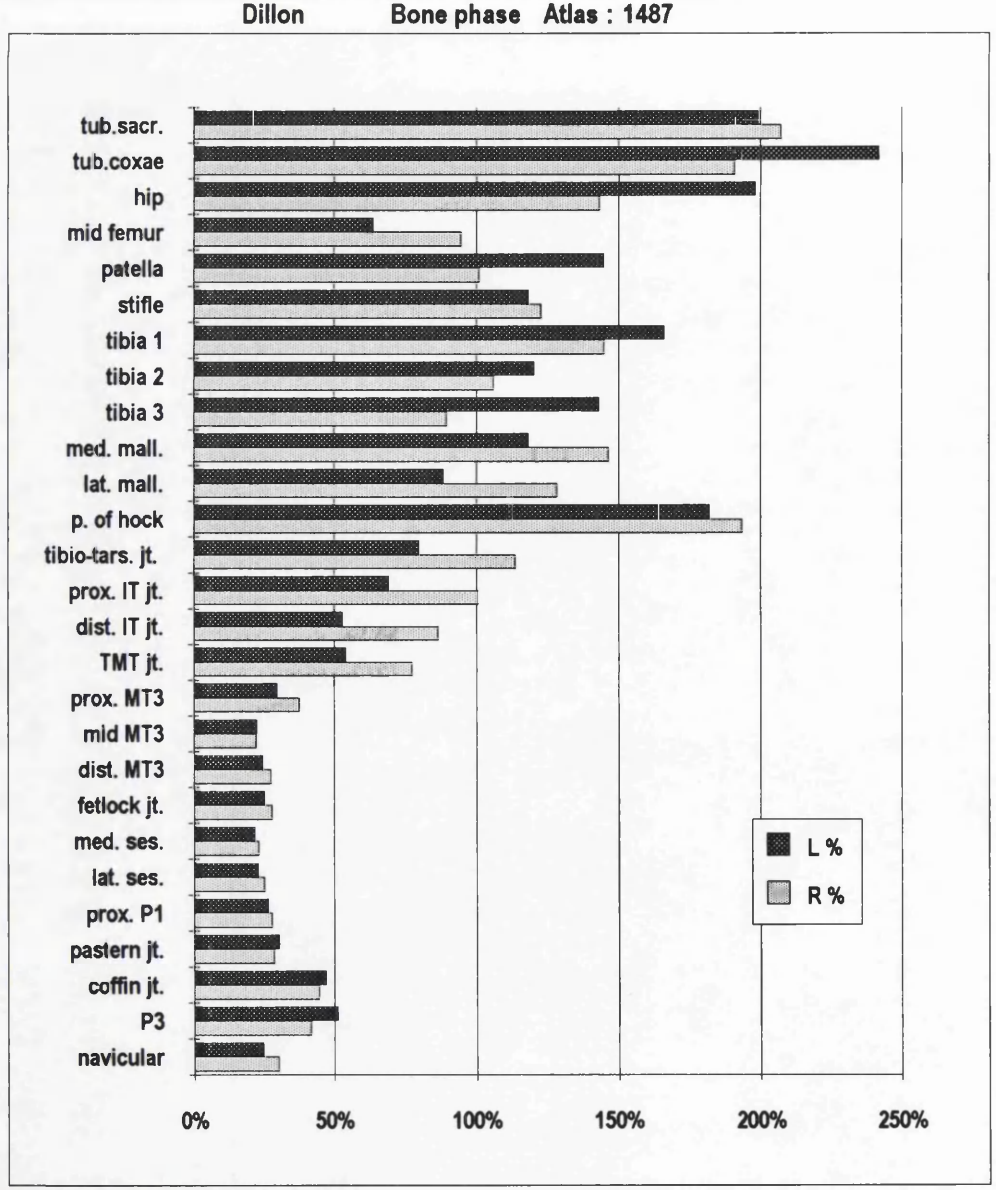
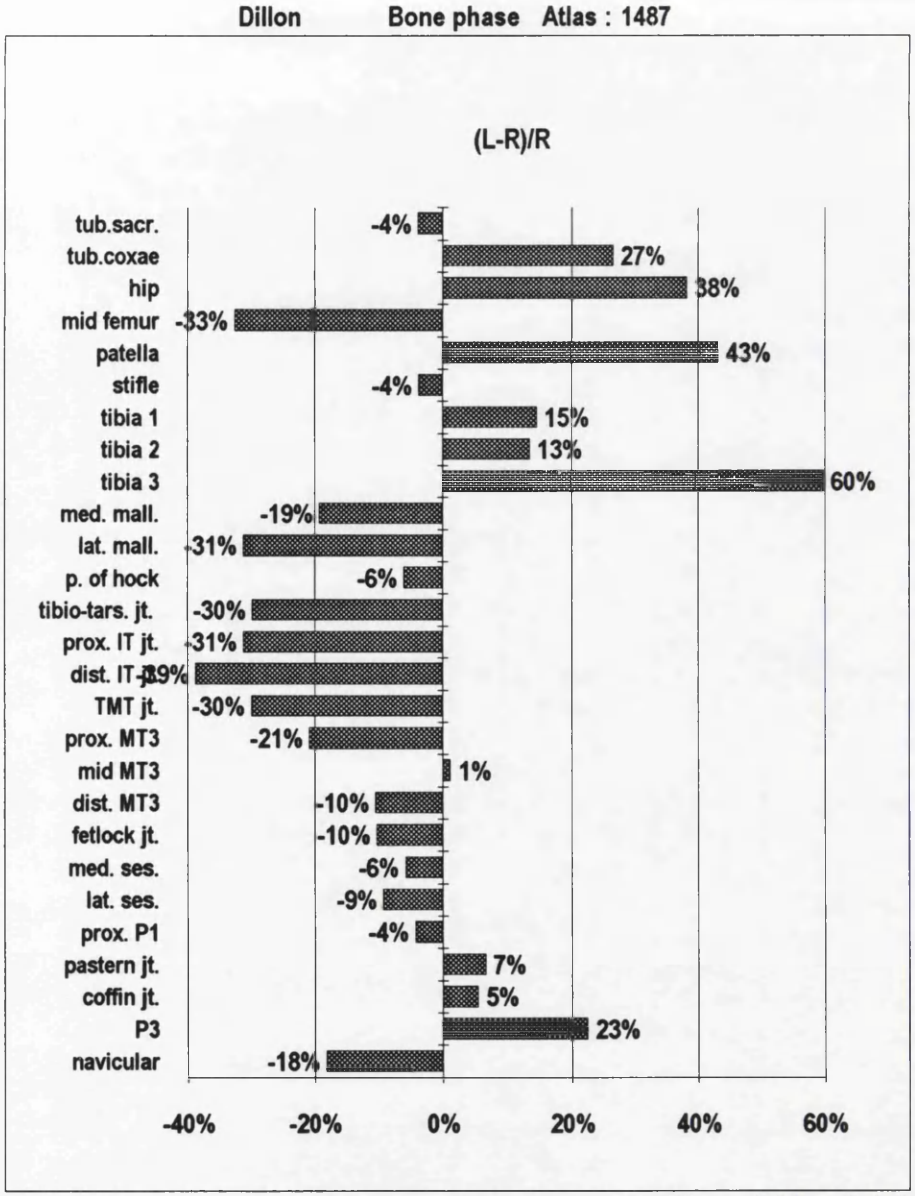


Figure A.9.a. Scintigraphy data of case no. 9. Page 1.



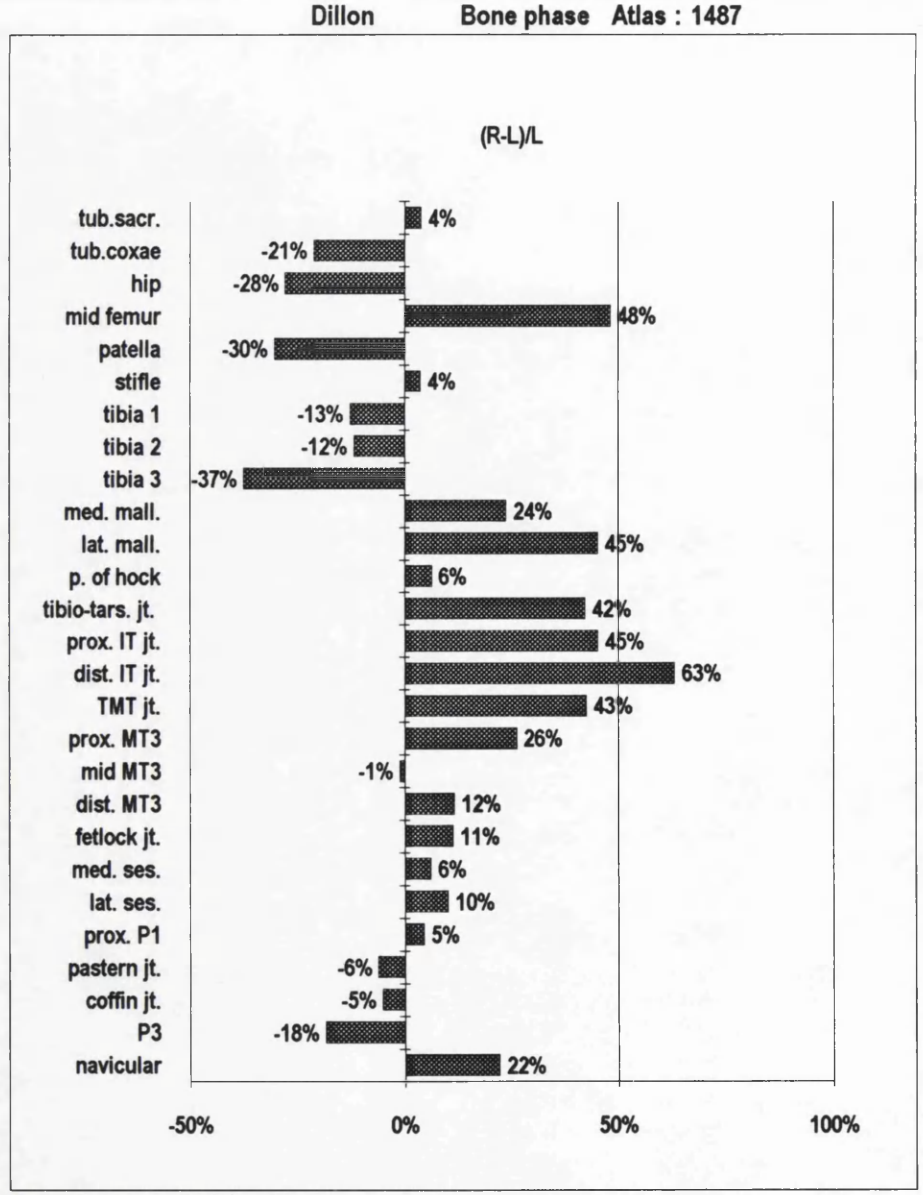


Figure A.9.b. Scintigraphy data of case no. 9. Page 2.

Gamma - scintigraphy report **Hind limbs**

RDA2 121162 **Bone phase** **Atlas : 2914**

	L count	R count		L %	R %		(L-R)/R		Lame RH (R-L)/L
tub.sacr.	3861	3593	tub.sacr.	132%	123%	tub.sacr.	7%	tub.sacr.	-7%
tub.coxae	2569	3438	tub.coxae	88%	118%	tub.coxae	-25%	tub.coxae	34%
hip	4632	8081	hip	159%	277%	hip	-43%	hip	74%
mid femur	1207	1630	mid femur	41%	56%	mid femur	-26%	mid femur	35%
patella	2527	2474	patella	87%	85%	patella	2%	patella	-2%
stifle	2622	2967	stifle	90%	102%	stifle	-12%	stifle	13%
tibia 1	2377	2213	tibia 1	82%	76%	tibia 1	7%	tibia 1	-7%
tibia 2	1773	1852	tibia 2	61%	64%	tibia 2	-4%	tibia 2	4%
tibia 3	2159	1944	tibia 3	74%	67%	tibia 3	11%	tibia 3	-10%
med. mall.	2081	1791	med. mall.	71%	61%	med. mall.	16%	med. mall.	-14%
lat. mall.	2265	2043	lat. mall.	78%	70%	lat. mall.	11%	lat. mall.	-10%
p. of hock	2444	1968	p. of hock	84%	68%	p. of hock	24%	p. of hock	-19%
tibio-tars. jt	2267	1661	tibio-tars. jt	78%	57%	tibio-tars. jt	36%	tibio-tars. jt	-27%
prox. IT jt.	2076	1271	prox. IT jt.	71%	44%	prox. IT jt.	63%	prox. IT jt.	-39%
dist. IT jt.	2116	1291	dist. IT jt.	73%	44%	dist. IT jt.	64%	dist. IT jt.	-39%
TMT jt.	1889	1516	TMT jt.	65%	52%	TMT jt.	25%	TMT jt.	-20%
prox. MT3	2198	1250	prox. MT3	75%	43%	prox. MT3	76%	prox. MT3	-43%
mid MT3	879	674	mid MT3	30%	23%	mid MT3	30%	mid MT3	-23%
dist. MT3	791	525	dist. MT3	27%	18%	dist. MT3	51%	dist. MT3	-34%
fetlock jt.	848	967	fetlock jt.	29%	33%	fetlock jt.	-12%	fetlock jt.	14%
med. ses.	880	764	med. ses.	30%	26%	med. ses.	15%	med. ses.	-13%
lat. ses.	868	656	lat. ses.	30%	23%	lat. ses.	32%	lat. ses.	-24%
prox. P1	672	519	prox. P1	23%	18%	prox. P1	29%	prox. P1	-23%
pastern jt.	641	504	pastern jt.	22%	17%	pastern jt.	27%	pastern jt.	-21%
coffin jt.	813	680	coffin jt.	28%	23%	coffin jt.	20%	coffin jt.	-16%
P3	810	610	P3	28%	21%	P3	33%	P3	-25%
navicular	558	603	navicular	19%	21%	navicular	-7%	navicular	8%
Mean whole limb counts :				62%	60%		3%		-3%
Mean difference between sample points :							17%		-9%

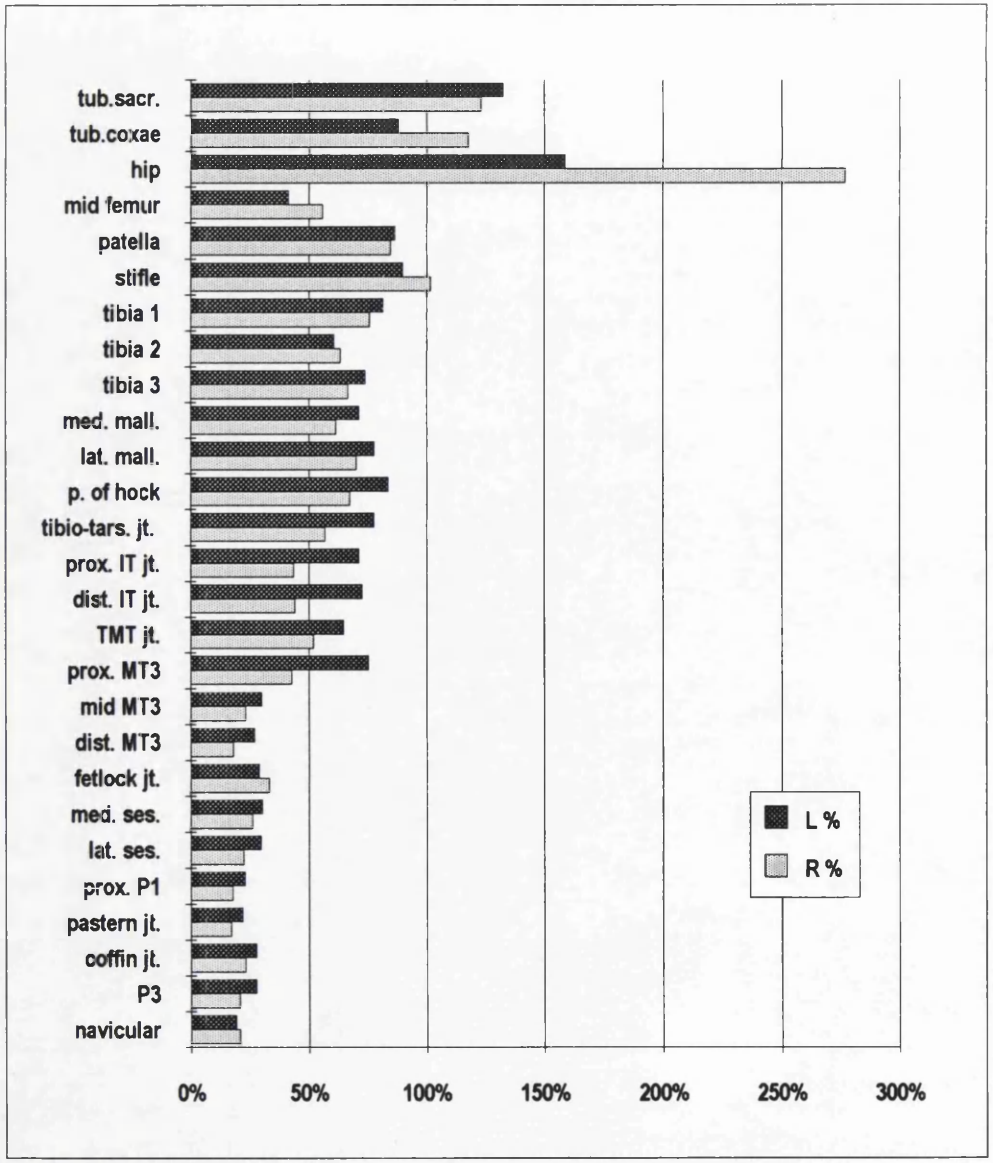
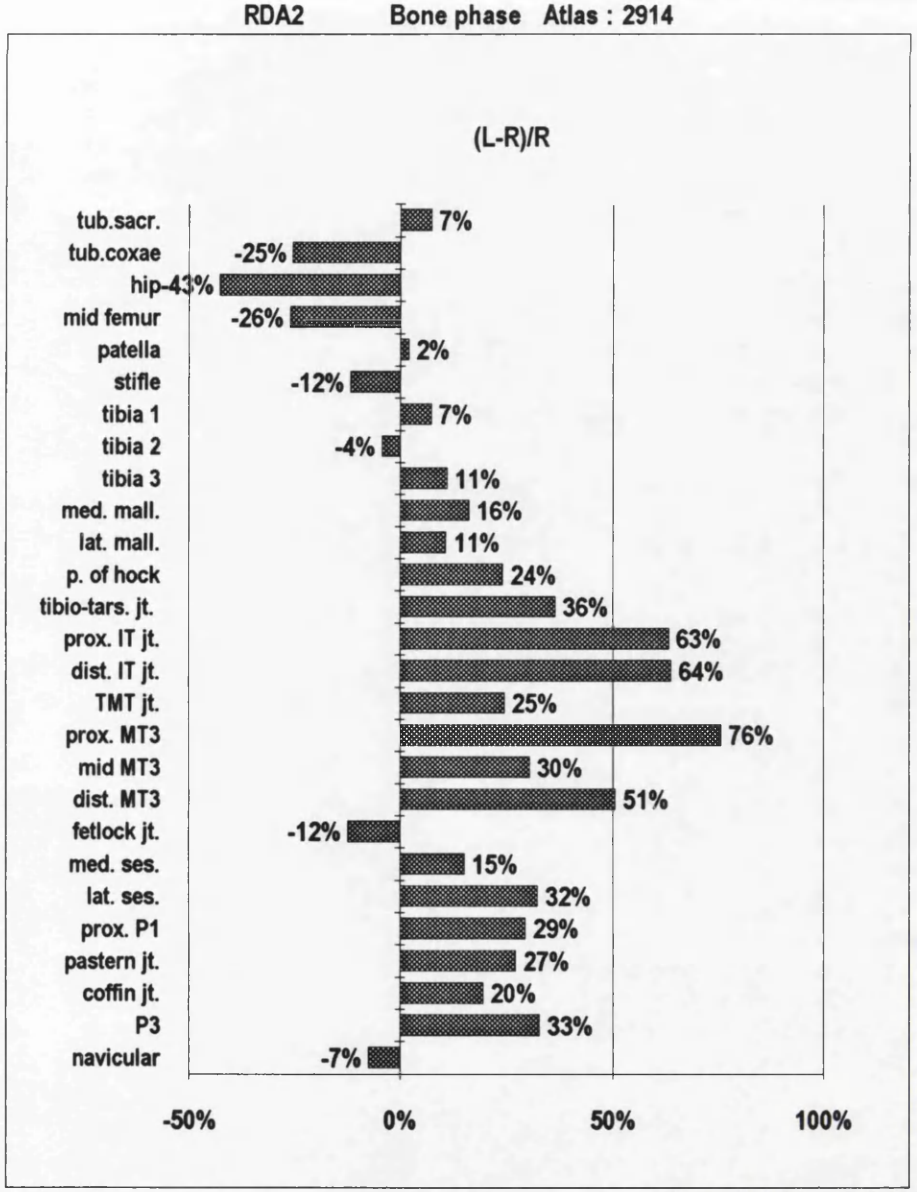


Figure A.10.a. Scintigraphy data of case no. 10. Page 1.



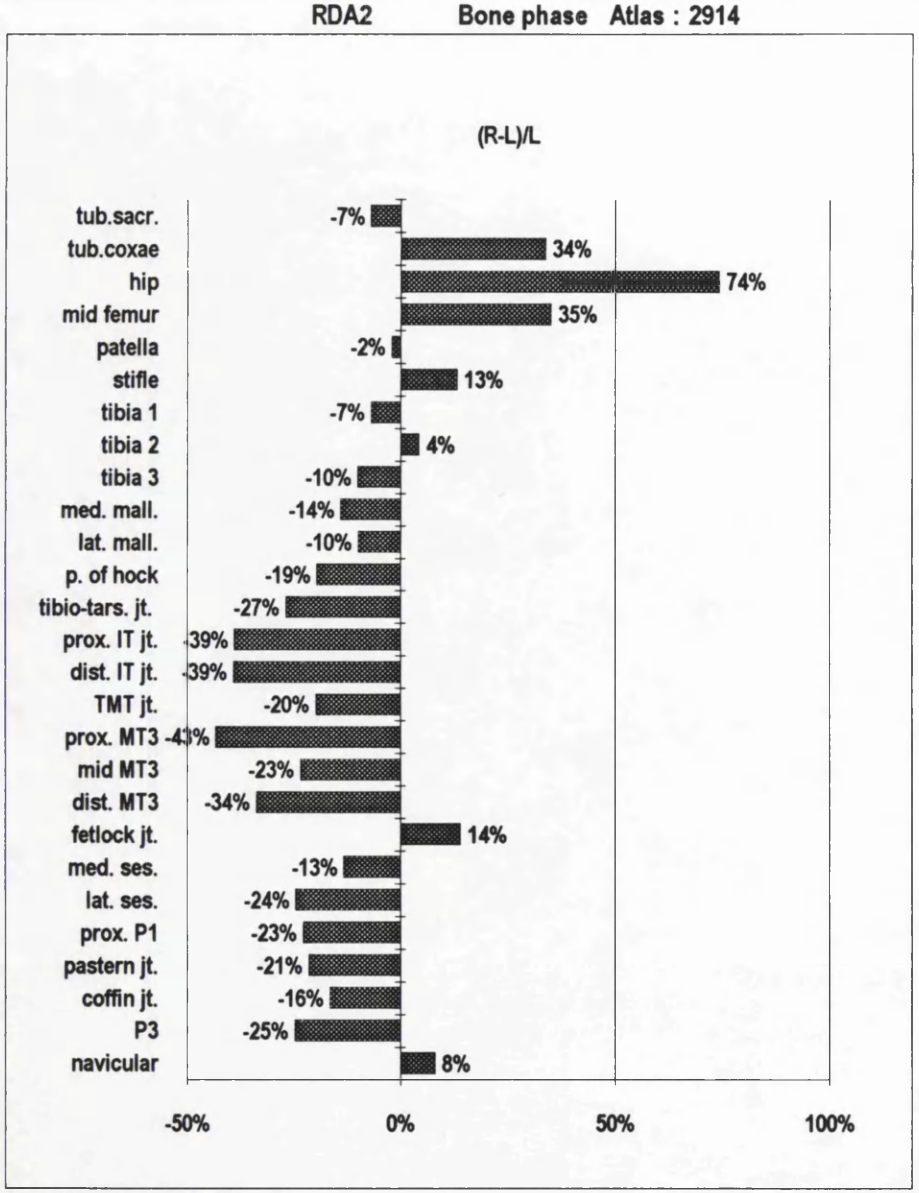


Figure A.10.b. Scintigraphy data of case no. 10. Page 2.

Gamma - scintigraphy report **Hind limbs**

Mc Leish 122948 **Bone phase** **Atlas : 2244**

	L count	R count		L %	R %		(L-R)/R		Lame RH (R-L)/L
tub.sacr.	1548	1325	tub.sacr.	69%	59%	tub.sacr.	17%	tub.sacr.	-14%
tub.coxae	2559	2227	tub.coxae	114%	99%	tub.coxae	15%	tub.coxae	-13%
hip	2255	1994	hip	100%	89%	hip	13%	hip	-12%
mid femur	880	1048	mid femur	39%	47%	mid femur	-16%	mid femur	19%
patella	899	826	patella	40%	37%	patella	9%	patella	-8%
stifle	762	723	stifle	34%	32%	stifle	5%	stifle	-5%
tibia 1	649	688	tibia 1	29%	31%	tibia 1	-6%	tibia 1	6%
tibia 2	592	671	tibia 2	26%	30%	tibia 2	-12%	tibia 2	13%
tibia 3	463	431	tibia 3	21%	19%	tibia 3	7%	tibia 3	-7%
med. mall.	948	1271	med. mall.	42%	57%	med. mall.	-25%	med. mall.	34%
lat. mall.	781	848	lat. mall.	35%	38%	lat. mall.	-8%	lat. mall.	9%
p. of hock	919	771	p. of hock	41%	34%	p. of hock	19%	p. of hock	-16%
tibio-tars. jt	704	618	tibio-tars. jt	31%	28%	tibio-tars. jt	14%	tibio-tars. jt	-12%
prox. IT jt.	979	599	prox. IT jt.	44%	27%	prox. IT jt.	63%	prox. IT jt.	-39%
dist. IT jt.	941	615	dist. IT jt.	42%	27%	dist. IT jt.	53%	dist. IT jt.	-35%
TMT jt.	609	579	TMT jt.	27%	26%	TMT jt.	5%	TMT jt.	-5%
prox. MT3	337	568	prox. MT3	15%	25%	prox. MT3	-41%	prox. MT3	69%
mid MT3	373	261	mid MT3	17%	12%	mid MT3	43%	mid MT3	-30%
dist. MT3	314	290	dist. MT3	14%	13%	dist. MT3	8%	dist. MT3	-8%
fetlock jt.	516	445	fetlock jt.	23%	20%	fetlock jt.	16%	fetlock jt.	-14%
med. ses.	346	338	med. ses.	15%	15%	med. ses.	2%	med. ses.	-2%
lat. ses.	363	320	lat. ses.	16%	14%	lat. ses.	13%	lat. ses.	-12%
prox. P1	496	437	prox. P1	22%	19%	prox. P1	14%	prox. P1	-12%
pastern jt.	548	407	pastern jt.	24%	18%	pastern jt.	35%	pastern jt.	-26%
coffin jt.	564	480	coffin jt.	25%	21%	coffin jt.	18%	coffin jt.	-15%
P3	479	406	P3	21%	18%	P3	18%	P3	-15%
navicular	231	207	navicular	10%	9%	navicular	12%	navicular	-10%
Mean whole limb counts :				35%	32%		9%		-8%
Mean difference between sample points :							11%		-6%

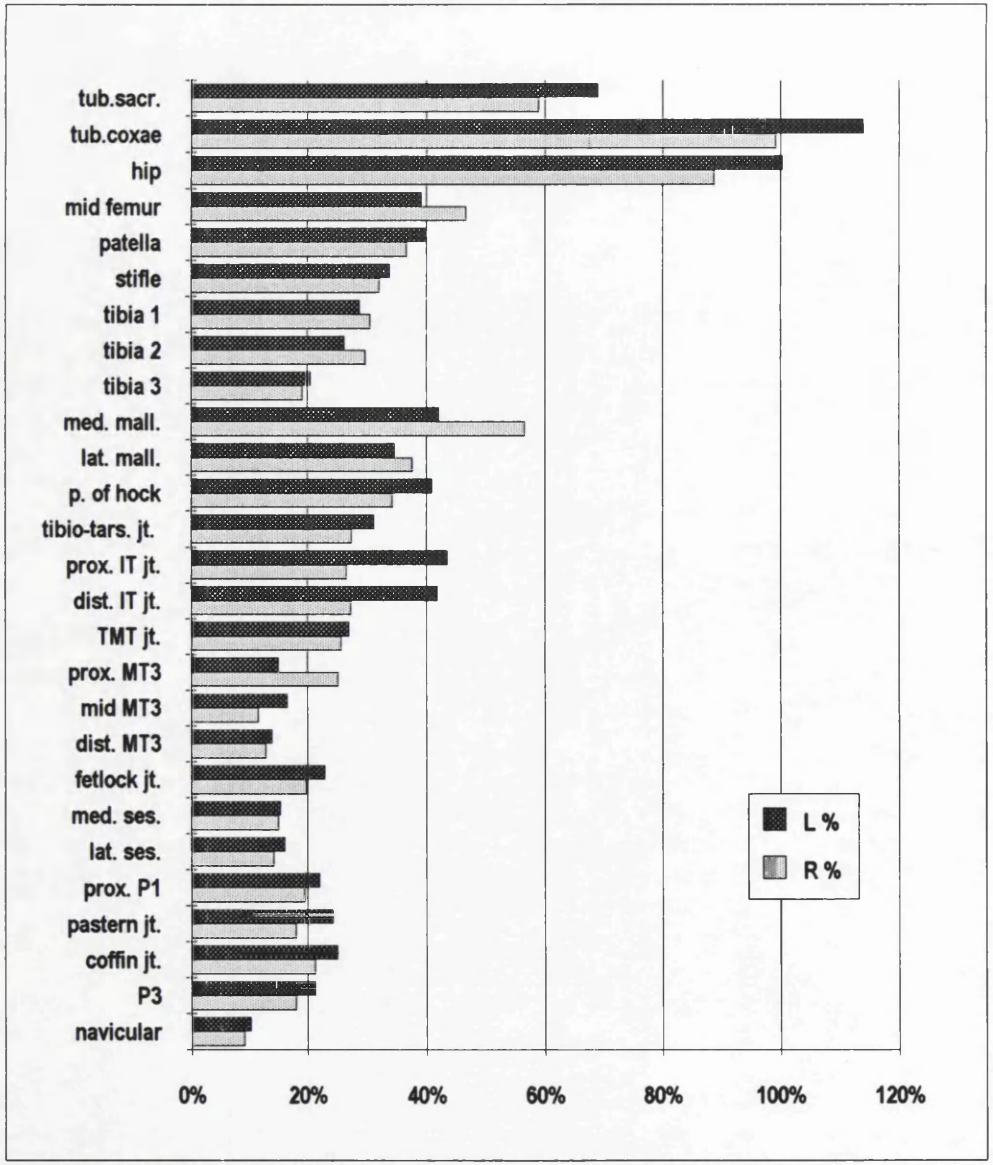
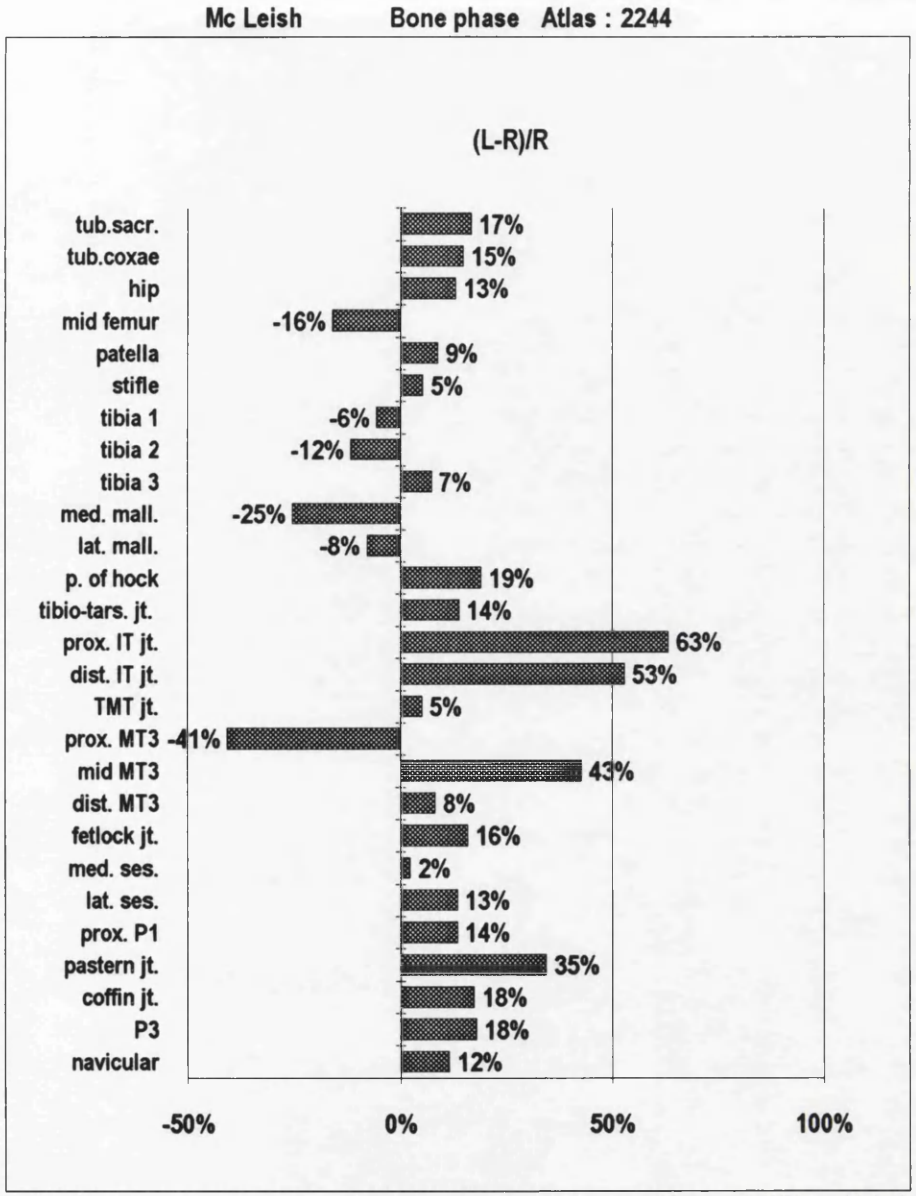


Figure A.11.a. Scintigraphy data of case no. 11. Page 1.



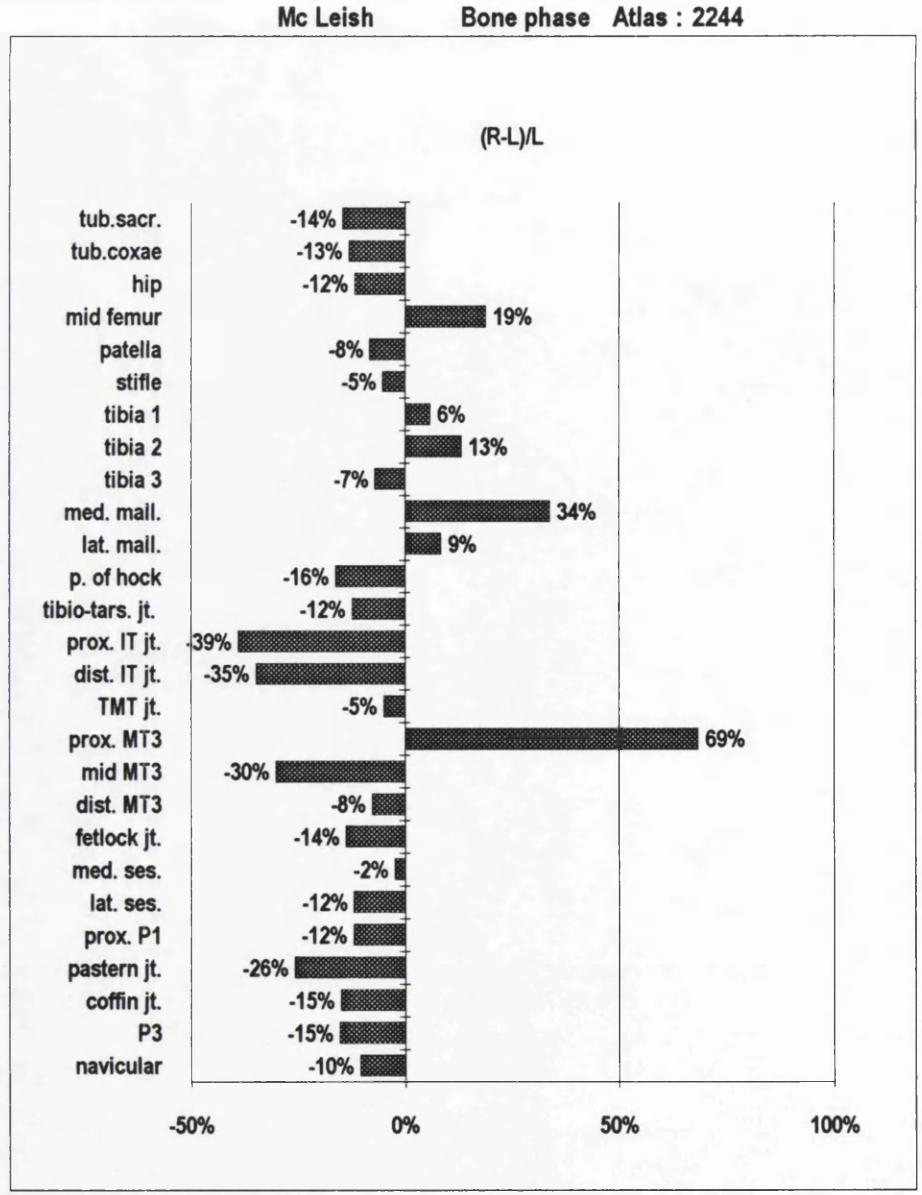


Figure A.11.b. Scintigraphy data of case no. 11. Page 2.

Gamma - scintigraphy report **Hind limbs**

Meighan 123126 **Bone phase** **Atlas : 1945**

	L count	R count		L %	R %		(L-R)/R		Lame RH (R-L)/L
tub.sacr.	3624	3348	tub.sacr.	186%	172%	tub.sacr.	8%	tub.sacr.	-8%
tub.coxae	1296	1677	tub.coxae	67%	86%	tub.coxae	-23%	tub.coxae	29%
hip	2214	1741	hip	114%	90%	hip	27%	hip	-21%
mid femur	697	795	mid femur	36%	41%	mid femur	-12%	mid femur	14%
patella	2641	2223	patella	136%	114%	patella	19%	patella	-16%
stifle	2186	1488	stifle	112%	77%	stifle	47%	stifle	-32%
tibia 1	2157	1449	tibia 1	111%	74%	tibia 1	49%	tibia 1	-33%
tibia 2	1193	1319	tibia 2	61%	68%	tibia 2	-10%	tibia 2	11%
tibia 3	987	1072	tibia 3	51%	55%	tibia 3	-8%	tibia 3	9%
med. mall.	1065	1247	med. mall.	55%	64%	med. mall.	-15%	med. mall.	17%
lat. mall.	1242	1320	lat. mall.	64%	68%	lat. mall.	-6%	lat. mall.	6%
p. of hock	991	969	p. of hock	51%	50%	p. of hock	2%	p. of hock	-2%
tibio-tars. jt	1028	1382	tibio-tars. jt	53%	71%	tibio-tars. jt	-26%	tibio-tars. jt	34%
prox. IT jt.	2108	1164	prox. IT jt.	108%	60%	prox. IT jt.	81%	prox. IT jt.	-45%
dist. IT jt.	1942	1826	dist. IT jt.	100%	94%	dist. IT jt.	6%	dist. IT jt.	-6%
TMT jt.	2234	3889	TMT jt.	115%	200%	TMT jt.	-43%	TMT jt.	74%
prox. MT3	821	927	prox. MT3	42%	48%	prox. MT3	-11%	prox. MT3	13%
mid MT3	492	650	mid MT3	25%	33%	mid MT3	-24%	mid MT3	32%
dist. MT3	723	833	dist. MT3	37%	43%	dist. MT3	-13%	dist. MT3	15%
fetlock jt.	866	1018	fetlock jt.	45%	52%	fetlock jt.	-15%	fetlock jt.	18%
med. ses.	719	695	med. ses.	37%	36%	med. ses.	3%	med. ses.	-3%
lat. ses.	656	856	lat. ses.	34%	44%	lat. ses.	-23%	lat. ses.	30%
prox. P1	756	898	prox. P1	39%	46%	prox. P1	-16%	prox. P1	19%
pastern jt.	754	911	pastern jt.	39%	47%	pastern jt.	-17%	pastern jt.	21%
coffin jt.	737	653	coffin jt.	38%	34%	coffin jt.	13%	coffin jt.	-11%
P3	569	606	P3	29%	31%	P3	-6%	P3	7%
navicular	353	382	navicular	18%	20%	navicular	-8%	navicular	8%
Mean whole limb counts :				67%	67%		-1%		1%
Mean difference between sample points :							-1%		7%

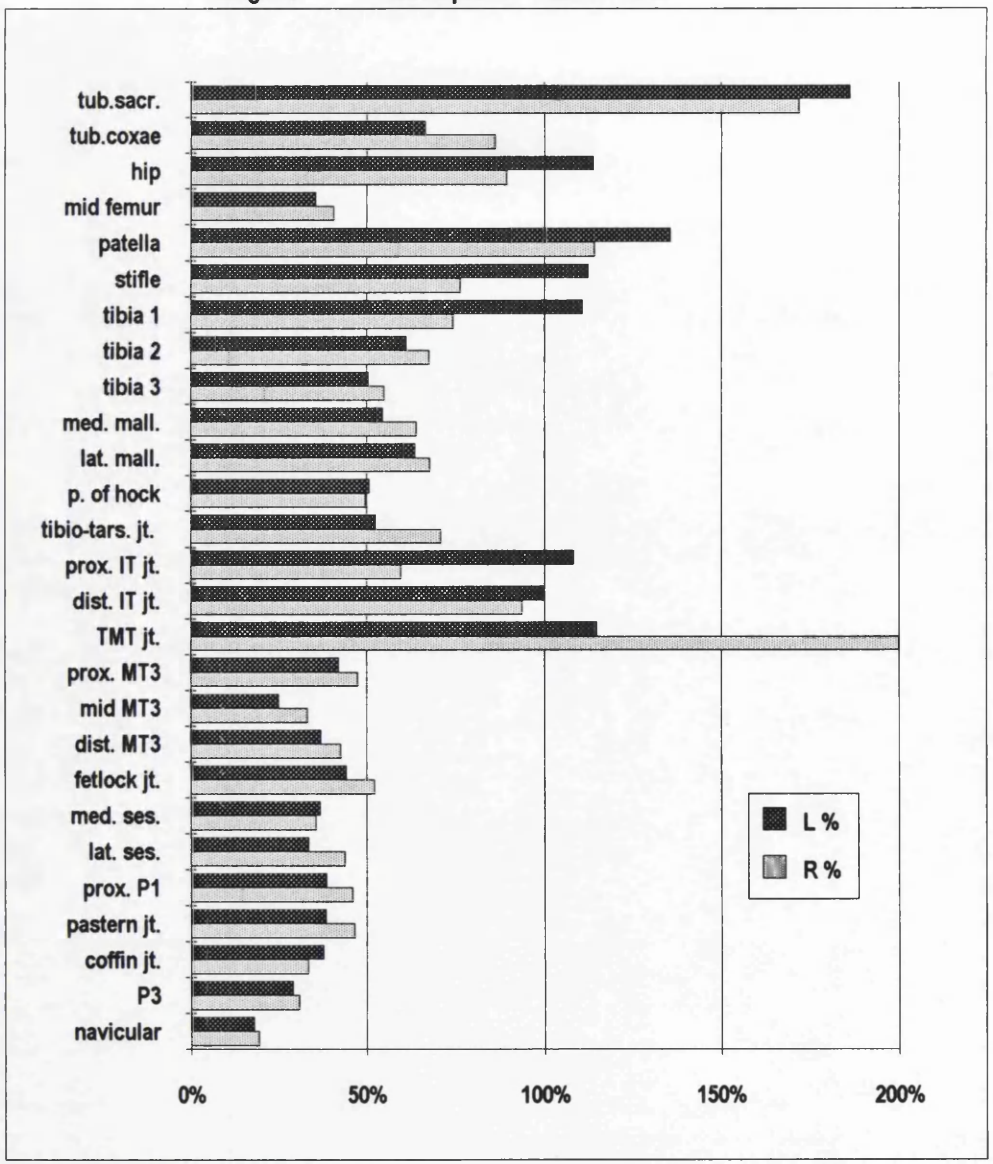
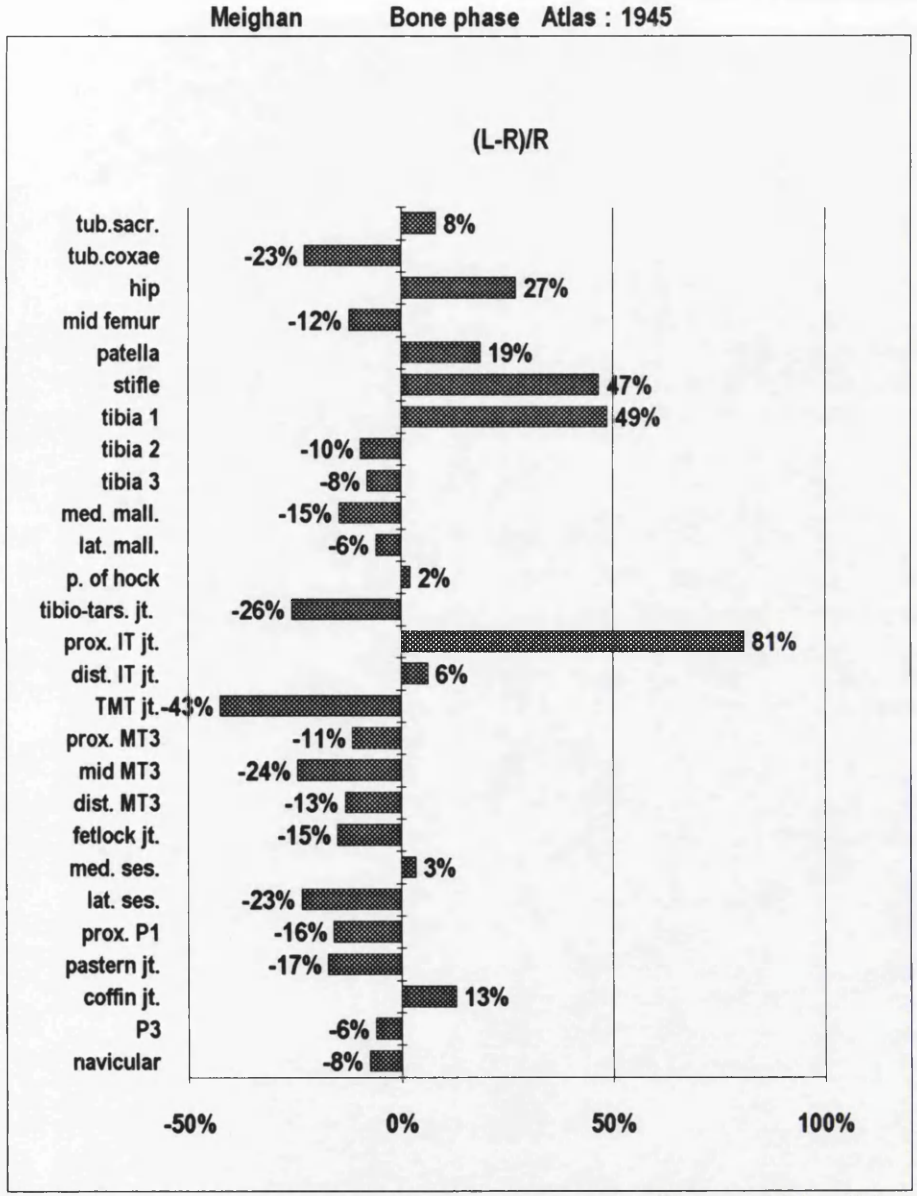


Figure A.12.a. Scintigraphy data of case no. 12. Page 1.



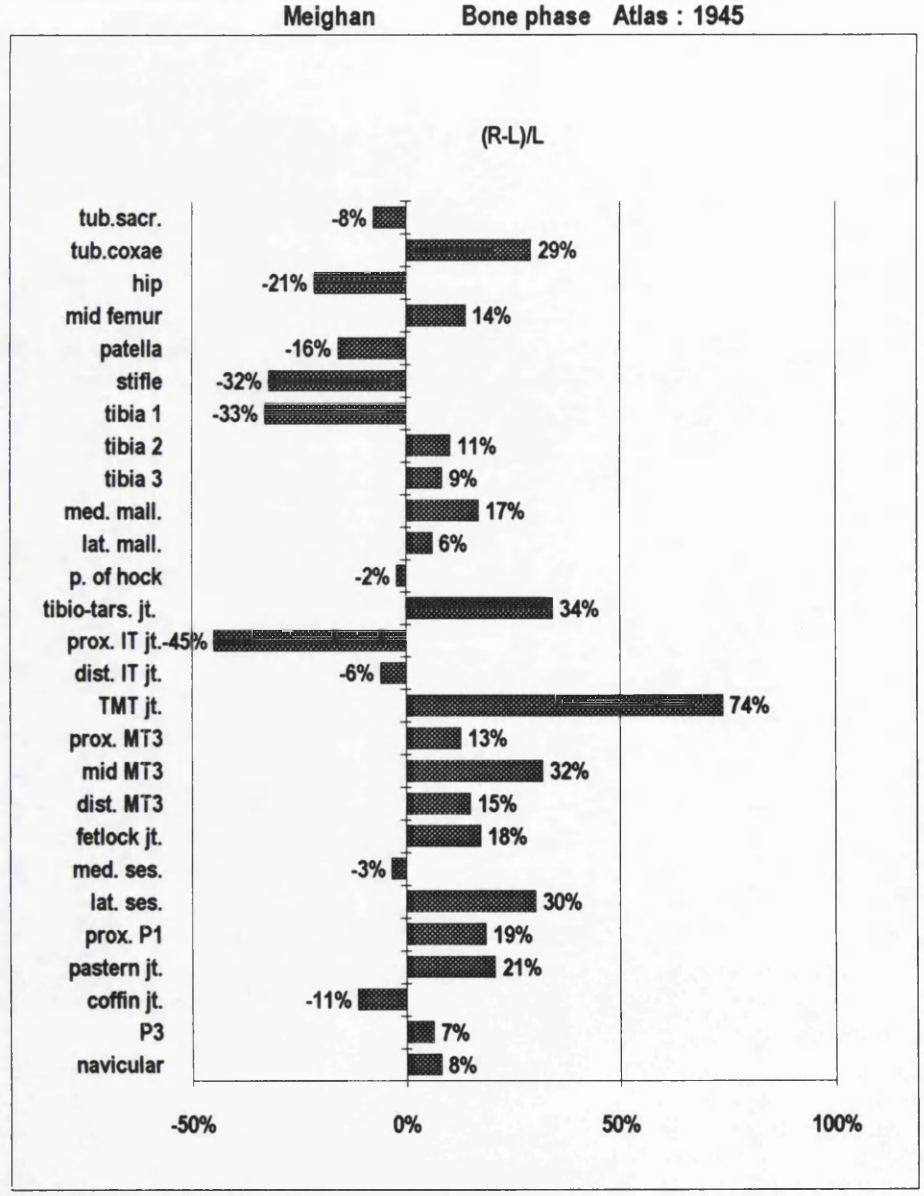


Figure A.12.b. Scintigraphy data of case no. 12. Page 2.

Gamma - scintigraphy report **Hind limbs**

Robinson 123614 **Bone phase** **Atlas : 1372**

	L count	R count		L %	R %		(L-R)/R		Lame RH (R-L)/L
tub.sacr.	1560	1625	tub.sacr.	114%	118%	tub.sacr.	-4%	tub.sacr.	4%
tub.coxae	1024	956	tub.coxae	75%	70%	tub.coxae	7%	tub.coxae	-7%
hip	1011	1266	hip	74%	92%	hip	-20%	hip	25%
mid femur	375	481	mid femur	27%	35%	mid femur	-22%	mid femur	28%
patella	691	815	patella	50%	59%	patella	-15%	patella	18%
stifle	595	770	stifle	43%	56%	stifle	-23%	stifle	29%
tibia 1	542	371	tibia 1	40%	27%	tibia 1	46%	tibia 1	-32%
tibia 2	383	577	tibia 2	28%	42%	tibia 2	-34%	tibia 2	51%
tibia 3	213	311	tibia 3	16%	23%	tibia 3	-32%	tibia 3	46%
med. mall.	173	233	med. mall.	13%	17%	med. mall.	-26%	med. mall.	35%
lat. mall.	179	195	lat. mall.	13%	14%	lat. mall.	-8%	lat. mall.	9%
p. of hock	155	192	p. of hock	11%	14%	p. of hock	-19%	p. of hock	24%
tibio-tars. jt	170	262	tibio-tars. jt	12%	19%	tibio-tars. jt	-35%	tibio-tars. jt	54%
prox. IT jt.	225	278	prox. IT jt.	16%	20%	prox. IT jt.	-19%	prox. IT jt.	24%
dist. IT jt.	253	758	dist. IT jt.	18%	55%	dist. IT jt.	-67%	dist. IT jt.	200%
TMT jt.	264	507	TMT jt.	19%	37%	TMT jt.	-48%	TMT jt.	92%
prox. MT3	185	198	prox. MT3	13%	14%	prox. MT3	-7%	prox. MT3	7%
mid MT3	122	107	mid MT3	9%	8%	mid MT3	14%	mid MT3	-12%
dist. MT3	191	151	dist. MT3	14%	11%	dist. MT3	26%	dist. MT3	-21%
fetlock jt.	279	246	fetlock jt.	20%	18%	fetlock jt.	13%	fetlock jt.	-12%
med. ses.	295	332	med. ses.	22%	24%	med. ses.	-11%	med. ses.	13%
lat. ses.	281	391	lat. ses.	20%	28%	lat. ses.	-28%	lat. ses.	39%
prox. P1	228	209	prox. P1	17%	15%	prox. P1	9%	prox. P1	-8%
pastern jt.	286	263	pastern jt.	21%	19%	pastern jt.	9%	pastern jt.	-8%
coffin jt.	304	324	coffin jt.	22%	24%	coffin jt.	-6%	coffin jt.	7%
P3	315	296	P3	23%	22%	P3	6%	P3	-6%
navicular	247	213	navicular	18%	16%	navicular	16%	navicular	-14%
Mean whole limb counts :				28%	33%		-14%		17%
Mean difference between sample points :							-10%		22%

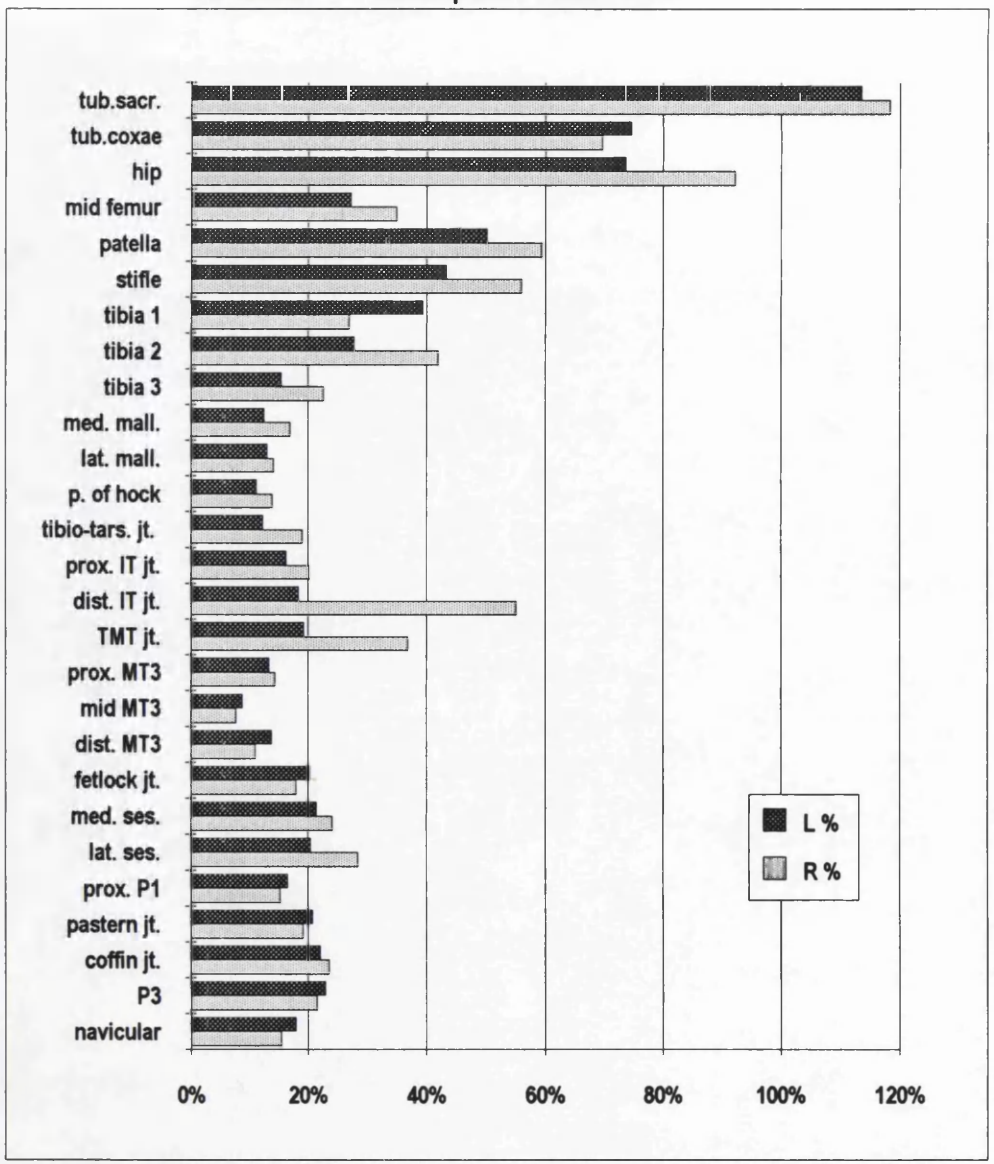
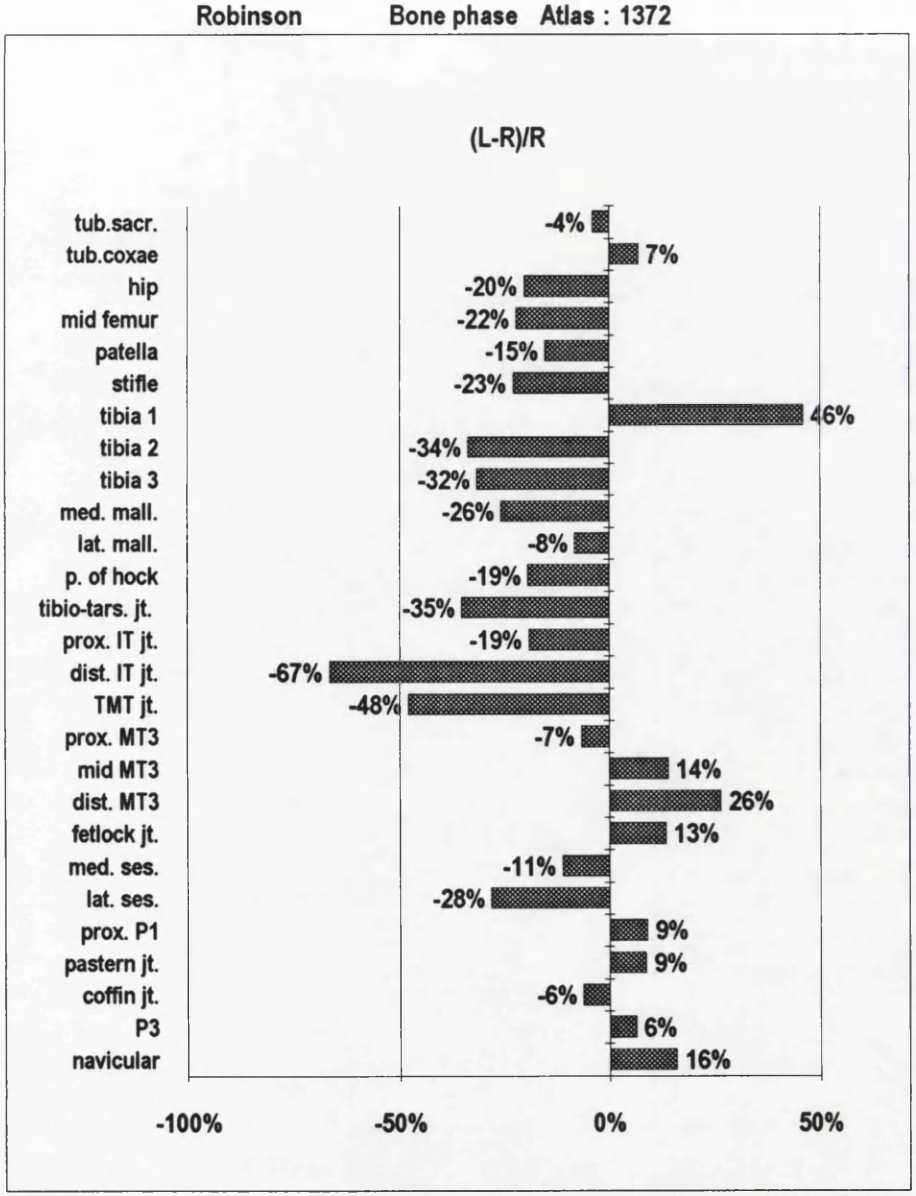


Figure A.13.a. Scintigraphy data of case no. 13. Page 1.



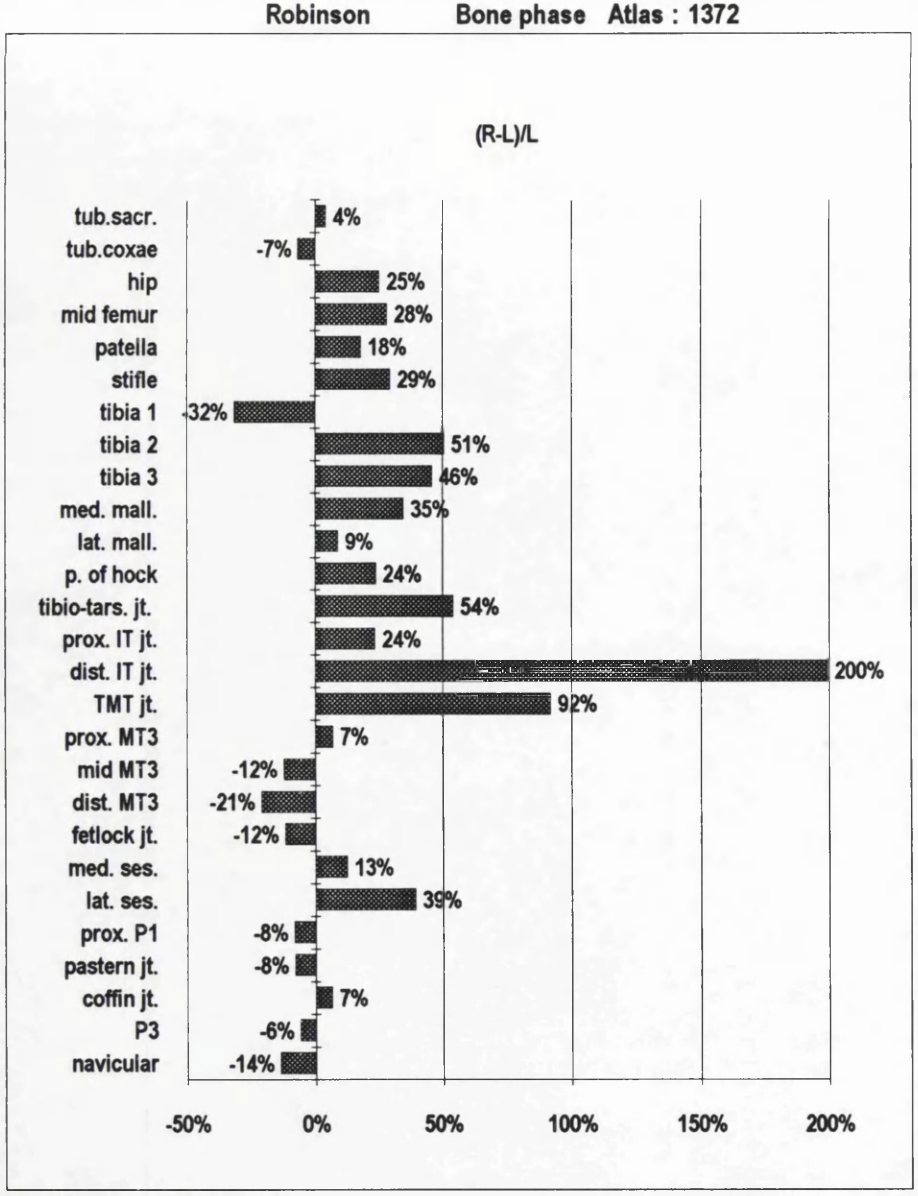


Figure A.13.b. Scintigraphy data of case no. 13. Page 2.

Gamma-Scintigraphy report **Spinal scan** **Date: 19/01/1994**

Robinson **No. 123614** **Bone Phase** **Atlas: 1372**

Counts

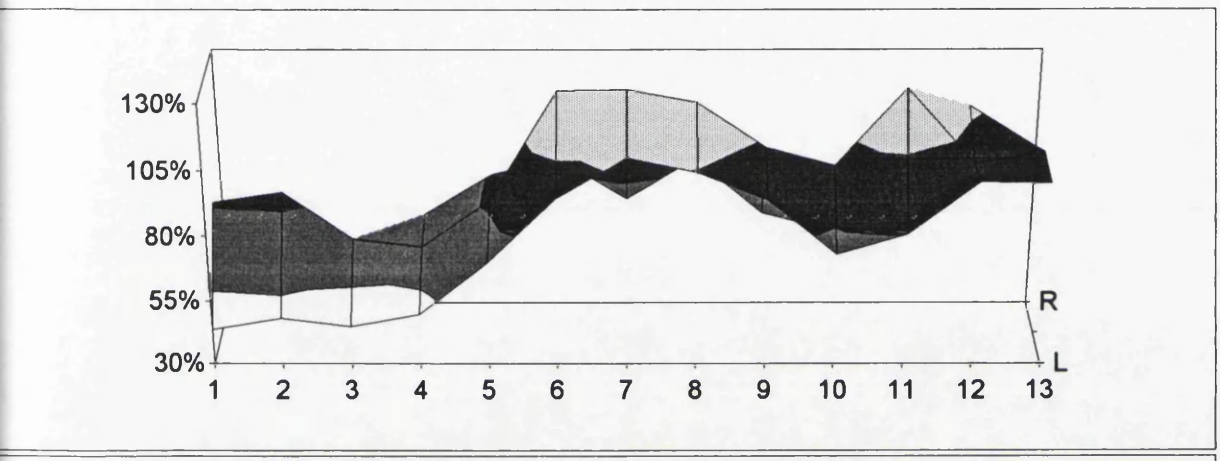
	1	2	3	4	5	6	7	8	9	10	11	12	13
R	635	693	602	903	1120	1205	987	1201	910	814	1223	1484	1267
M	1122	1176	924	882	1131	1710	1716	1650	1413	1319	1721	1327	1388
L	597	659	613	681	958	1298	1509	1434	1291	1003	1108	1385	1377

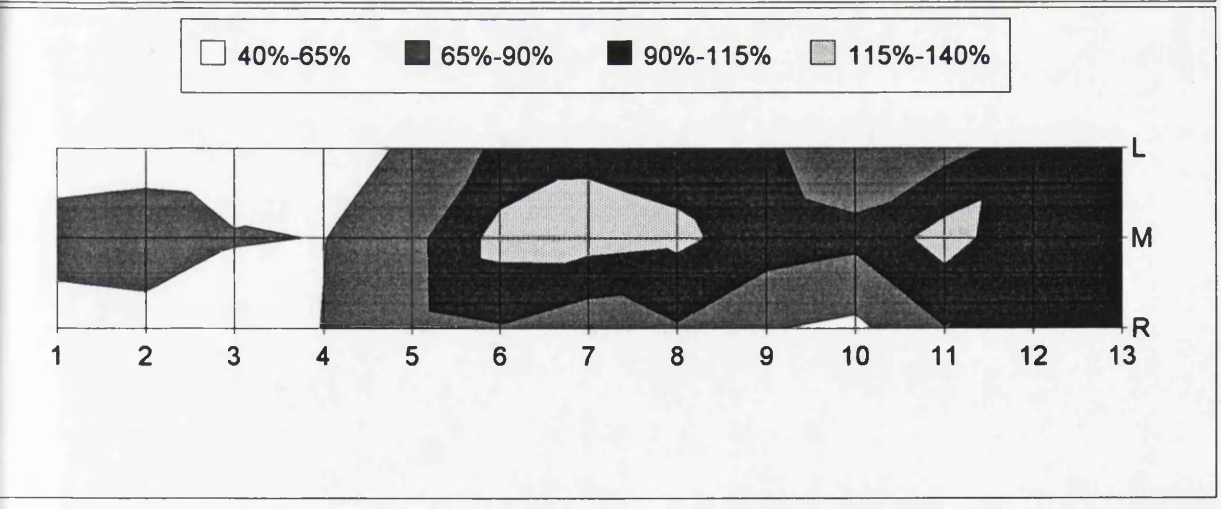
% of reference count

	1	2	3	4	5	6	7	8	9	10	11	12	13
R	46%	51%	44%	66%	82%	88%	72%	88%	66%	59%	89%	108%	92%
M	82%	86%	67%	64%	82%	125%	125%	120%	103%	96%	125%	97%	101%
L	44%	48%	45%	50%	70%	95%	110%	105%	94%	73%	81%	101%	100%

Right / Left difference R%- L%

1	2	3	4	5	6	7	8	9	10	11	12	13
3%	2%	-1%	16%	12%	-7%	-38%	-17%	-28%	-14%	8%	7%	-8%





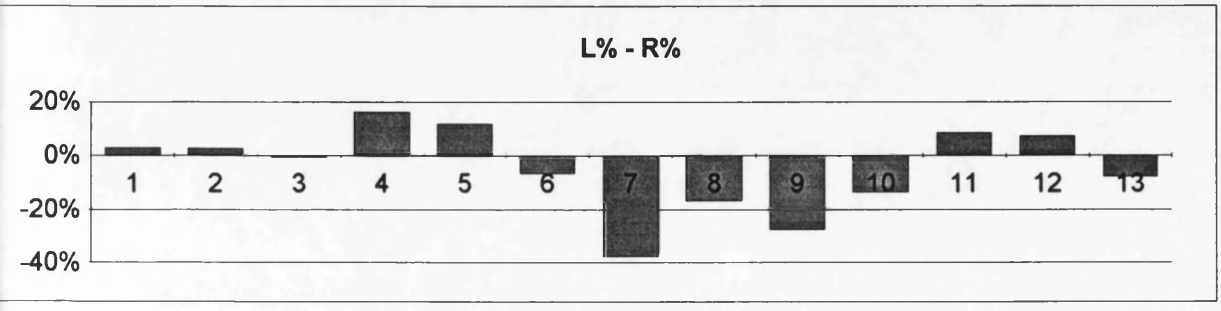
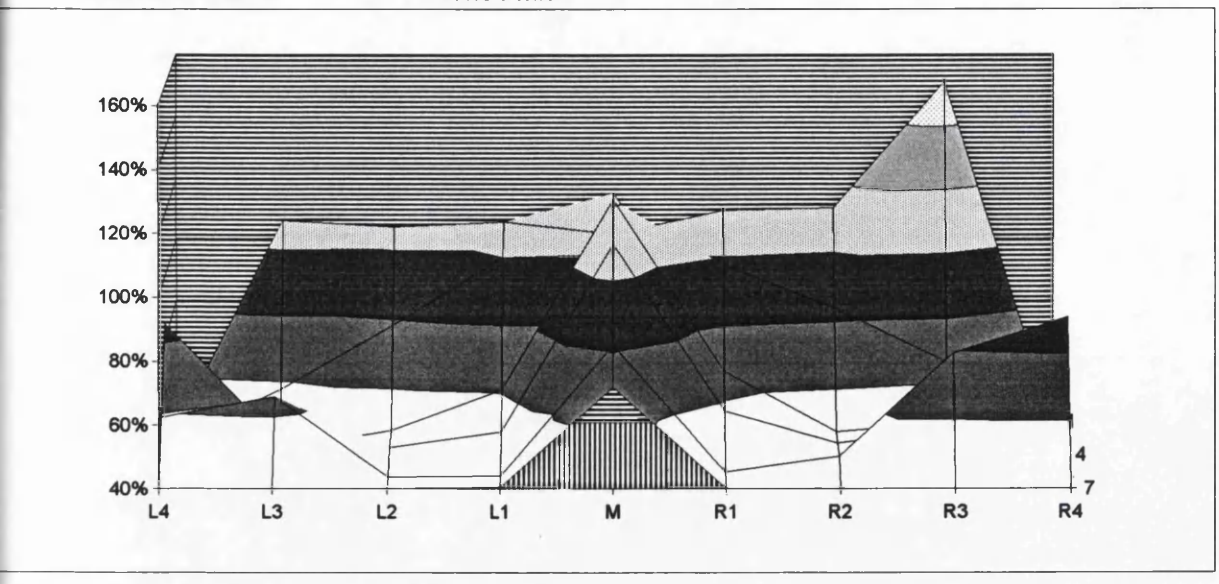


Figure A.14. Spinal scan of case no 13.



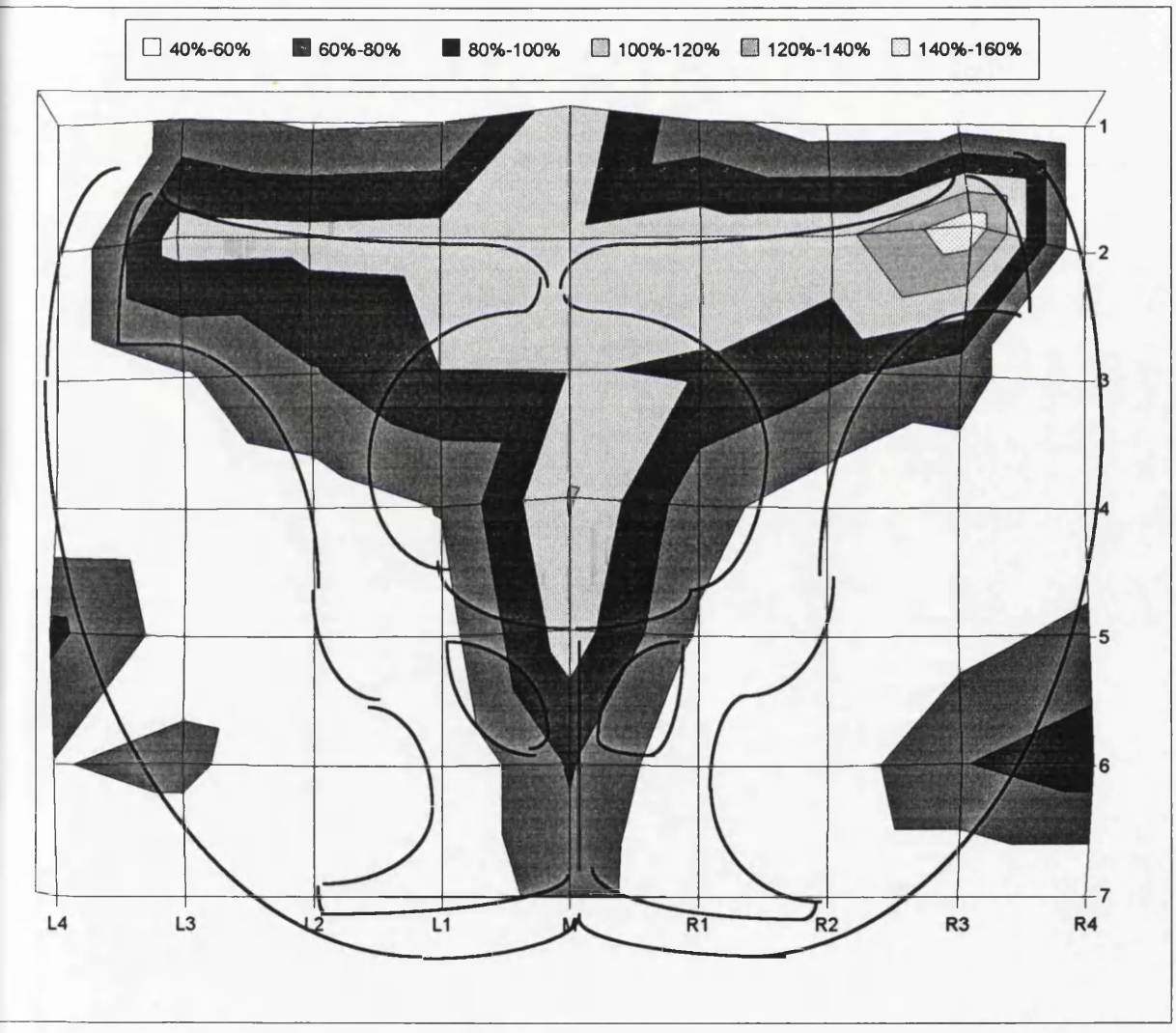


Figure A.15. Pelvic scan of case no. 13.

Gamma - scintigraphy report **Hind limbs** Bone phase

Ireland 124043 Date: 17/03/94 Atlas: 1449

	L count	R count		L %	R %		(L-R)/R		Lame RH (R-L)/L
tub.sacr.	2559	3524	tub.sacr.	177%	243%	tub.sacr.	-27%	tub.sacr.	38%
tub.coxae	2734	2429	tub.coxae	189%	168%	tub.coxae	13%	tub.coxae	-11%
hip	1675	1113	hip	116%	77%	hip	50%	hip	-34%
mid femur	1800	1636	mid femur	124%	113%	mid femur	10%	mid femur	-9%
patella	2423	1756	patella	167%	121%	patella	38%	patella	-28%
stifle	1705	1428	stifle	118%	99%	stifle	19%	stifle	-16%
tibia 1	1718	1876	tibia 1	119%	129%	tibia 1	-8%	tibia 1	9%
tibia 2	1038	872	tibia 2	72%	60%	tibia 2	19%	tibia 2	-16%
tibia 3	799	1305	tibia 3	55%	90%	tibia 3	-39%	tibia 3	63%
med. mall.	1689	1825	med. mall.	117%	126%	med. mall.	-7%	med. mall.	8%
lat. mall.	1635	1388	lat. mall.	113%	96%	lat. mall.	18%	lat. mall.	-15%
p. of hock	1575	1417	p. of hock	109%	98%	p. of hock	11%	p. of hock	-10%
tibio-tars. jt	1585	1320	tibio-tars. jt	109%	91%	tibio-tars. jt	20%	tibio-tars. jt	-17%
prox. IT jt.	2107	2221	prox. IT jt.	145%	153%	prox. IT jt.	-5%	prox. IT jt.	5%
dist. IT jt.	2045	5269	dist. IT jt.	141%	364%	dist. IT jt.	-61%	dist. IT jt.	158%
TMT jt.	2003	4941	TMT jt.	138%	341%	TMT jt.	-59%	TMT jt.	147%
prox. MT3	1332	3052	prox. MT3	92%	211%	prox. MT3	-56%	prox. MT3	129%
mid MT3	1158	1106	mid MT3	80%	76%	mid MT3	5%	mid MT3	-4%
dist. MT3	1102	1113	dist. MT3	76%	77%	dist. MT3	-1%	dist. MT3	1%
fetlock jt.	1469	1476	fetlock jt.	101%	102%	fetlock jt.	0%	fetlock jt.	0%
med. ses.	1352	1526	med. ses.	93%	105%	med. ses.	-11%	med. ses.	13%
lat. ses.	1243	1087	lat. ses.	86%	75%	lat. ses.	14%	lat. ses.	-13%
prox. P1	1518	1384	prox. P1	105%	96%	prox. P1	10%	prox. P1	-9%
pastern jt.	1425	1276	pastern jt.	98%	88%	pastern jt.	12%	pastern jt.	-10%
coffin jt.	1577	2000	coffin jt.	109%	138%	coffin jt.	-21%	coffin jt.	27%
P3	1208	1501	P3	83%	104%	P3	-20%	P3	24%
navicular	1225	756	navicular	85%	52%	navicular	62%	navicular	-38%
Mean whole limb counts :				112%	129%		-14%		16%
Mean difference between sample points :							-1%		15%

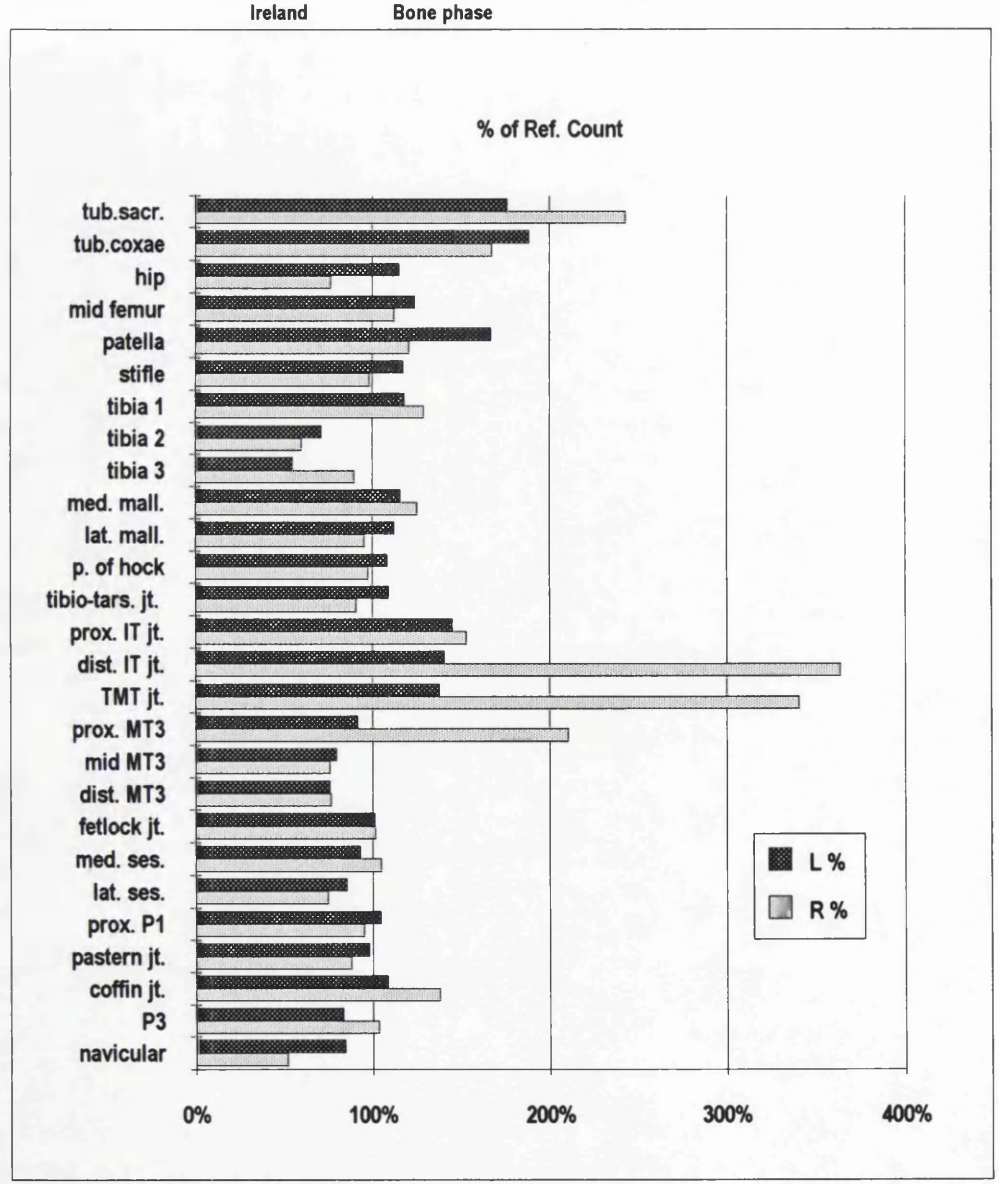
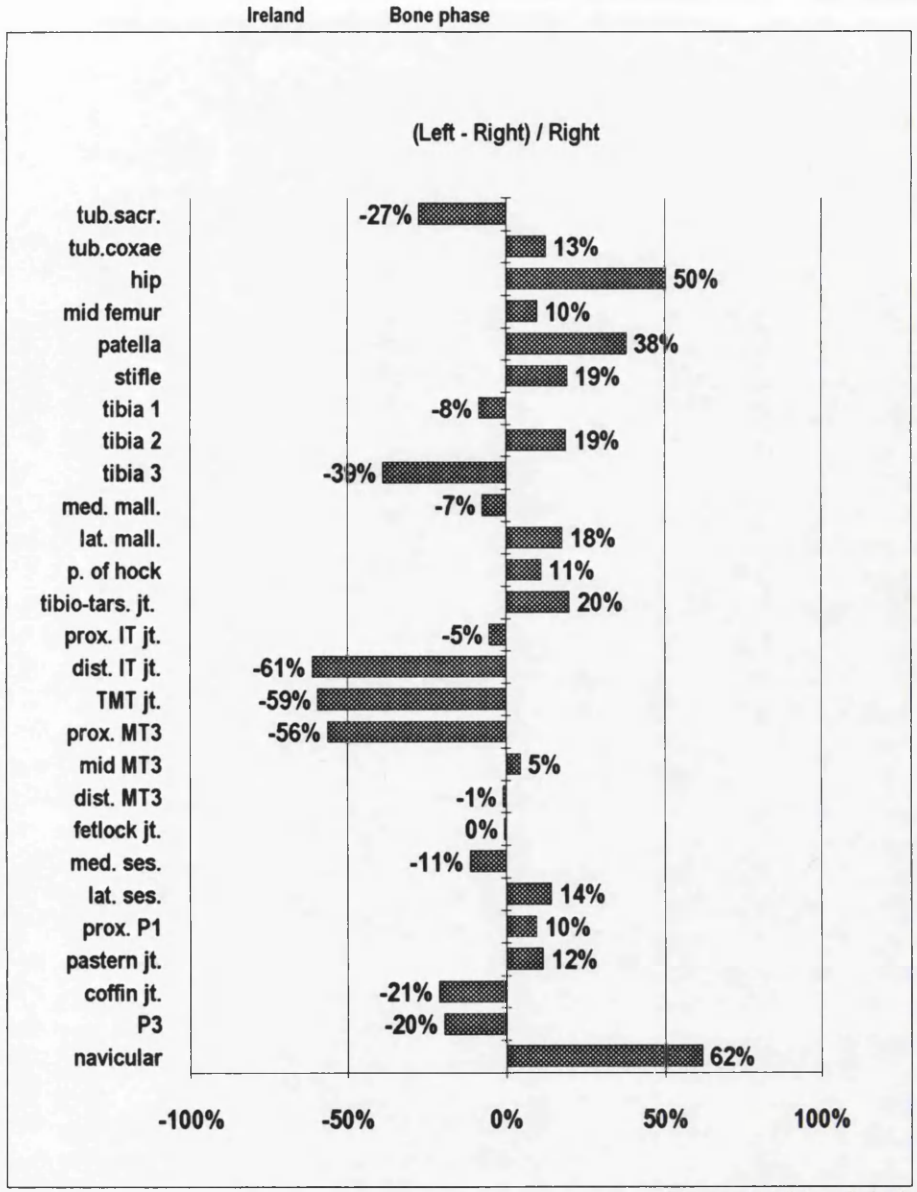


Figure A.16.a. Scintigraphy data of case no. 14. Page 1.



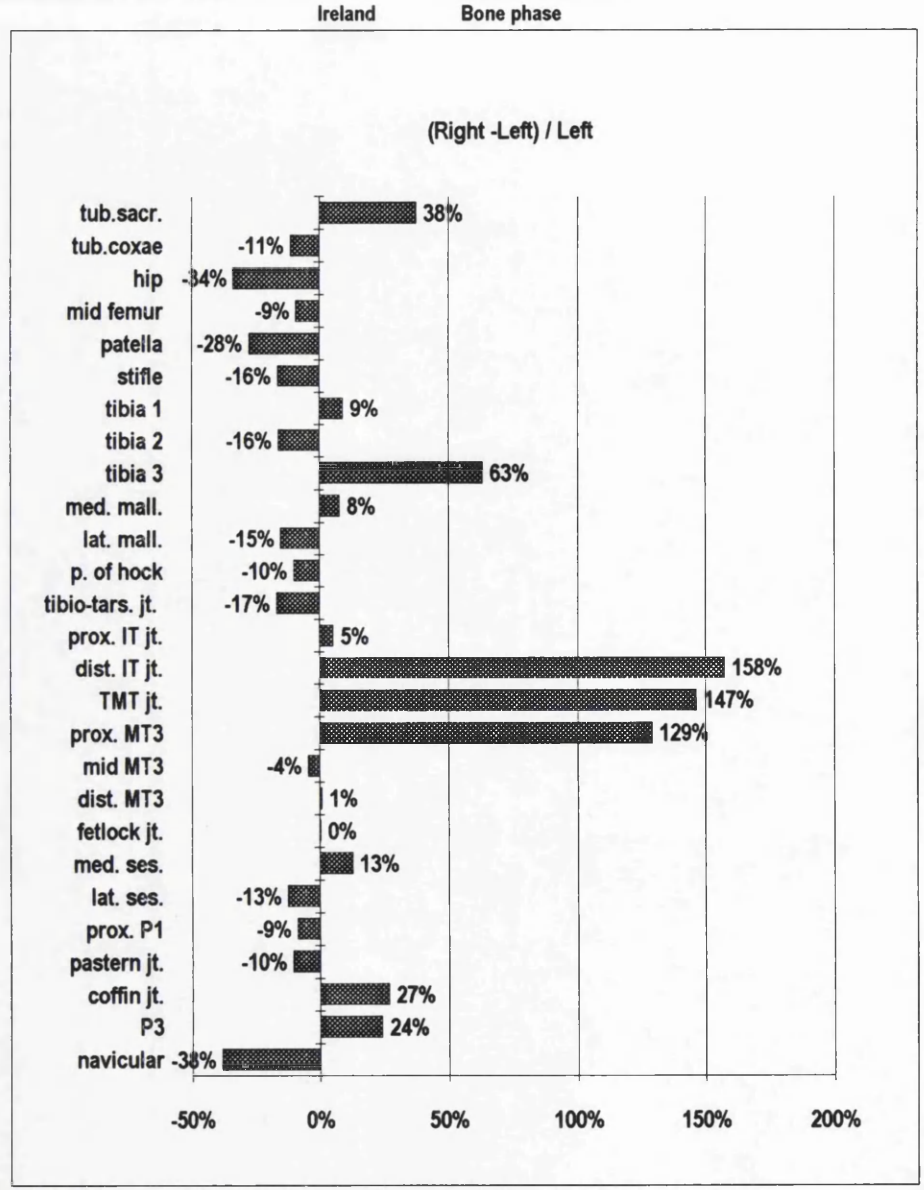


Figure A.16.b. Scintigraphy data of case no. 14. Page 2.

Gamma - scintigraphy report **Hind limbs** Bone Phase

MacKenzie 108976 Date: 26/06/92 Atlas: 1204

	L count	R count		L %	R %		(L-R)/R		(R-L)/L
tub.sacr.	1496	1420	tub.sacr.	124%	118%	tub.sacr.	5%	tub.sacr.	-5%
tub.coxae	882	694	tub.coxae	73%	58%	tub.coxae	27%	tub.coxae	-21%
hip	1487	2295	hip	124%	191%	hip	-35%	hip	54%
mid femur	898	1388	mid femur	75%	115%	mid femur	-35%	mid femur	55%
patella	848	913	patella	70%	76%	patella	-7%	patella	8%
stifle	787	794	stifle	65%	66%	stifle	-1%	stifle	1%
tibia 1	706	765	tibia 1	59%	64%	tibia 1	-8%	tibia 1	8%
tibia 2	957	558	tibia 2	79%	46%	tibia 2	72%	tibia 2	-42%
tibia 3	660	545	tibia 3	55%	45%	tibia 3	21%	tibia 3	-17%
med. mall.	962	645	med. mall.	80%	54%	med. mall.	49%	med. mall.	-33%
lat. mall.	1119	553	lat. mall.	93%	46%	lat. mall.	102%	lat. mall.	-51%
p. of hock	881	610	p. of hock	73%	51%	p. of hock	44%	p. of hock	-31%
tibio-tars. jt	1130	646	tibio-tars. jt	94%	54%	tibio-tars. jt	75%	tibio-tars. jt	-43%
prox. IT jt.	847	631	prox. IT jt.	70%	52%	prox. IT jt.	34%	prox. IT jt.	-26%
dist. IT jt.	838	590	dist. IT jt.	70%	49%	dist. IT jt.	42%	dist. IT jt.	-30%
TMT jt.	874	519	TMT jt.	73%	43%	TMT jt.	68%	TMT jt.	-41%
prox. MT3	1254	688	prox. MT3	104%	57%	prox. MT3	82%	prox. MT3	-45%
mid MT3	1392	490	mid MT3	116%	41%	mid MT3	184%	mid MT3	-65%
dist. MT3	1830	384	dist. MT3	152%	32%	dist. MT3	377%	dist. MT3	-79%
fetlock jt.	1975	601	fetlock jt.	164%	50%	fetlock jt.	229%	fetlock jt.	-70%
med. ses.	973	402	med. ses.	81%	33%	med. ses.	142%	med. ses.	-59%
lat. ses.	1390	502	lat. ses.	115%	42%	lat. ses.	177%	lat. ses.	-64%
prox. P1	2009	482	prox. P1	167%	40%	prox. P1	317%	prox. P1	-76%
pastern jt.	2191	595	pastern jt.	182%	49%	pastern jt.	268%	pastern jt.	-73%
coffin jt.	1175	592	coffin jt.	98%	49%	coffin jt.	98%	coffin jt.	-50%
P3	1599	494	P3	133%	41%	P3	224%	P3	-69%
navicular	4005	362	navicular	333%	30%	navicular	1006%	navicular	-91%
Mean whole limb counts :				108%	59%		84%		-46%
Mean difference between sample points :							132%		-35%

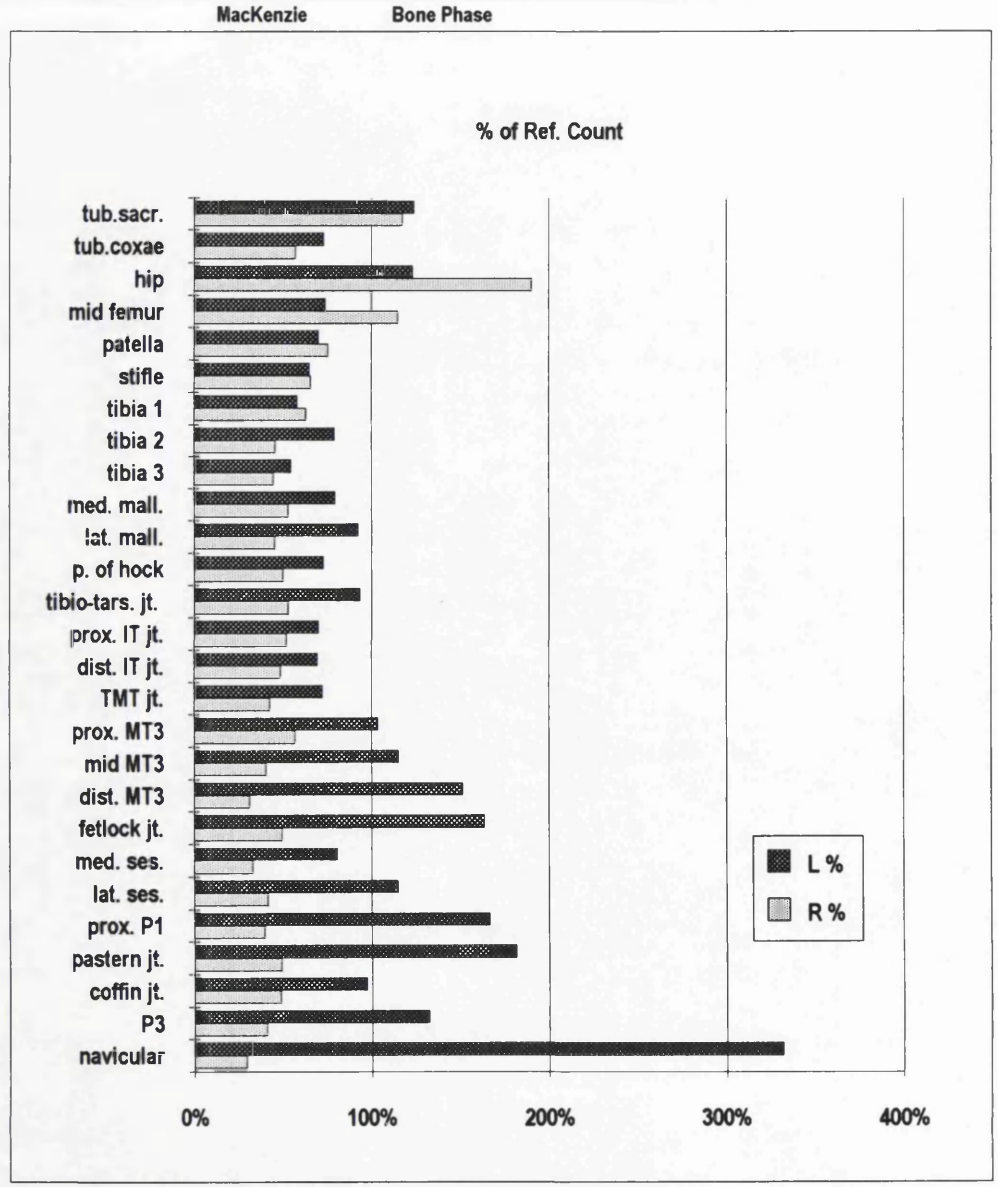
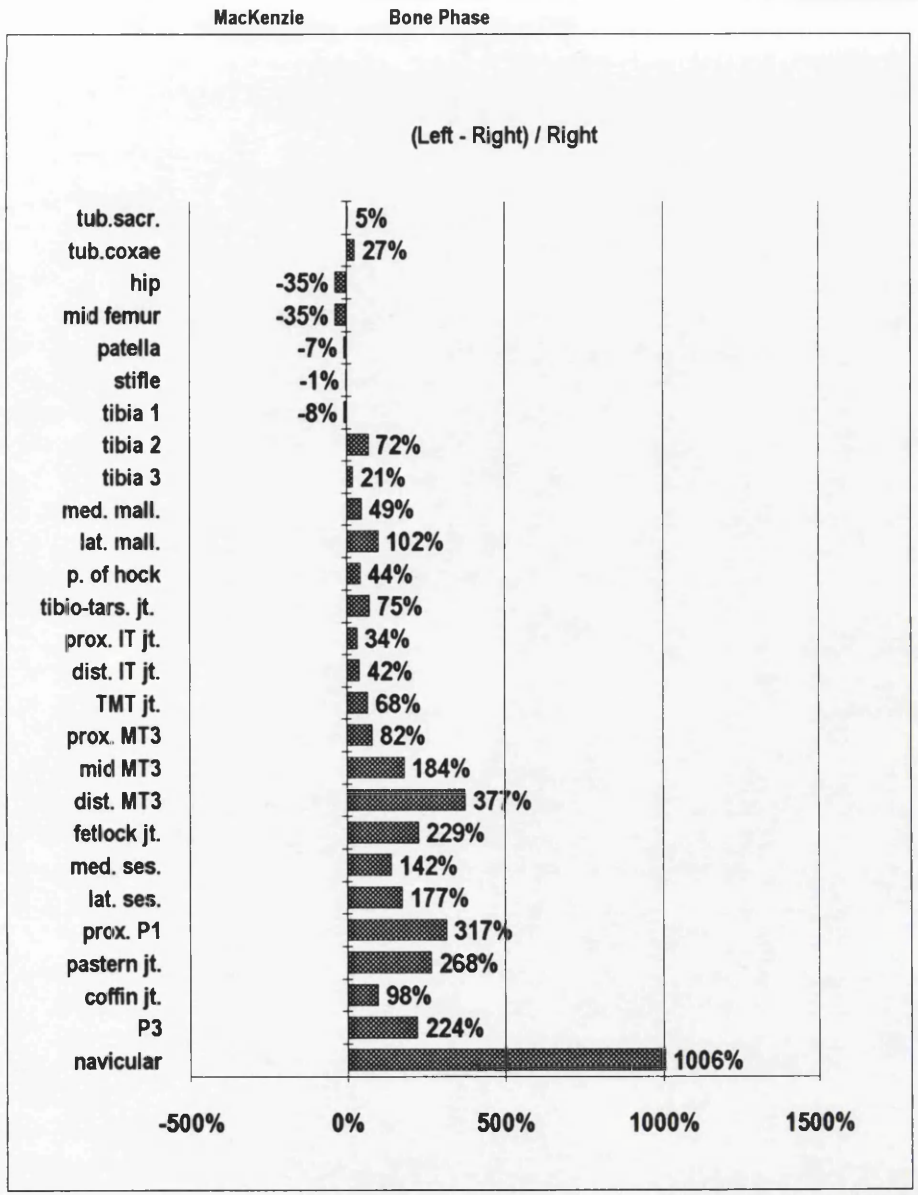


Figure A.17.a. Scintigraphy data of case no. 15. Page1.



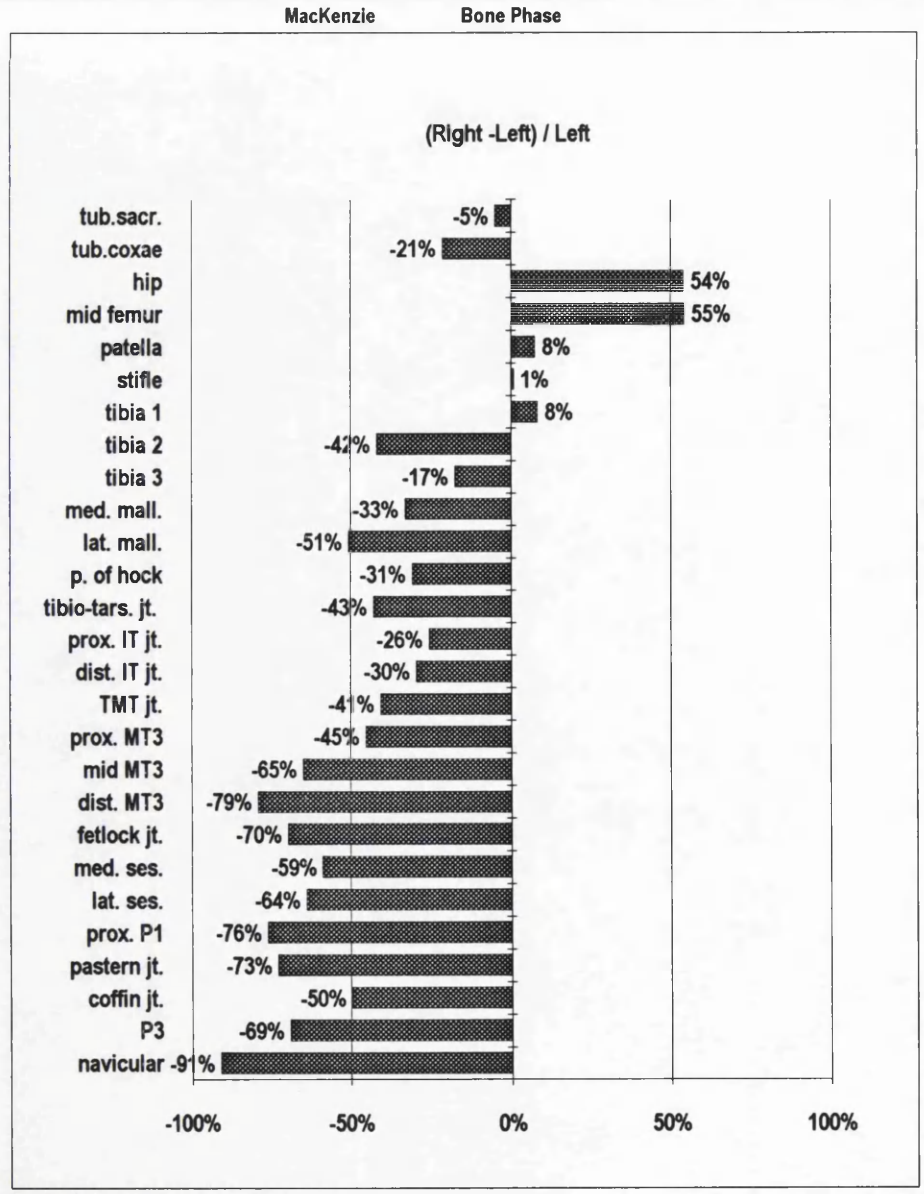


Figure A.17.b. Scintigraphy data of case no. 15. Page 2.

Gamma - scintigraphy report Hind limbs

Milroy 123128 Bone phase Atlas : 1512

	L count	R count		L %	R %		(L-R)/R		Lame RH (R-L)/L
tub.sacr.	2270	2402	tub.sacr.	150%	159%	tub.sacr.	-5%	tub.sacr.	6%
tub.coxae	2130	2712	tub.coxae	141%	179%	tub.coxae	-21%	tub.coxae	27%
hip	1607	2029	hip	106%	134%	hip	-21%	hip	26%
mid femur	617	1088	mid femur	41%	72%	mid femur	-43%	mid femur	76%
patella	1655	1741	patella	109%	115%	patella	-5%	patella	5%
stifle	1529	1662	stifle	101%	110%	stifle	-8%	stifle	9%
tibia 1	1539	1677	tibia 1	102%	111%	tibia 1	-8%	tibia 1	9%
tibia 2	1019	929	tibia 2	67%	61%	tibia 2	10%	tibia 2	-9%
tibia 3	972	895	tibia 3	64%	59%	tibia 3	9%	tibia 3	-8%
med. mall.	1356	1023	med. mall.	90%	68%	med. mall.	33%	med. mall.	-25%
lat. mall.	877	968	lat. mall.	58%	64%	lat. mall.	-9%	lat. mall.	10%
p. of hock	767	1005	p. of hock	51%	66%	p. of hock	-24%	p. of hock	31%
tibio-tars. jt	984	1059	tibio-tars. jt	65%	70%	tibio-tars. jt	-7%	tibio-tars. jt	8%
prox. IT jt.	1076	1139	prox. IT jt.	71%	75%	prox. IT jt.	-6%	prox. IT jt.	6%
dist. IT jt.	1111	1020	dist. IT jt.	73%	67%	dist. IT jt.	9%	dist. IT jt.	-8%
TMT jt.	1048	1098	TMT jt.	69%	73%	TMT jt.	-5%	TMT jt.	5%
prox. MT3	834	976	prox. MT3	55%	65%	prox. MT3	-15%	prox. MT3	17%
mid MT3	490	638	mid MT3	32%	42%	mid MT3	-23%	mid MT3	30%
dist. MT3	661	887	dist. MT3	44%	59%	dist. MT3	-25%	dist. MT3	34%
fetlock jt.	818	1072	fetlock jt.	54%	71%	fetlock jt.	-24%	fetlock jt.	31%
med. ses.	848	936	med. ses.	56%	62%	med. ses.	-9%	med. ses.	10%
lat. ses.	859	954	lat. ses.	57%	63%	lat. ses.	-10%	lat. ses.	11%
prox. P1	880	929	prox. P1	58%	61%	prox. P1	-5%	prox. P1	6%
pastern jt.	843	942	pastern jt.	56%	62%	pastern jt.	-11%	pastern jt.	12%
coffin jt.	792	778	coffin jt.	52%	51%	coffin jt.	2%	coffin jt.	-2%
P3	651	507	P3	43%	34%	P3	28%	P3	-22%
navicular	464	360	navicular	31%	24%	navicular	29%	navicular	-22%
Mean whole limb counts :				70%	77%		-9%		10%
Mean difference between sample points :							-6%		10%

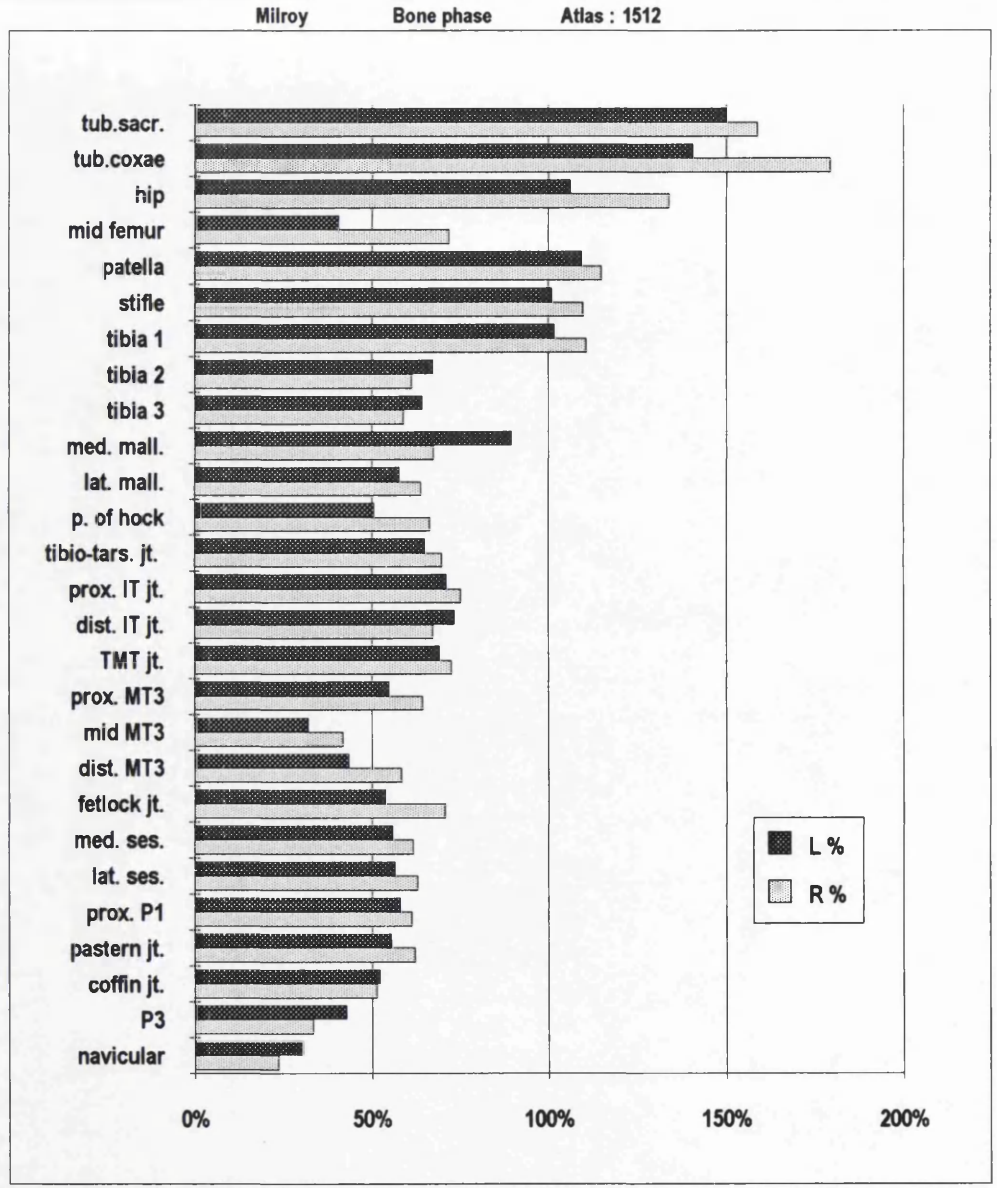
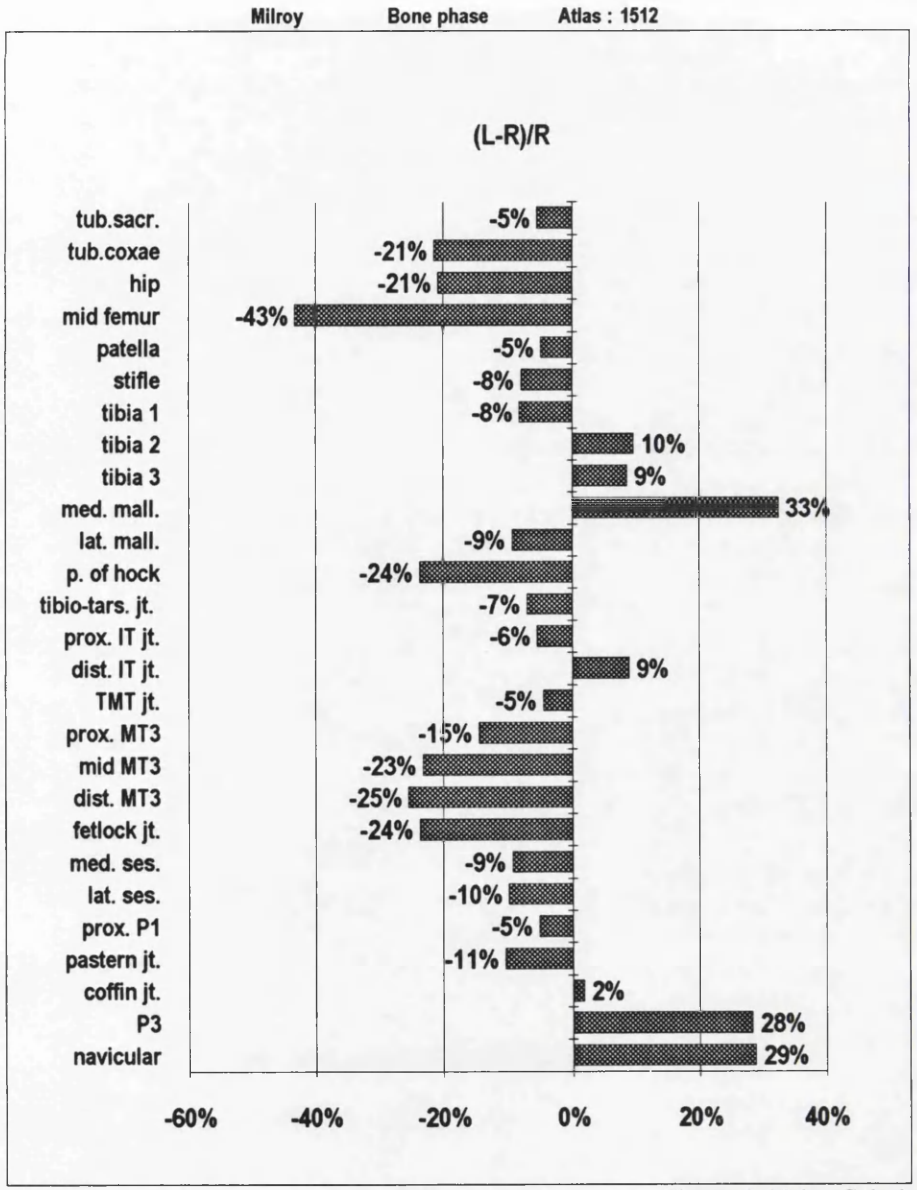


Figure A.18.a. Scintigraphy data of case no. 16. Page 1.



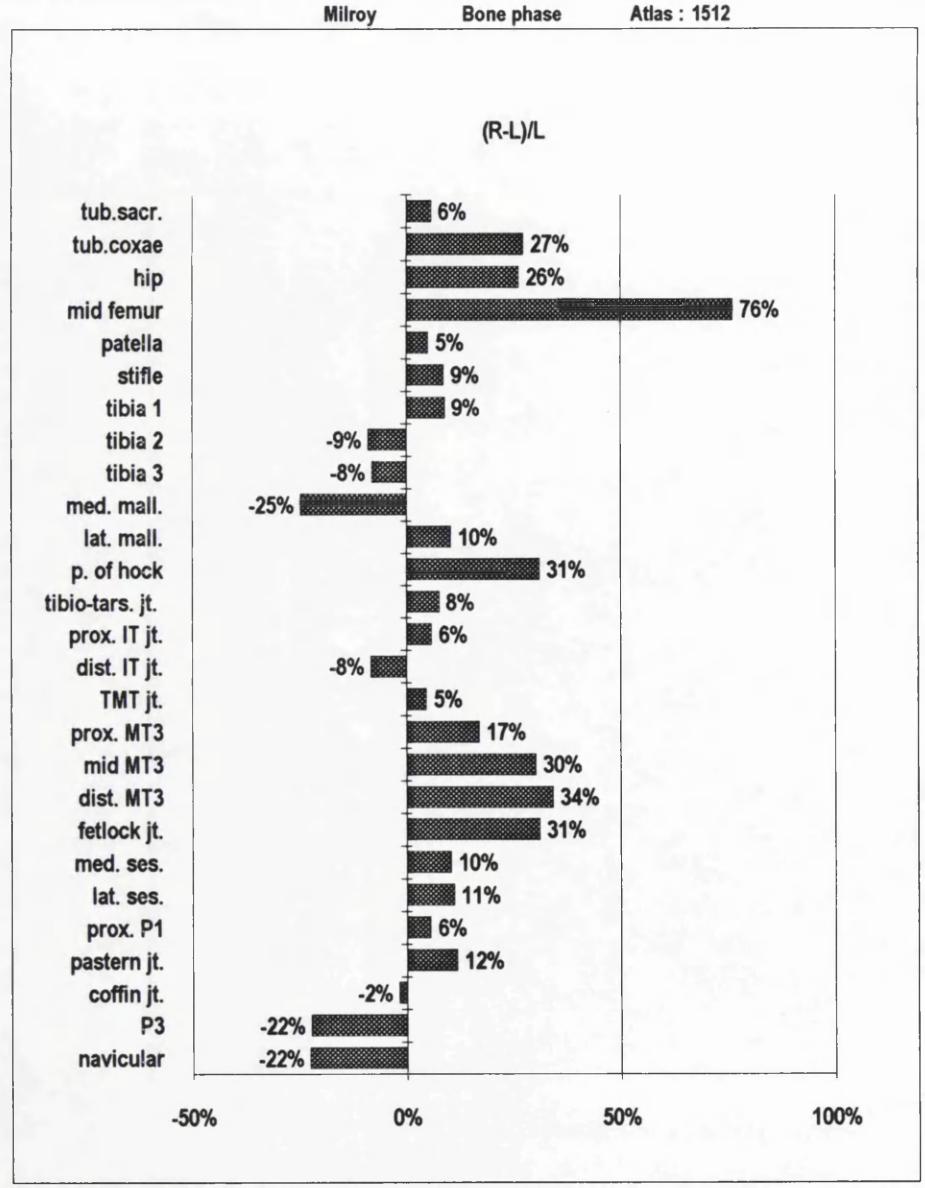


Figure A.18.b. Scintigraphy data of case no. 16. Page 2.

Gamma - scintigraphy report **Hind limbs** Bone Phase

Finlay 118264 Date: 03/10/91 Atlas: 1649

	L count	R count		L %	R %		(L-R)/R		Lame RH (R-L)/L
tub.sacr.	1828	1857	tub.sacr.	111%	113%	tub.sacr.	-2%	tub.sacr.	2%
tub.coxae	2263	1383	tub.coxae	137%	84%	tub.coxae	64%	tub.coxae	-39%
hip	1131	1175	hip	69%	71%	hip	-4%	hip	4%
mid femur	773	796	mid femur	47%	48%	mid femur	-3%	mid femur	3%
patella	568	448	patella	34%	27%	patella	27%	patella	-21%
stifle	1008	606	stifle	61%	37%	stifle	66%	stifle	-40%
tibia 1	1296	1079	tibia 1	79%	65%	tibia 1	20%	tibia 1	-17%
tibia 2	1131	1067	tibia 2	69%	65%	tibia 2	6%	tibia 2	-6%
tibia 3	673	706	tibia 3	41%	43%	tibia 3	-5%	tibia 3	5%
med. mall.	853	1102	med. mall.	52%	67%	med. mall.	-23%	med. mall.	29%
lat. mall.	0	0	lat. mall.	0%	0%	lat. mall.		lat. mall.	
p. of hock	684	686	p. of hock	41%	42%	p. of hock	0%	p. of hock	0%
tibio-tars. jt	700	875	tibio-tars. jt	42%	53%	tibio-tars. jt	-20%	tibio-tars. jt	25%
prox. IT jt.	0	0	prox. IT jt.	0%	0%	prox. IT jt.		prox. IT jt.	
dist. IT jt.	760	767	dist. IT jt.	46%	47%	dist. IT jt.	-1%	dist. IT jt.	1%
TMT jt.	809	711	TMT jt.	49%	43%	TMT jt.	14%	TMT jt.	-12%
prox. MT3	633	550	prox. MT3	38%	33%	prox. MT3	15%	prox. MT3	-13%
mid MT3	397	373	mid MT3	24%	23%	mid MT3	6%	mid MT3	-6%
dist. MT3	387	419	dist. MT3	23%	25%	dist. MT3	-8%	dist. MT3	8%
fetlock jt.	520	559	fetlock jt.	32%	34%	fetlock jt.	-7%	fetlock jt.	8%
med. ses.	518	467	med. ses.	31%	28%	med. ses.	11%	med. ses.	-10%
lat. ses.	511	464	lat. ses.	31%	28%	lat. ses.	10%	lat. ses.	-9%
prox. P1	481	577	prox. P1	29%	35%	prox. P1	-17%	prox. P1	20%
pastern jt.	618	763	pastern jt.	37%	46%	pastern jt.	-19%	pastern jt.	23%
coffin jt.	655	748	coffin jt.	40%	45%	coffin jt.	-12%	coffin jt.	14%
P3	476	410	P3	29%	25%	P3	16%	P3	-14%
navicular	622	327	navicular	38%	20%	navicular	90%	navicular	-47%
Mean whole limb counts :				49%	46%		7%		-7%
Mean difference between sample points :							9%		-4%

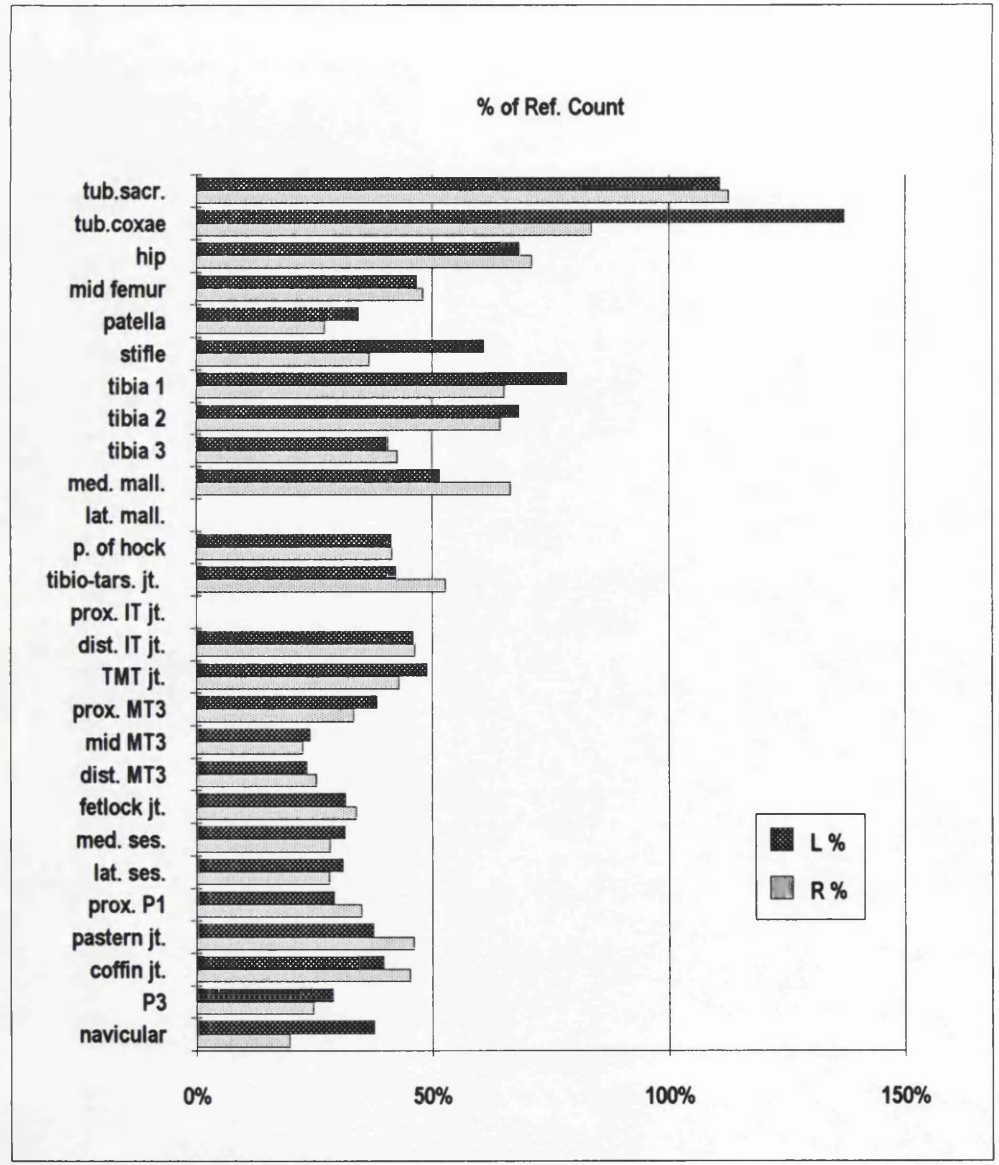
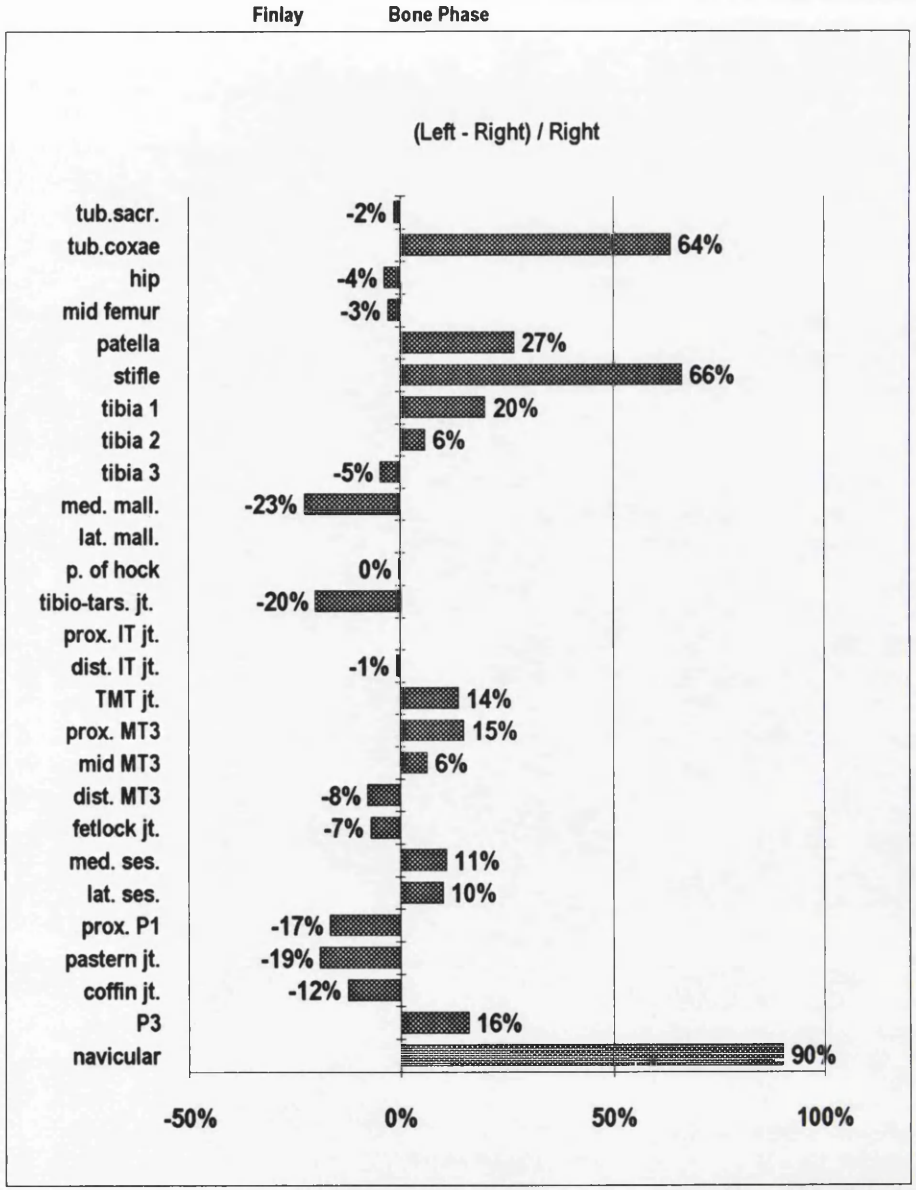


Figure A.19.a. Scintigraphy data of case no. 17. Page 1.



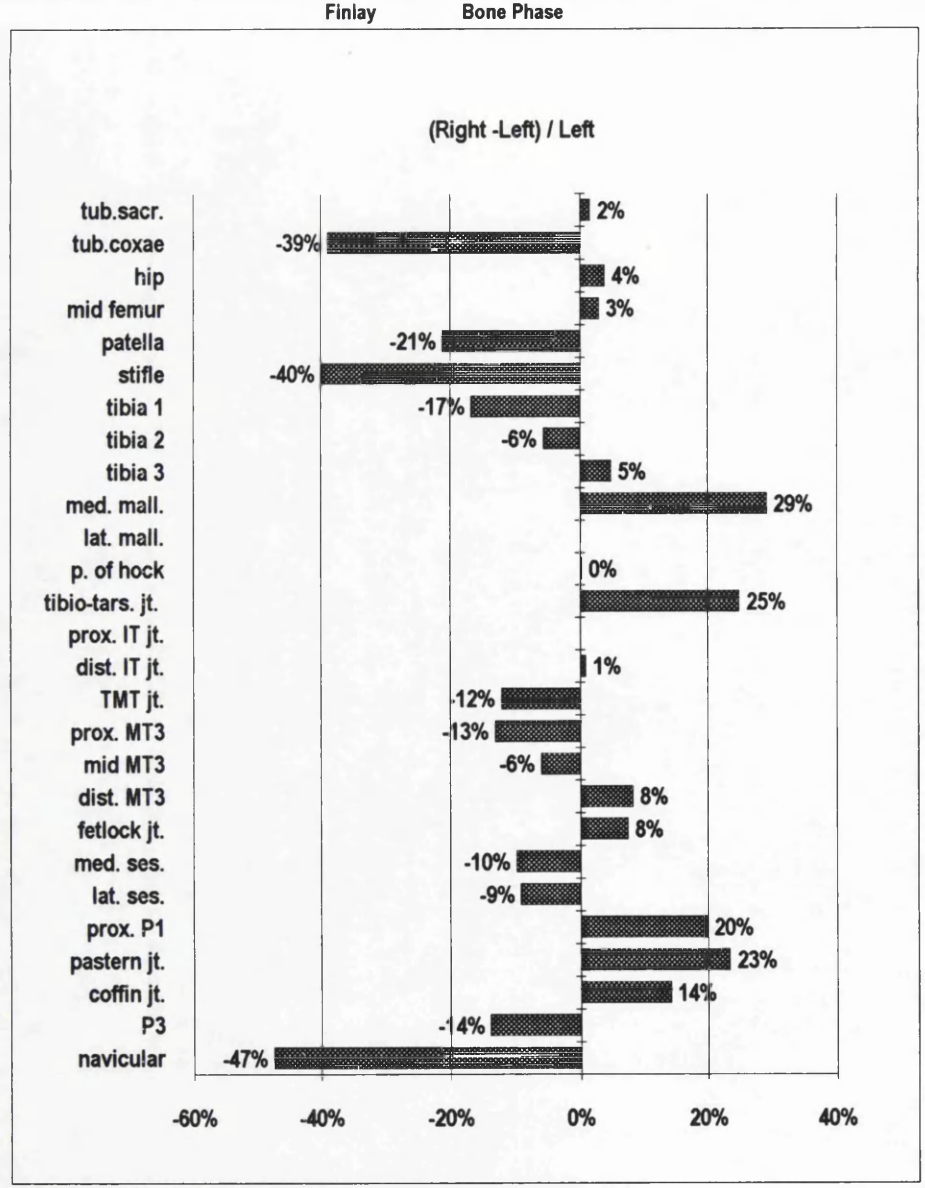


Figure A.19.b. Scintigraphy data of case no. 17. Page 2.

APPENDIX B:

RADIOGRAPHS

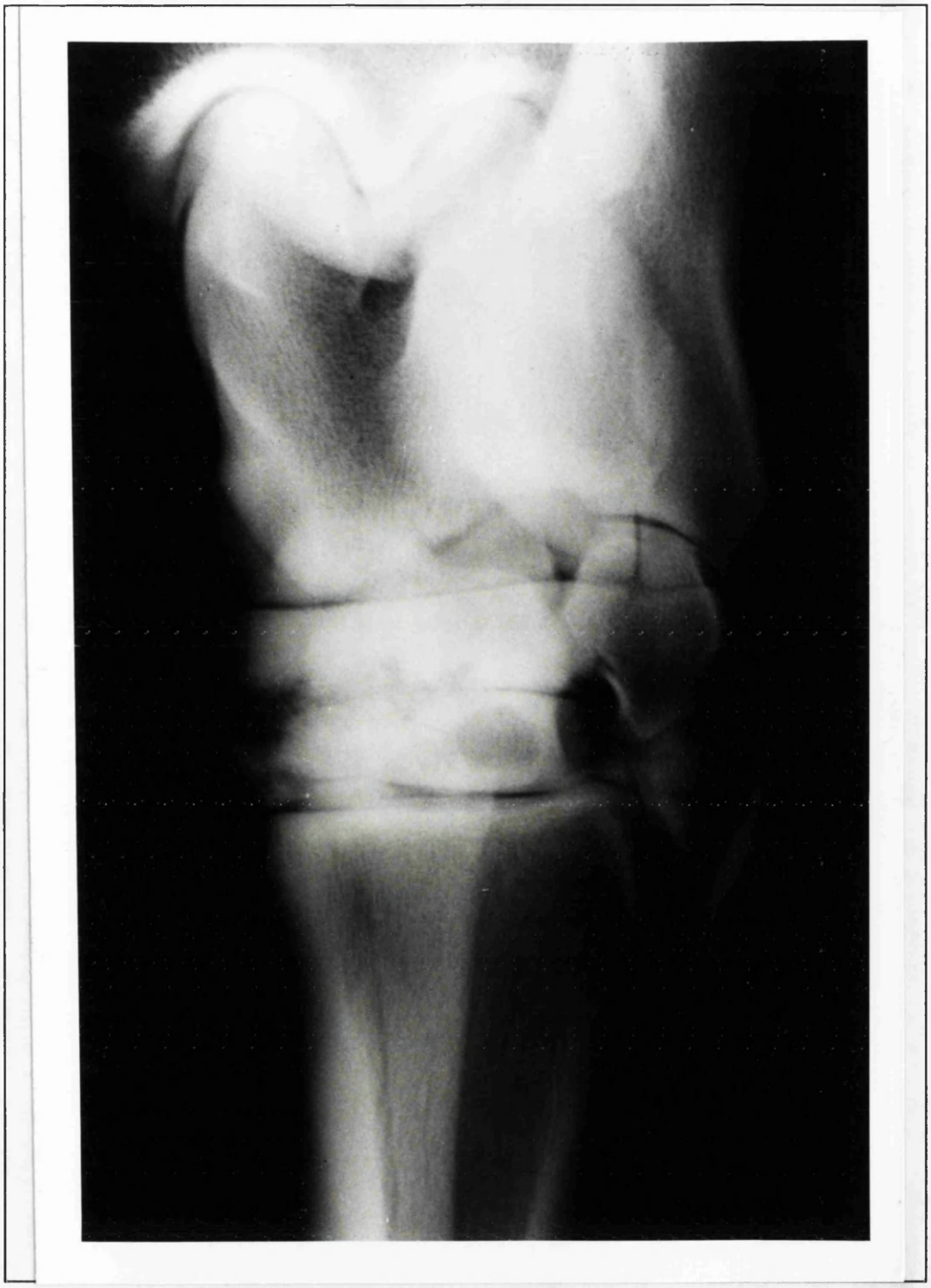


Figure B.1. *DL-PlM O radiographic view of the right tarsus of case no. 1. There is partial obliteration of the DIT joint and an extensive area of subchondral bone lysis. The TMT joint shows irregular joint margins and small areas of lysis. There is a large exostosis on the proximal dorso-medial aspect of MT3. The changes in the left hock were of a similar extent.*

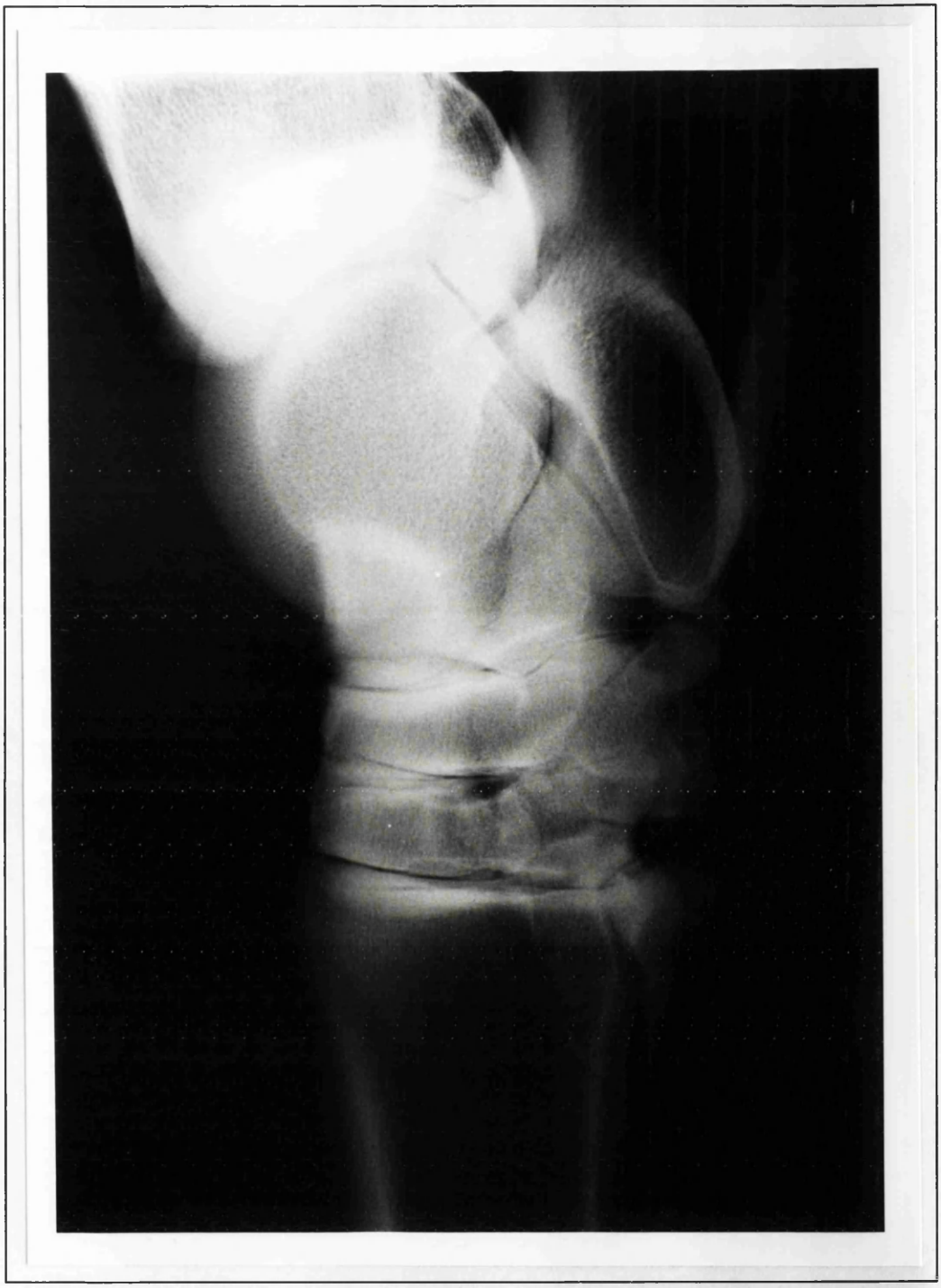


Figure B.2. *Latero-medial radiographic view of the right tarsus of case no. 2. The radiographic changes in these joints were graded as "doubtful". There is a small osteophyte on the dorsal-medial aspect of the TMT joint and slight "lipping" of the two other joints.*

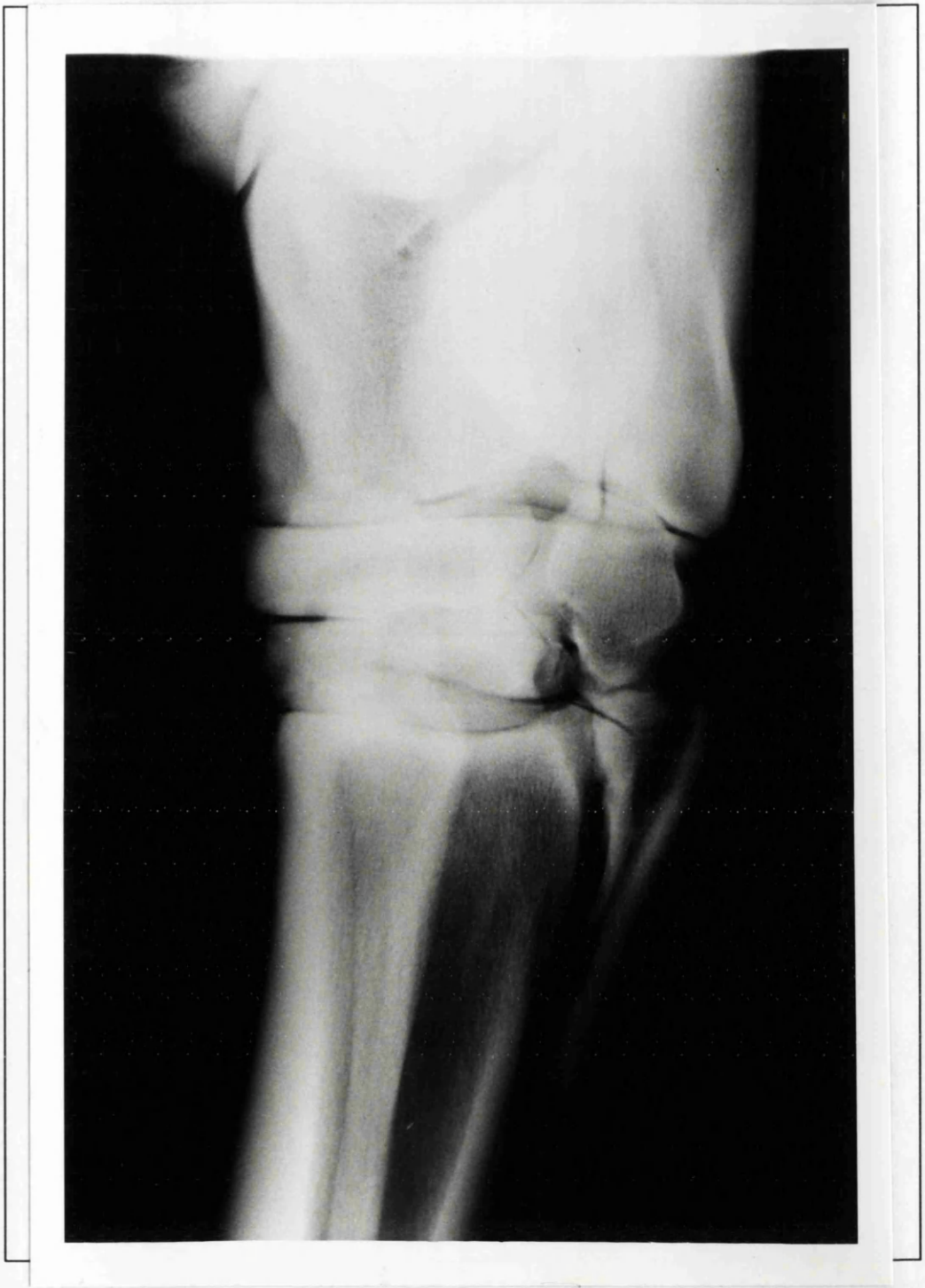


Figure B.3. *DL-PlM O view of the right tarsus of case no. 3. A large osteophyte on the distal border of the central tarsal bone and a lucent zone in the dorso-medial aspect of the DIT joint can be noted. The TMT and PIT joints show slight irregular margins. The central tarsal bone is sclerotic.*

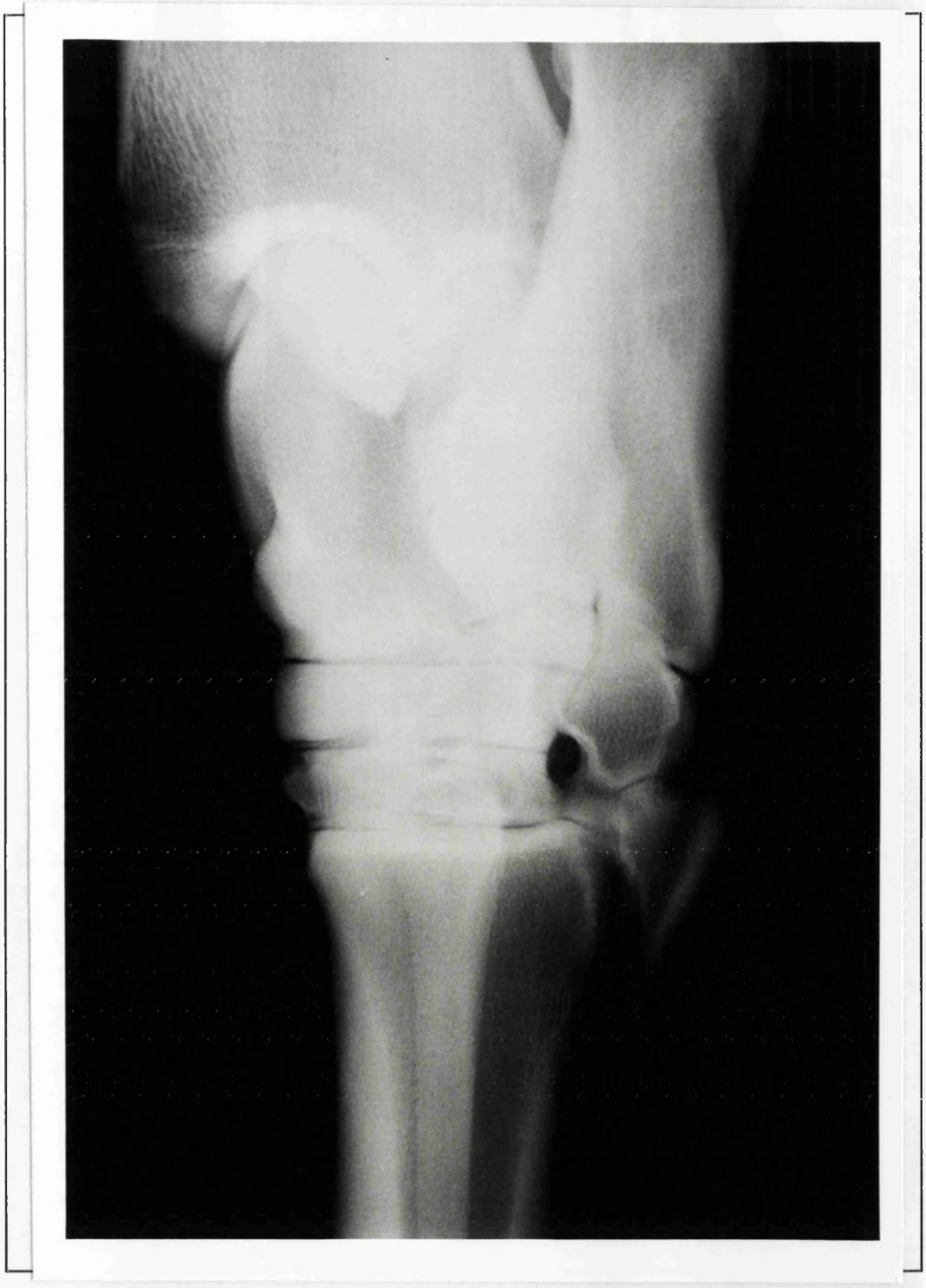


Figure B.4. *DL-PlM O radiographic view of the right tarsus of case no. 4. There is slight "lipping" and irregularities in the subchondral bone plate of the DIT joint. There is an enthesiophyte on the dorso-medial aspect of proximal MT3 and slight sclerosis of the central tarsal bone. Follow up radiographs of this case during a 18 month period showed minimal progression of the changes.*

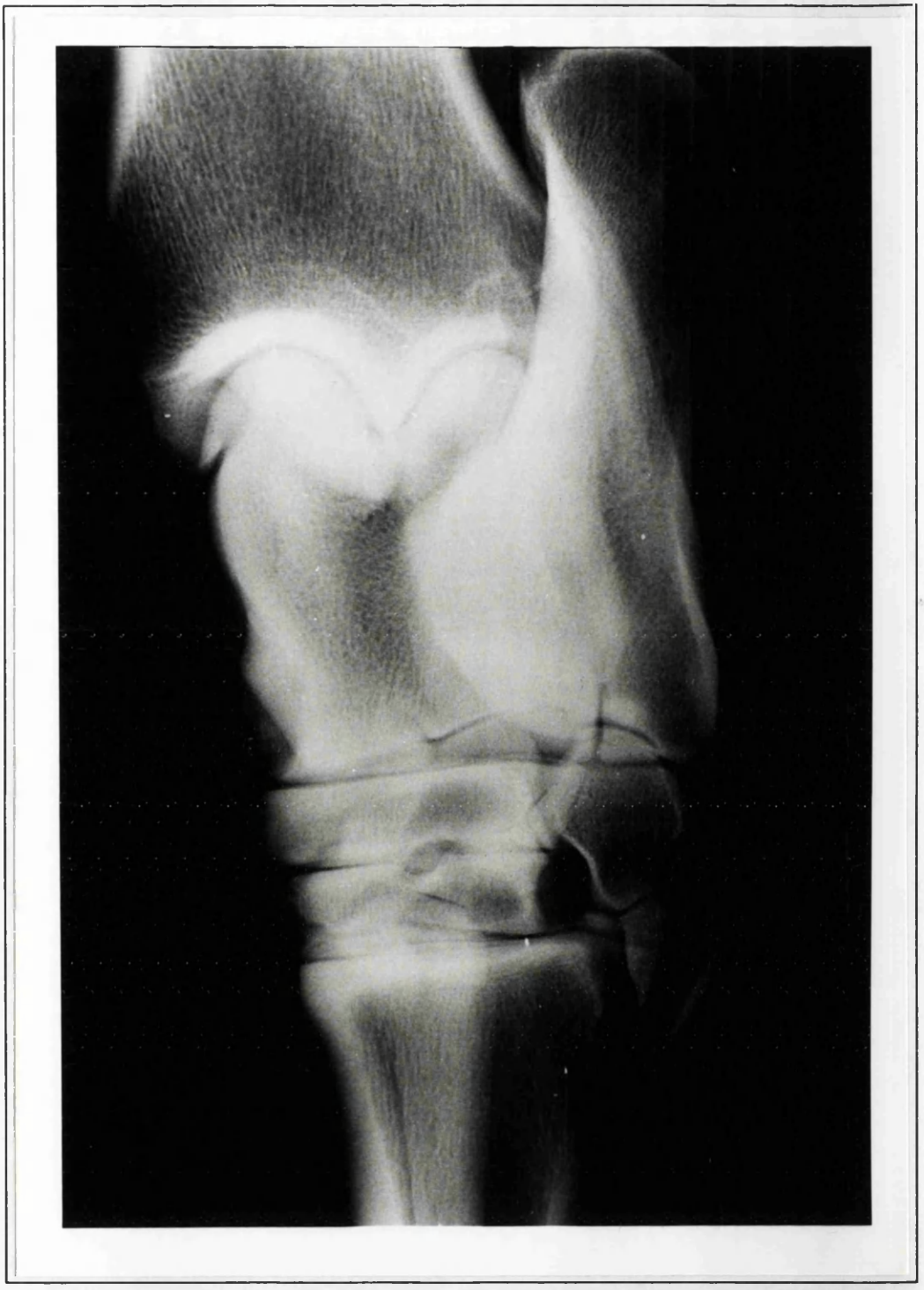


Figure B.5. *DL-PlM O radiographic view of the right tarsus of case no. 5. The radiographic signs are only "doubtful" for the presence of spavin. There is slight bone production on the dorso-medial cortex of the third tarsal bone and a small enthesiophyte on the dorsal aspect of MT3.*

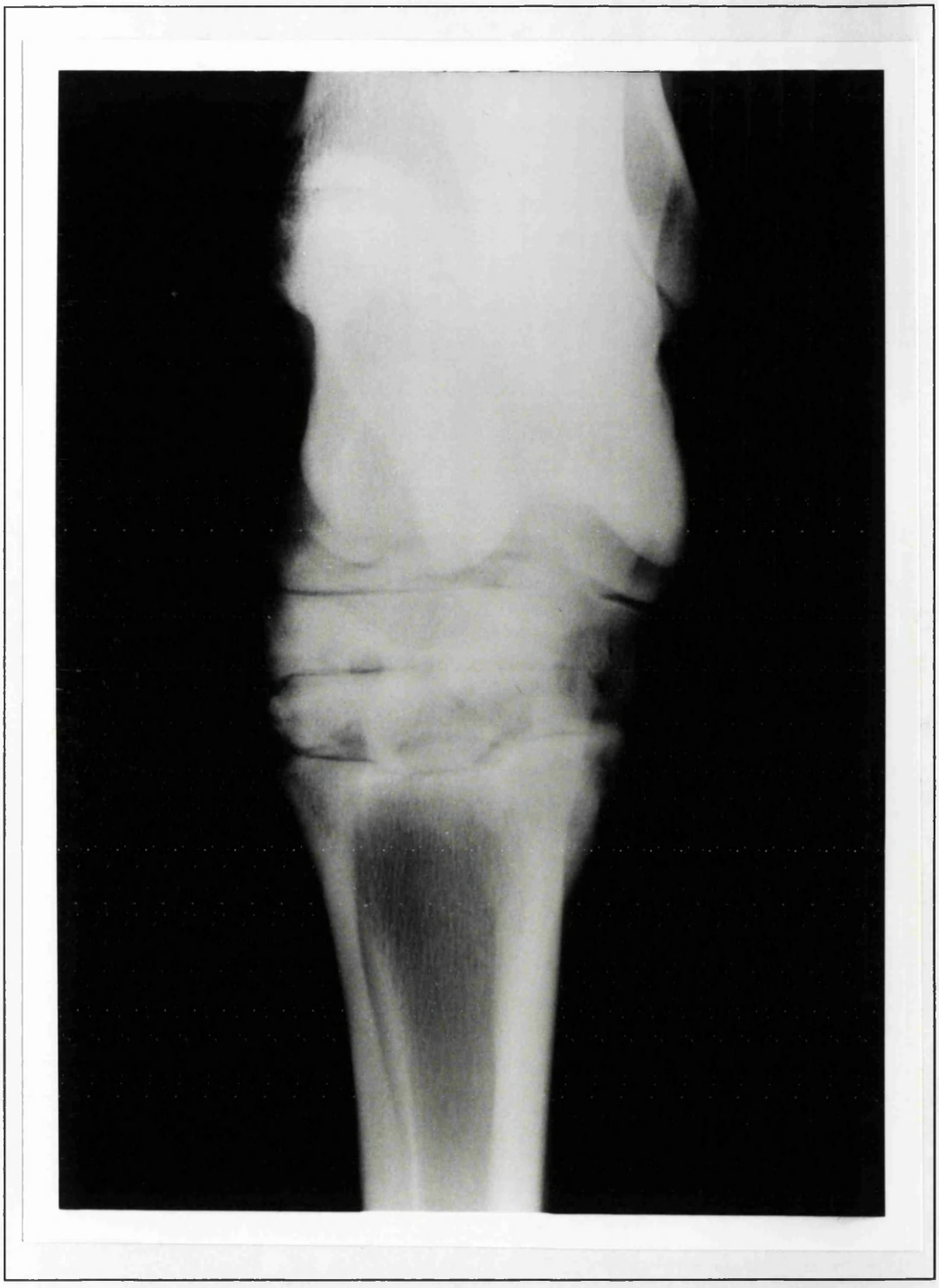


Figure B.6. *Dorso-plantar radiographic view of the left tarsus of case no. 6. The changes were graded as severe. There are subchondral bone irregularities in the DIT joint. There is new bone production on the dorso-medial aspect of the distal tarsal bones, tarsal canal and obliterating the non-articular space between the third and central tarsal bones. There appears to be narrowing of the joint space of the DIT and TMT joints.*

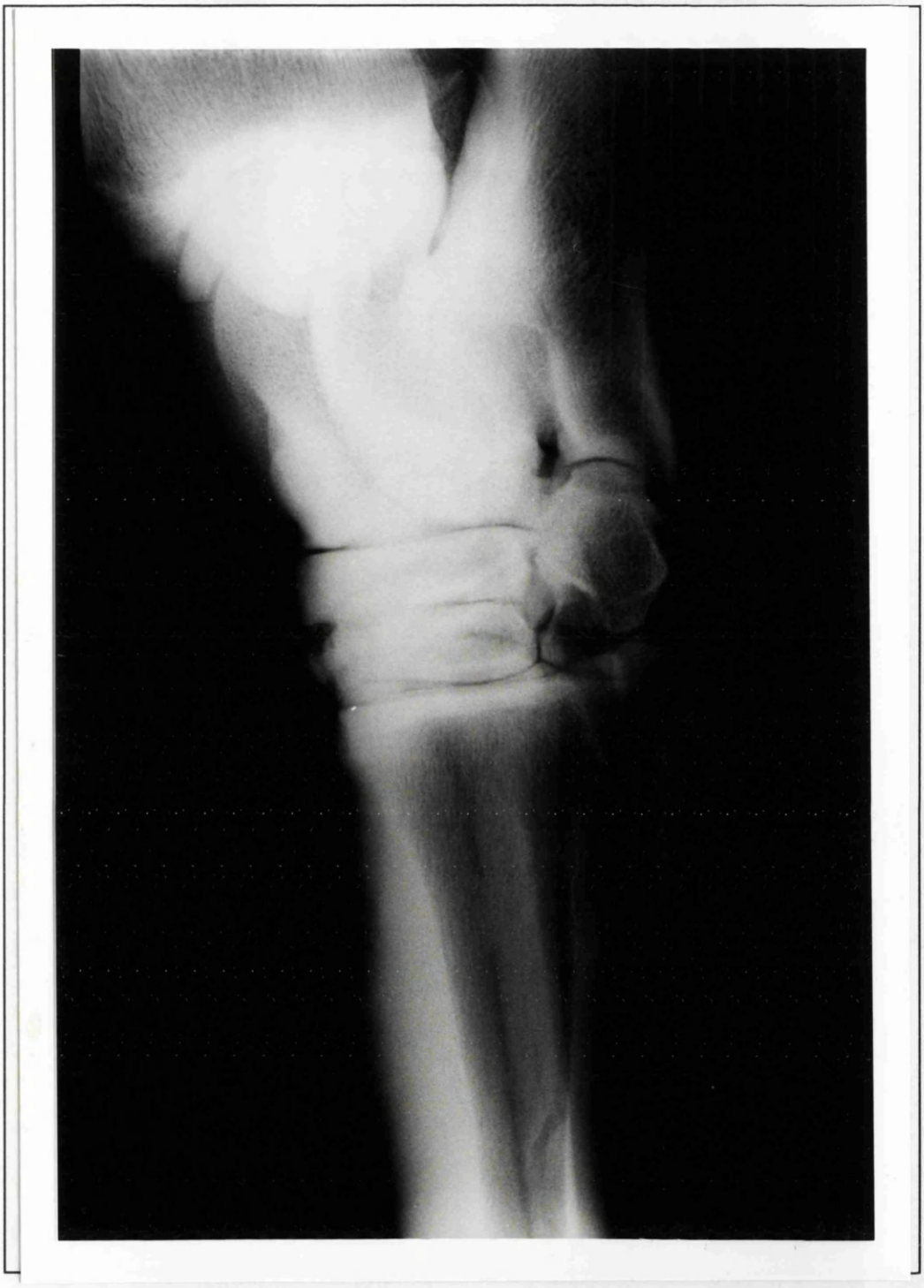


Figure B.7. *DL-PlM O radiographic view of the right tarsus of case no. 7. The changes in these joints were graded as "moderate". There is subchondral bone lysis and possible collapse of the DIT joint space. There are osteophytes on the dorsal aspect of the third tarsal bone and the dorsal aspect of MT3. The TMT joint is less severely affected. There were similar changes in the left hock.*

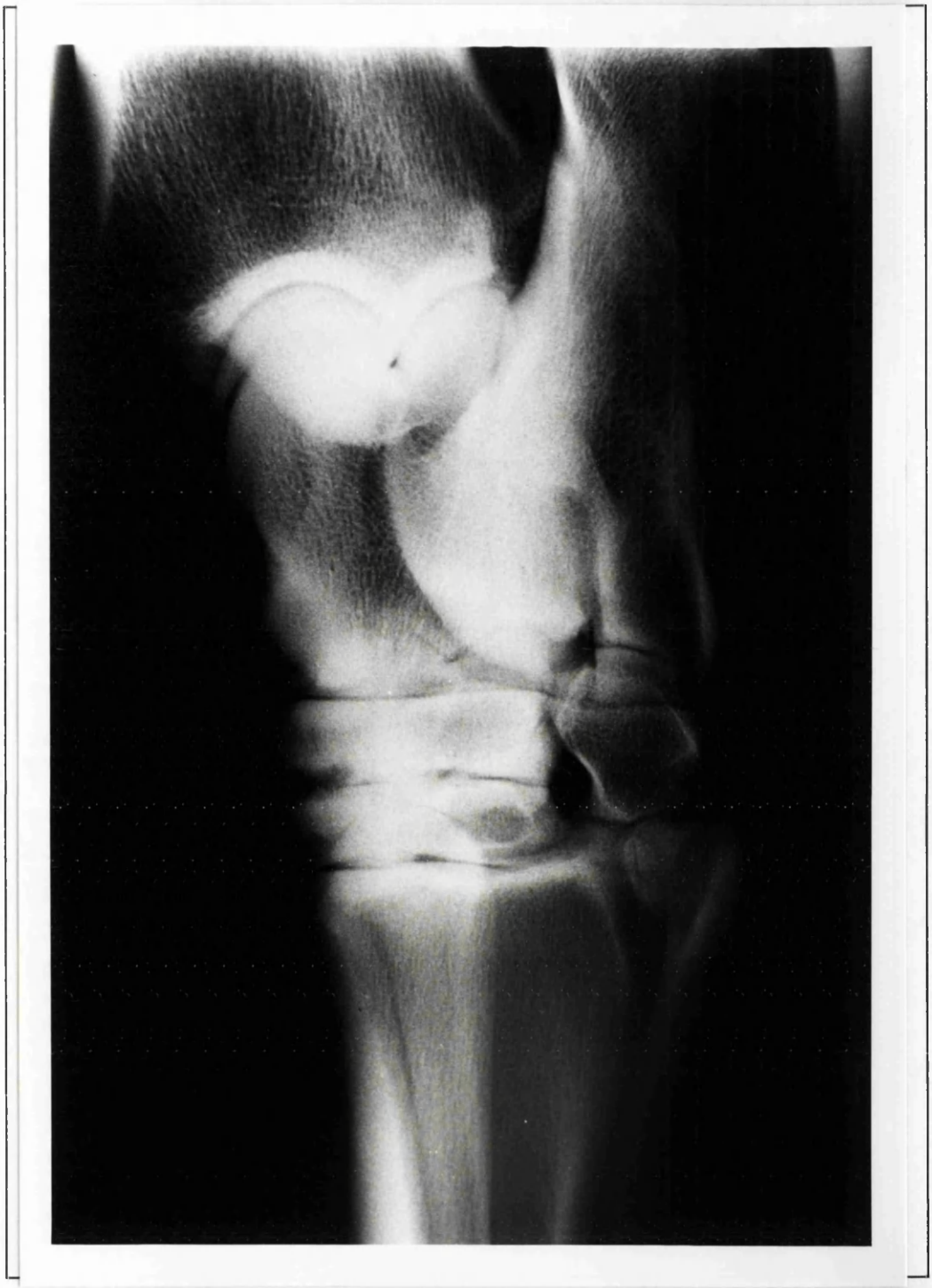


Figure B.8. *DL-PlM O view of the right tarsus of case no. 8. There are large exostoses on the dorso-medial aspects of the central tarsal, third tarsal and Proximal MT3 bones. There is almost complete bridging of the DIT joint, but ankylosis is not occurring due to the extensive subchondral bone destruction. There are early joint margin changes in the PIT joint.*

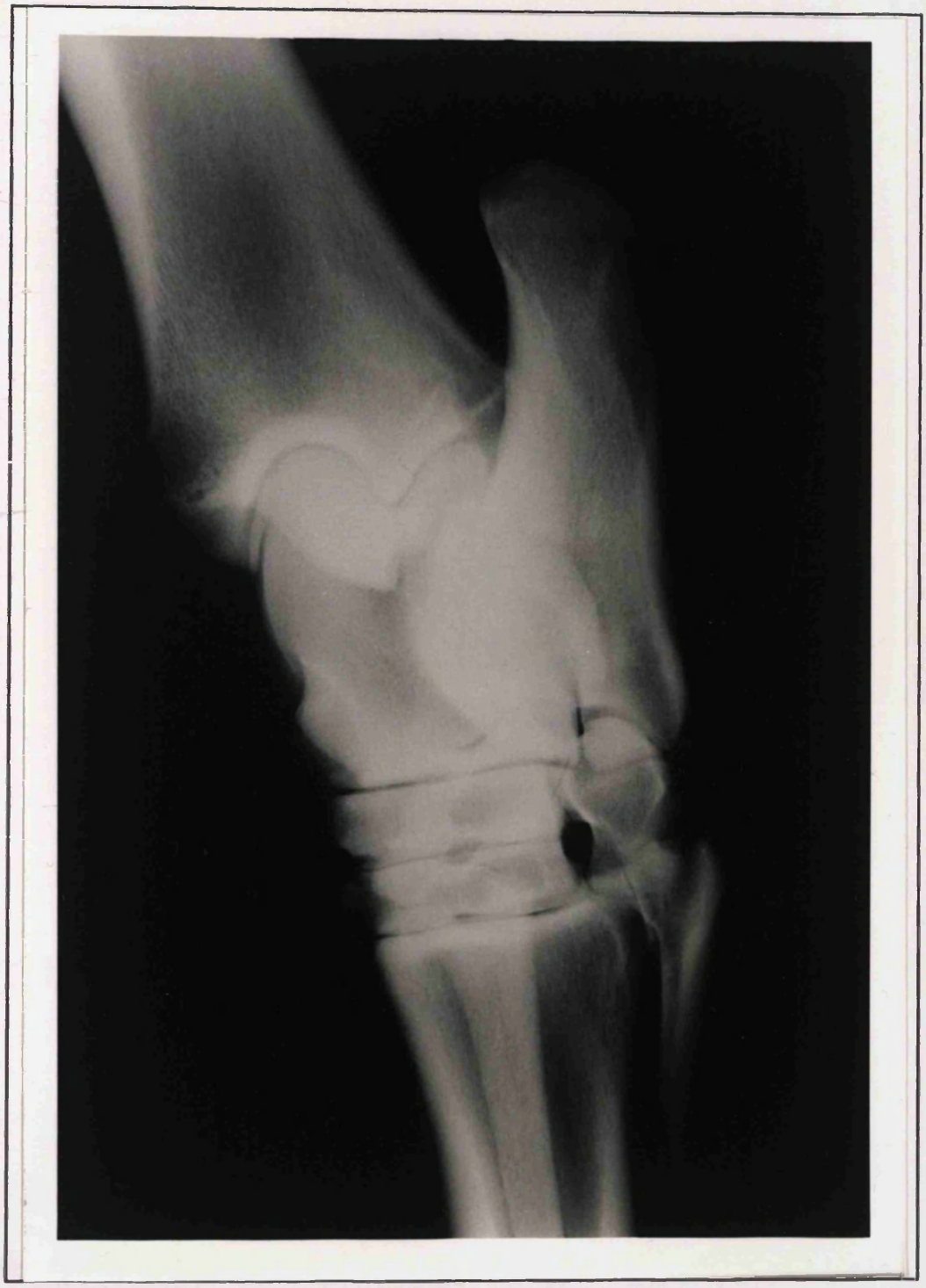


Figure B.9. *DL-PlM O radiograph of the right tarsus of case no. 10. There are small osteophytes on the dorso-medial aspect of the DIT and TMT joints. There is a small area of lysis in the DIT joint margin a mild bone production on the dorsal cortices of the tarsal bones.*

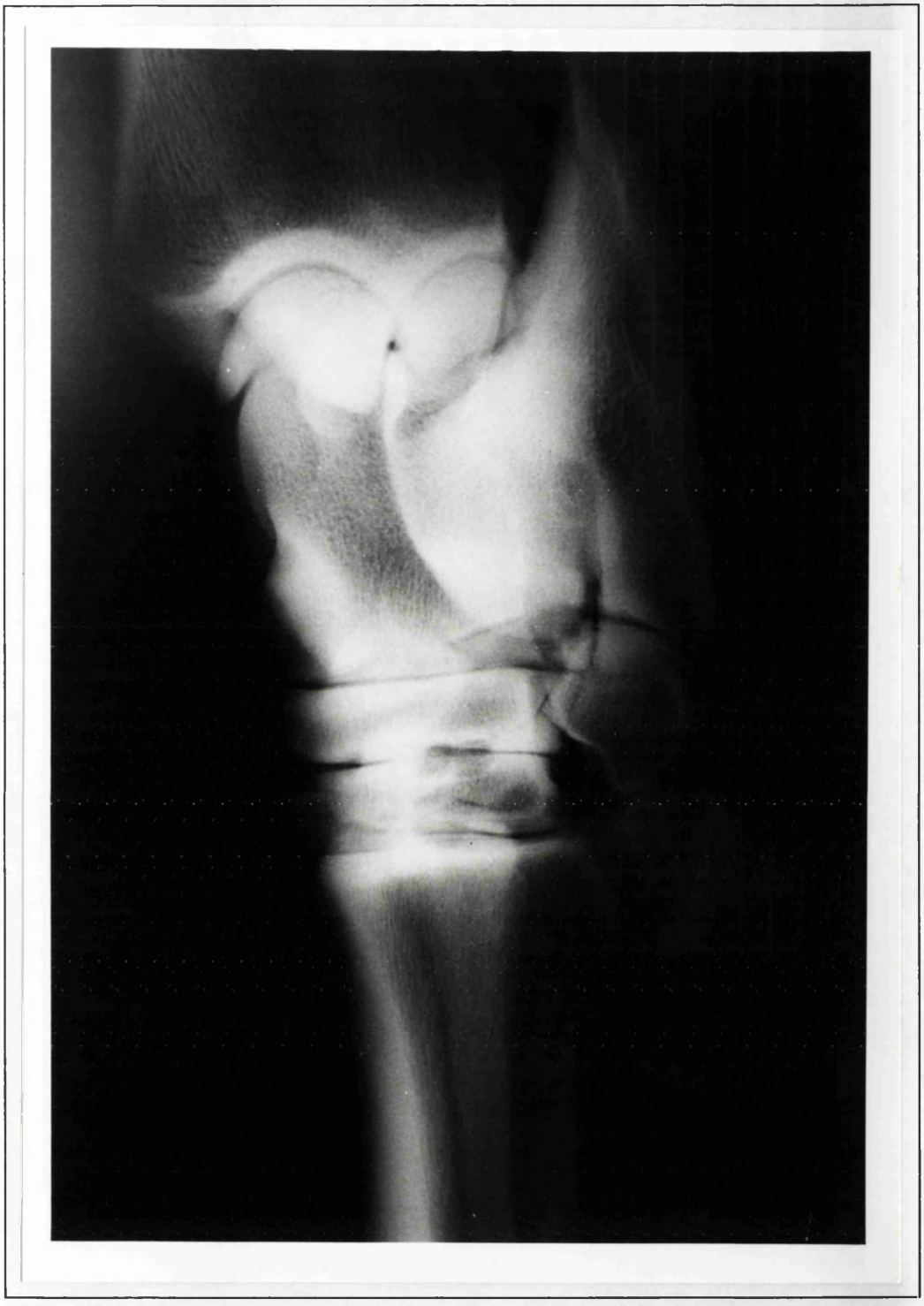


Figure B.10. *DL-PlM O radiographic view of the left tarsus of case no 11. There are hardly any changes indicative of bone spavin. There is a small osteophyte on the proximal aspect of MT3. and slight lipping of the DIT and TMT joints.*

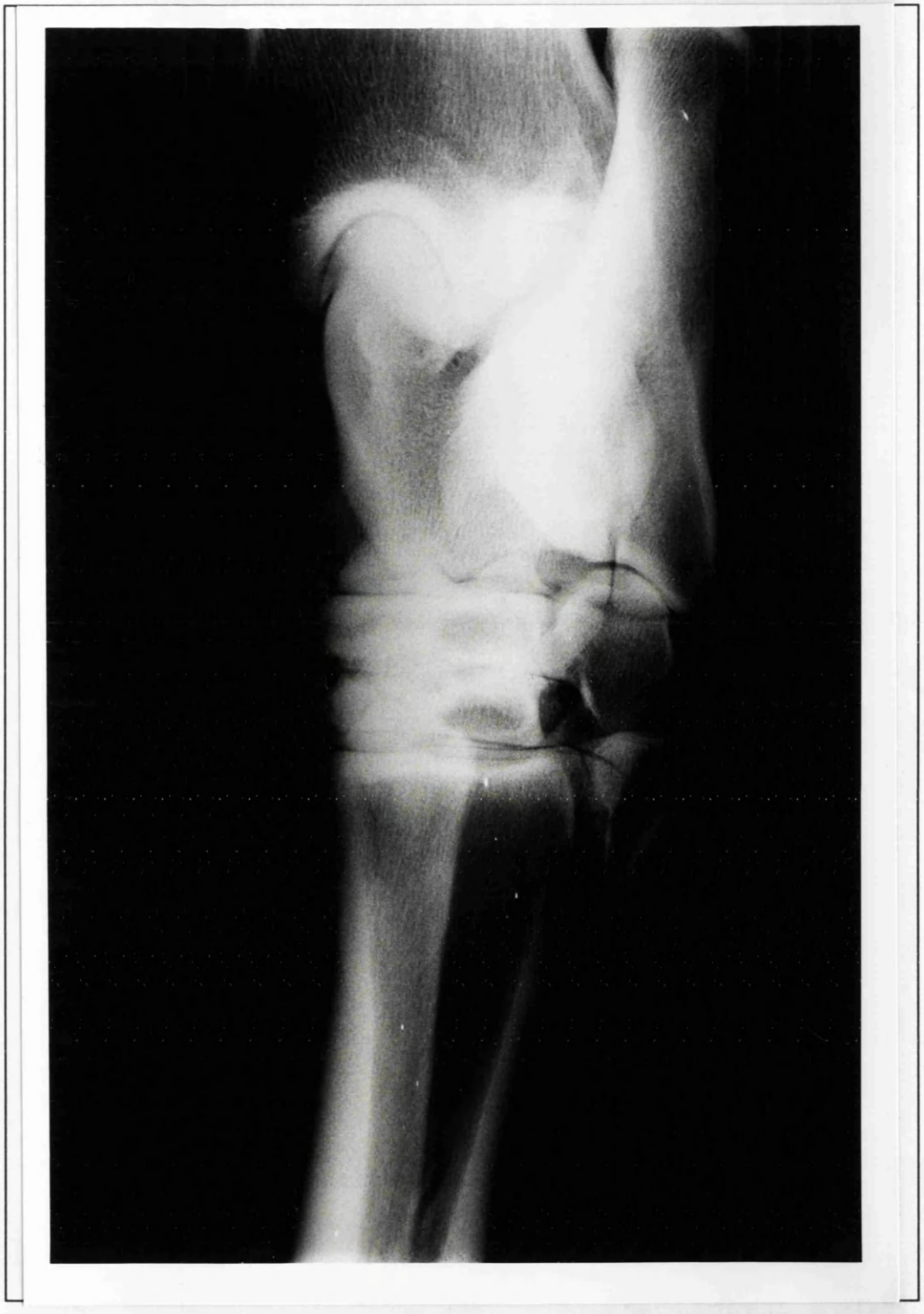


Figure B.11. *DL-PlM O radiographic view of the right tarsus of case no. 12. There is partial ankylosis of the DIT joint and an extensive area of bone lysis. The TMT joint shows irregularities in the subchondral bone plate and slight "lipping". There is also some "lipping" of the PIT joint.*

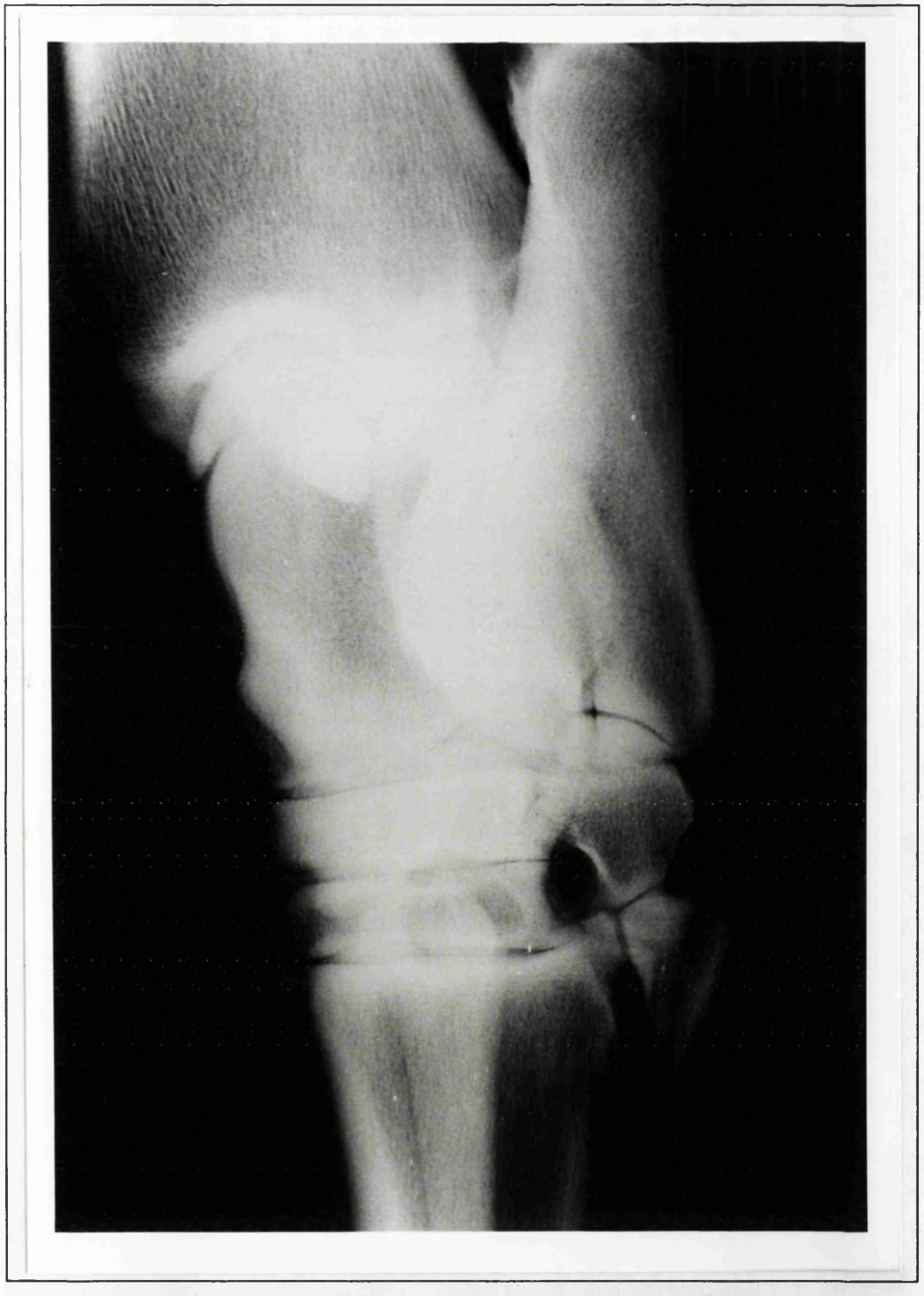


Figure B.12. *DL-PlM O radiographic view of the right tarsus of case no. 13. There is sclerosis of the central tarsal bone and a cystic lesion in the proximal articular surface of the central tarsal bone. Some new bone production can be seen in the non-articular space between the central and third tarsal bones.*

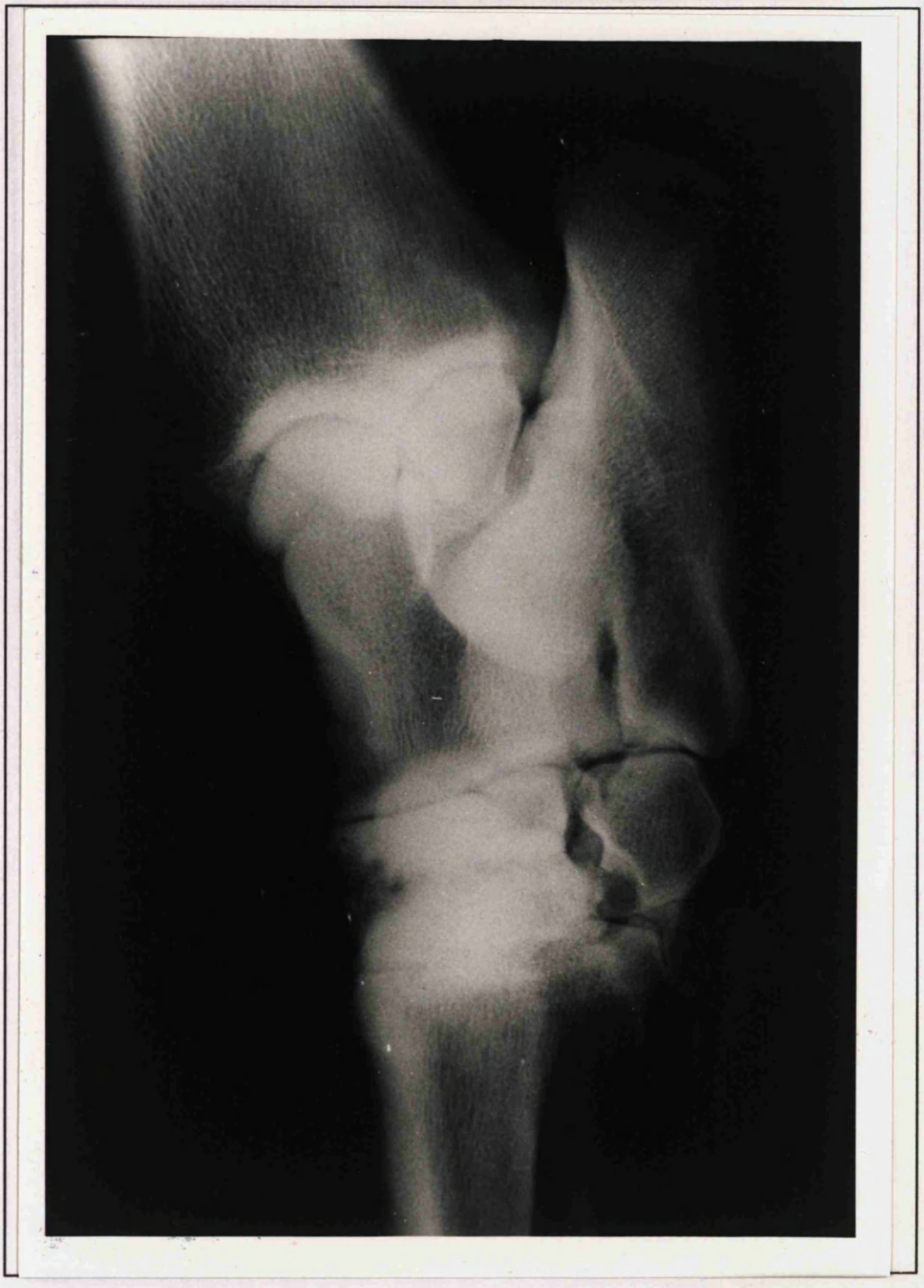


Figure B.13. *DL-PlM O radiograph of the right tarsus of case no. 14. There is apparent ankylosis of the DIT and TMT joints accompanied by an area of bone lysis in the dorso-medial aspect of the DIT joint. There are large exostosis bridging these joints and an extensive area of bone lysis. The PIT joint has an irregular joint margin.*

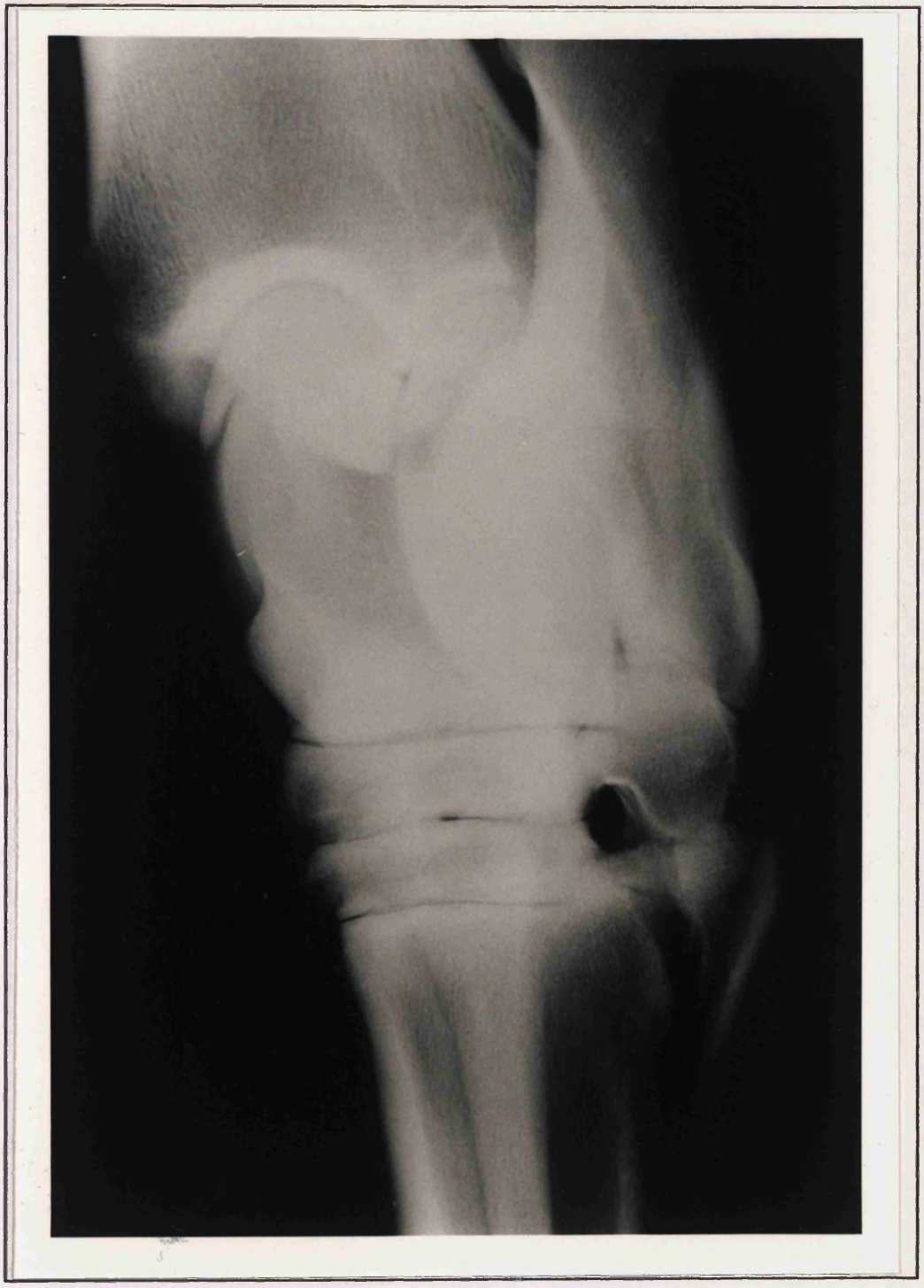


Figure B.14. *DL-PlM O radiographic view of the left tarsus of case no.15. The DIT and TMT joints show irregular joint margins and there is moderate bone production on the dorso-medial aspect of the central and third tarsal bones. The contralateral tarsus showed similar changes.*

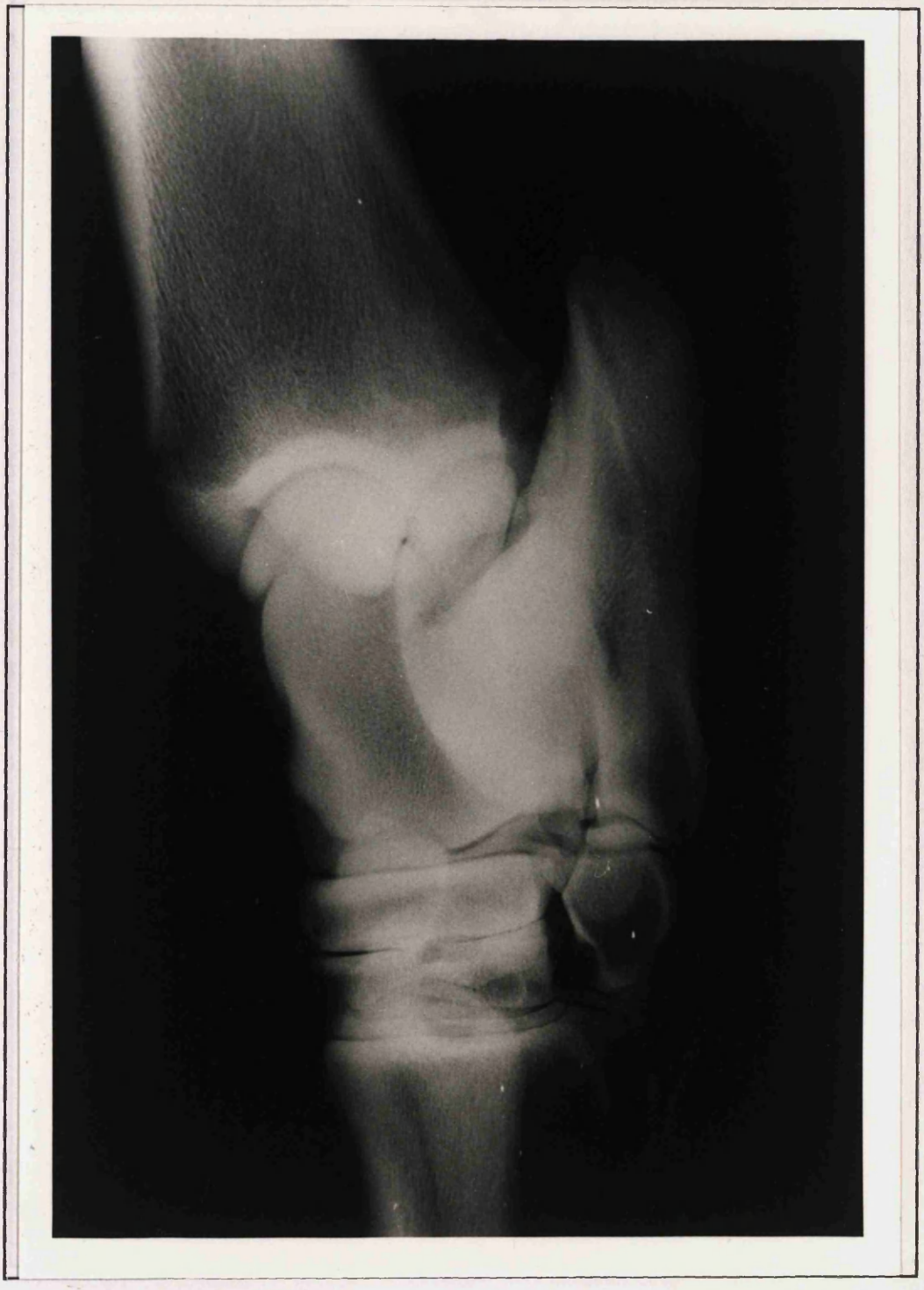


Figure B.15. *DL-PlM O radiographic view of the right tarsus of case no.16. There is a small lucency in the dorso-medial aspect of the distal articular margin of the central tarsal bone. There is slight "lipping" of the DIT and TMT joints.*

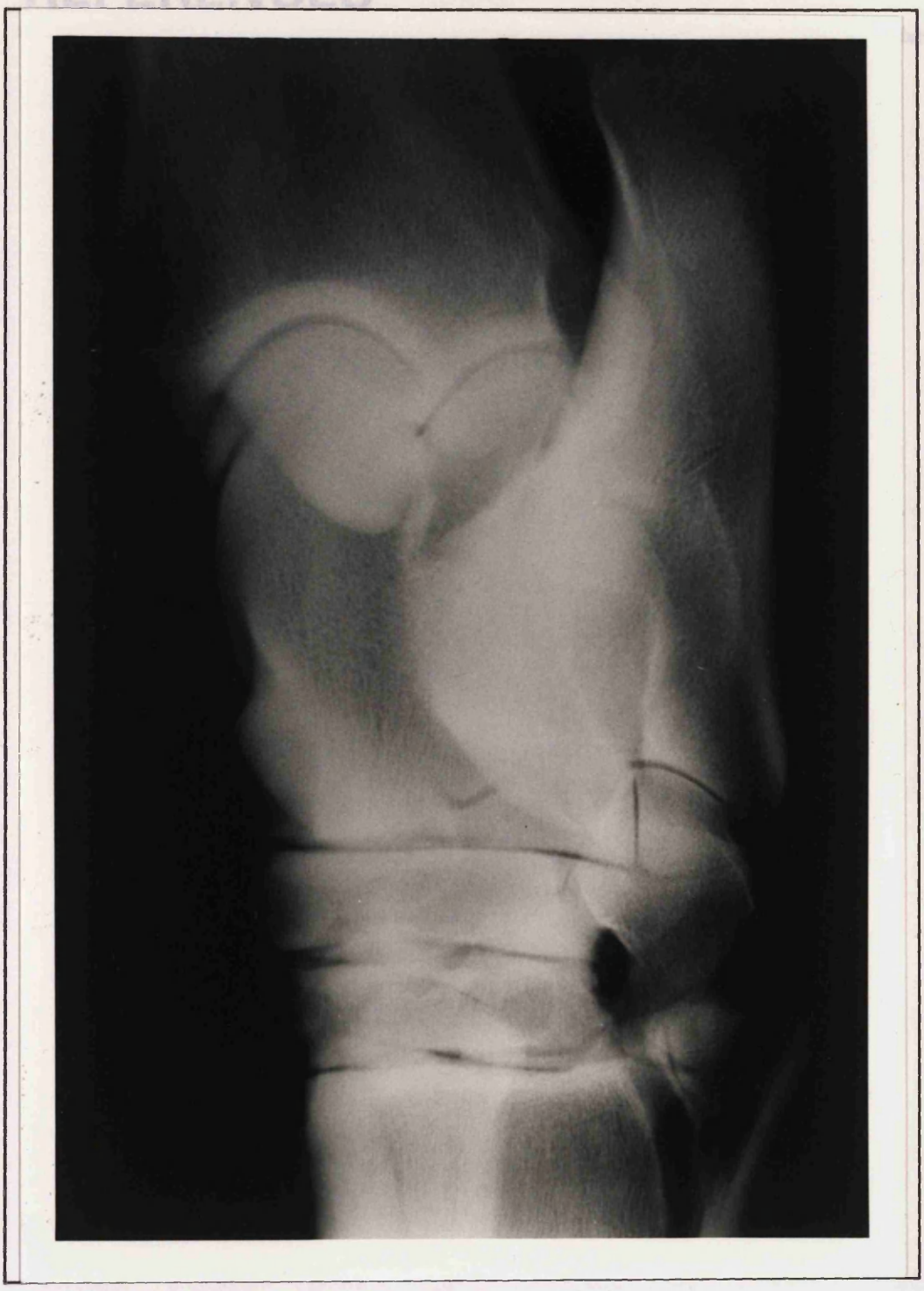


Figure B.16. *DL-PlM O radiographic view of the right tarsus of case no.17. There is a large enthesiophyte on the dorsal aspect of the proximal MT3. There is very mild "lipping" of the other two joints.*

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