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QUANTITATIVE RADIOGRAPHIC INTERPRETATION AND CONSERVATIVE TREATMENT OUTCOME IN HORSES WITH OSTEOARTHRITIS OF THE DISTAL TARSAL JOINTS

by

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ABSTRACT

Various radiographic rating scales (RRSs) for use in horses with distal tarsal joint osteoarthritis (DTJ OA) have been described in the literature but little information is available on their reliability in use. The aim of the first experiment of the study was to develop a RRS based on the consensus of experts in equine diagnostic imaging and orthopaedics, and to test the RRS for reliability. For this purpose 17 experts were invited to participate in an iterative consultation process (Delphi) designed to develop an agreement on the importance of radiographic features, reported to be consistent with DTJ OA. This process was conducted by electronic questionnaire. Rradiographic features for which an agreement was found, were incorporated in the RRS, which used a visual analogue scale. To test the RRS's reliability nine equine surgeons from two academic institutions applied the RRS on two occasions, and a verbal descriptive rating scale, to three sets of tarsal radiographs, each comprising 4 standard radiographic views. Reliability was assessed using Bland-Altman plots and by calculating the 95% agreement limits. ANOVA was used to identify significant interactions between the ratings of different assessors made from different views and on each occasion.
Of 17 invited experts nine participated and completed the consultation process. Seven radiographic features were identified and used in the RRS. Rating of DTJ OA was different for the nine equine surgeons (assessors). The most precise assessor's second ratings were between 16 mm higher and 18 mm lower than the 1st. Significant variables were: "joint", "assessor" and "assessment" (univariable ANOVA); and "joint and assessor" and "assessor and assessment" (multivariable ANOVA). Reliability of the verbal descriptive rating scale was higher than for the RRS. The RRS developed for radiographic interpretation of DTJ OA as a result of the Delphi consultation process was less reliable than the use of a verbal descriptive rating scale. The repeatability of the RRS was not affected by the assessors' professional experience. In conclusion the RRS would not be useful clinically.
Osteoarthritis of the DTJ, affecting the distal intertarsal (DIT) and tarsometatarsal (TMT) joint, is a common cause of hindlimb lameness in horses. Management options include i.a. treatment of the affected joints but only anecdotal information is available on the outcome. The aim of the second experiment of this study was to document short and long term treatment outcome in horses receiving i.a. methylprednisolone acetate (MPA; Depo-MedroneV) or triamcinolone acetonide (TR; Adcortyl) with or without hyaluronic acid (HA; Hyonate) as treatment of DTJ OA.Cases were selected by searching medical records. Inclusion criteria included ≥50% improvement in lameness following i.a. analgesia of the DIT and/or TMT joint and i.a. treatment with TR (+/- HA) or MPA. Change in lameness grade between examinations was tested using a Wilcoxon signed rank test for each horse, and between horses, grouped according to radiographic severity of DTJ OA and treatment, using a Mann Whitney test. Significance was set at $P<0.05$. Long term outcome was assessed using an owner telephone questionnaire. A positive treatment outcome was no lameness with the horse able to perform as intended without NSAID administration.
Horses treated once with i.a. MPA or TR (+/- HA) showed improvement in hindlimb lameness after a median of 56 days ($P<0.000$). No difference was found between the use of MPA and TR ($P=0.81$). In horses treated twice, no further improvement was seen after the first treatment ($P=0.141$). Lameness in horses with diffuse increased radiopharmaceutical uptake (IRU) of the DTJ identified at scintigraphy tended to improve, in contrast to horses with focal IRU (Pfocal = 0.1; Pdiffuse = 0.032). Radiographic severity of OA did not affect outcome. 13/34 horses (38.2%) had a positive and 21/34 (61.8%) a negative long term outcome. It was concluded that intra-articular corticosteroids can be effective in the management of DTJ OA in horses.

AUTHOR'S DECLARATION

I, Raphael Labens, declare that the work in this thesis is original, was carried out solely by myself or with due acknowledgements. It has not been submitted in any form for another degree or professional qualification.

Raphael Labens

Part of this thesis has been accepted for presentation elsewhere:

ABSTRACT

Labens, R.;Voûte, L. and Mellor, D.J. (2006) Intra-articular treatment outcome in 51 horses with distal tarsal joint pain.
Poster presented at the World Veterinary Orthopaedic Congress Keystone, Colorado, USA Feb 25th – March 4th 2006
Abstract submitted for the 2006 BEVA Congress, Birmingham

Labens, R.; Innocent, G. and Voûte, L. (2006) Design and reliability of a quantitative radiographic grading scale for use in horses with bone spavin
Abstract submitted for the 2006 BEVA Congress, Birmingham

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I also want to thank Dr. Giles Innocent and Dr. Dom Mellor for statistical advice, the veterinary experts for their participation in the Delphi consultation process and colleagues at the University of Glasgow and Edinburgh for participating in the reliability study.
Lastly I dedicate this thesis to my father, Georg Labens (1940-1995) and the rest of my family who has to put up with my absence from home.

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LIST OF ABBREVIATIONS

DTJ	Distal tarsal joints
OA	Osteoarthitis
PIT	Proximal intertarsal
DIT	Distal intertarsal
TMT	Tarsometatarsal
DPl	Dorsoplantar
LM	Lateromedial
DL-PlMO	Dorsolateral-plantaromedial oblique
DM-PlLO	Dosomedial-plantarolateral oblique
PlL-DMO	Plantarolateral-dorsomedial oblique
IRU	Increased radiopharmaceutical uptake
MPA	Methylprednisolone acetate
TR	Triamcinolone acetonide
HA	Hyaluronic acid
MIA	Monoiodoacetate
ROI	Region of interest
MNC	Mean number of counts
RRS	Radiographic rating scale
i.a.	intra-articular
ICC	Intraclass correlation coefficient
κ	Kappa
NSAID	Nonsteroidal anti-inflammatory drugs
ANOVA	Analysis of variance

CHAPTER 1
INTRODUCTION

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INTRODUCTION

Horses with osteoarthritis (OA) of the distal tarsal joints (DTJ) represent a significant proportion of the orthopaedic case load at the Weipers Centre for Equine Welfare, the equine hospital unit of the Faculty of Veterinary Medicine, University of Glasgow, and other facilities which manage referred equine orthopaedic cases (Wyn-Jones and May, 1986).

The condition, which may affect the tarsometatarsal (TMT), distal intertarsal (DIT) and occasionally the proximal intertarsal (PIT) joint, is also known as bone spavin. This disease has been a well recognized problem in horses for several centuries, causing hindlimb lameness of variable severity (it was first recorded in the literature around the 13th century (Thomas, 1912)). Despite this, no definitive cause has been determined but various predisposing factors have been identified. OA is considered a degenerative joint disease (DJD) leading to the destruction of the articular surfaces of the DTJ, resulting in peri-articular new bone and osteophyte formation, subchondral bone lysis and spontaneous ankylosis of the DTJ. In severe cases an abnormal shape to the medial aspect of the DTJ may develop due to voluminous peri-articular new bone formation and soft tissue fibrosis (Gough and Munroe, 1998; Baxter *et al.*, 2003b).

Radiography (Butler *et al.*, 2000) and scintigraphy (Murray *et al.*, 2004) are useful diagnostic tools. However, clinical diagnosis of osteoarthritis of the DTJ is based on both abnormal findings on diagnostic imaging and a decrease in lameness following intra-articular analgesia of the affected joints (Dabareiner *et al.*, 2005).

Treatment includes conservative and surgical options. Conservative treatment options typically include a restricted exercise regimen, remedial shoeing, intra-articular and/or systemic administration of anti-inflammatory medication and nutritional supplements. Surgical management comprises techniques promoting ankylosis of the affected synovial compartments, and techniques for decompressing diseased subchondral bone or desensitizing the region of the DTJ (Baxter *et al.*, 2003a).

Irrespective of the treatment option chosen, outcome is often unpredictable and management of the disease may not result in an animal fit for its intended use (Gough and Munroe, 1998).

Information on surgical treatment outcome can be readily found in the veterinary literature (Baxter *et al.*, 2003a), but evidence on outcome for intra-articular medication of the DTJ is sparse and poor quality.

There is evidence that treatment outcome is associated with the presence of certain radiographic abnormalities (Barneveld, 1983b; Dyson, 2004). However, detection and quantification of radiographic abnormalities is an inexact science and although rating scales have been used in veterinary research to increase the objectivity of radiographic interpretation, information about their reliability is often lacking (Barneveld, 1983b; Burtscher, 1994; Dechant *et al.*, 2003). The author has experience using the quantitative radiographic rating scale described by Burtscher (1994) but has concerns about its reliability (Labens, 2005).

This thesis describes a study of the radiographic interpretation of osteoarthritic changes of the DTJ in horses. The aims of the study were to develop a quantitative radiographic rating scale and to investigate its reliability when applied in clinical cases. A qualitative research method, specifically the Delphi consultation process, was used in the development of the rating scale (Jones and Hunter, 1995). This method, based on developing agreement between experts in equine diagnostic imaging and orthopaedics, enabled radiographic features of high diagnostic value for DTJ OA to be identified for inclusion in a rating scale. In a second study, a retrospective investigation of treatment outcome following the intra-articular administration of corticosteroids in 51 horses with DTJ OA was carried out. Here, the aims were to report short and long term treatment outcome and to determine whether there was an association between the findings of radiographic or nuclear scintigraphic examination and outcome.

CHAPTER 2

ANATOMY

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ANATOMY

The distal tarsal joints consist of the proximal (PIT), distal intertarsal (DIT) and tarsometatarsal (TMT) joint. In contrast to the tarsocrural joint, which forms the 4th major articulation of the tarsus, the DIT, TMT and PIT joints are low motion joints allowing only minimal movement (Wissdorf *et al.*, 1998).

The PIT joint (*Art. talocalcaneocentralis et calcaneoquartalis*) is formed by the talus, calcaneus, central tarsal bone and 4th tarsal bone. The DIT joint (*Art. centrodistalis*) is formed by the central tarsal bone, 3rd tarsal bone and fused 1st and 2nd tarsal bone. Towards the plantar aspect of the tarsus the DIT joint is supported by the 4th tarsal bone.
The TMT joint (*Artt. tarsometatarseae*) consists of the articular surfaces of the fused 1st and 2nd, the 3rd and 4th tarsal bones, and the 2nd , 3rd and 4th metatarsi **(Figures 2.1, 2.2, 2.4,** and **2.5)** .
Strong medial and lateral collateral ligaments, consisting of long and short components, are found at the medial and lateral aspect of the DTJ. These ligaments together with the capsular attachments of the DTJ, the dorsal, plantar and tarsal interosseous ligaments, and the tarsometatarsal ligaments confer the rigidity on the distal tarsal joints. Osseous spurs commonly identified in lateromedial radiographic projections at the proximal aspect of the third metatarsus may represent entheseophyte formation at the insertion of the dorsal tarsal ligament or fibularis tertius tendon (Wissdorf *et al.*, 1998).

The laterodistal talocalcaneal joint, which forms the articulation between the talus and calcaneus together with three other synovial compartments (*Art. talocalcanea plantaroproximalis, plantarointermedialis and plantaromedialis*), communicates with the PIT joint (Wissdorf *et al.*, 1998). Osteoarthritis of the talocalcaneal joint has recently been reported in a case series of 18 horses (Smith *et al.*, 2005). In ten of the cases OA of the DIT joint was diagnosed concurrently (Smith *et al.*, 2005).

The frequency of the anatomical communication between the TMT and DIT joint is variable, ranging from 18 to 100% of horses (described in Chapter 3) (Barneveld, 1983b; Friker *et al.*, 2000).

The medial branch of the tendon of the tibialis cranialis muscle (cunean tendon) is closely associated with the medial aspect of the distal tarsal joints. The cunean tendon overlays the cunean bursa and inserts at the fused 1st and 2nd tarsal bone, and also at the proximal end of the 2nd metatarsal bone in a small number of horses (Burtscher, 1994). The bursa may span from the proximal metatarsus to the level of the medial tubercle of the talus **(Figures 2.6.1** and **2.6.2)** (Burtscher 1994).

Intra-articular analgesia of the DIT joint is most easily performed at the medial aspect of the DTJ, where the 3rd tarsal bone, central tarsal bone and fused 1st and 2nd tarsal bone converge, with the horse weight bearing. The needle is introduced in a medial to lateral orientation.
Injection of the TMT joint is performed at the palpable depression between the 4th tarsal and 4th metatarsal bone, with the needle introduced in a proximo-distomedial orientation (Bassage and Ross, 2003).

Figures 2.1, 2.2, 2.4 and **2.5** show four images of the tarsal skeleton to illustrate the normal anatomy. These images correspond to the four standard radiographic projections (DPl, LM, DL-PlMO, DM-PlLO) frequently obtained in horses for the radiographic diagnosis of DTJ OA. A bony specimen from a horse with DTJ OA, showing ankylosis of the DIT joint, is displayed in **Figure 2.3.**

Dissections of the cunean tendon and the medial aspect of the DTJ in a cadaver specimen are shown in **Figures 2.7** and **2.8.**

Figure 2.1: Lateral view of the tarsus

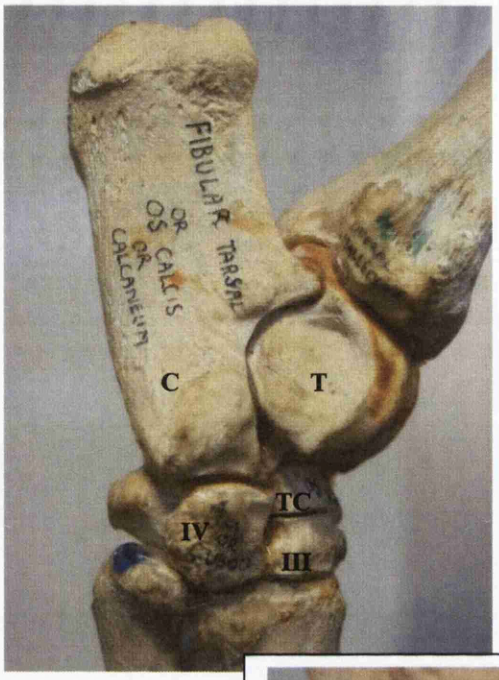


Figure 2.2: Dorsolateral view of the tarsus

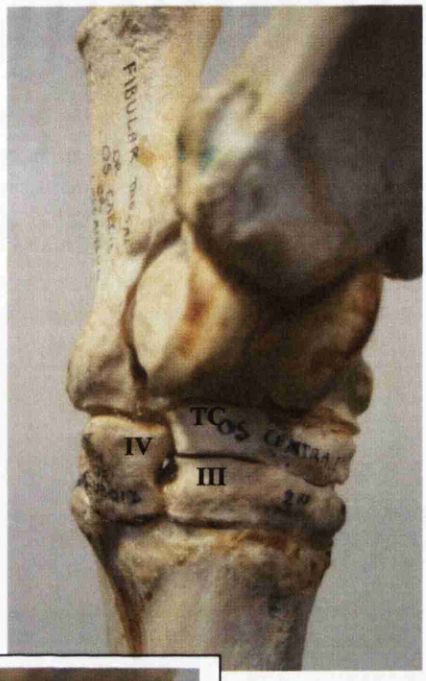
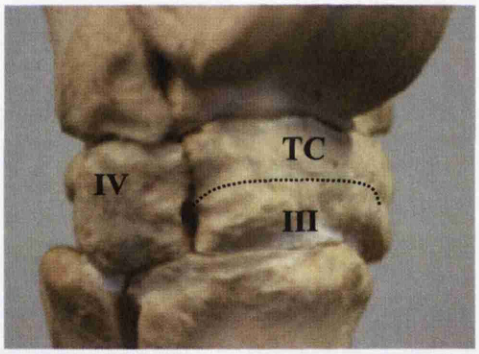
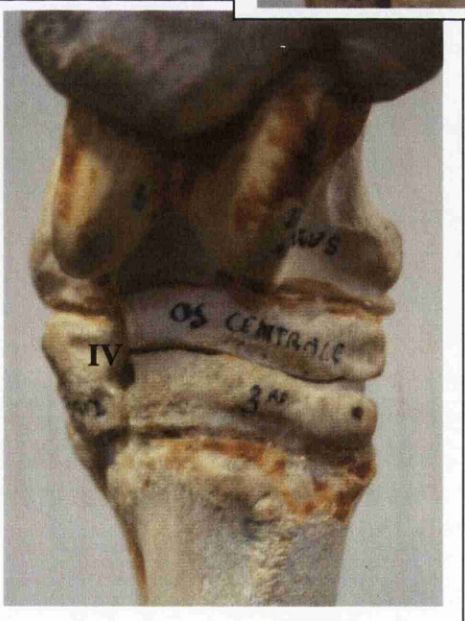


Figure 2.3: Dorsolateral view of the tarsus



Horse with DTJ OA and ankylosis of the DIT joint (---) level of DIT joint



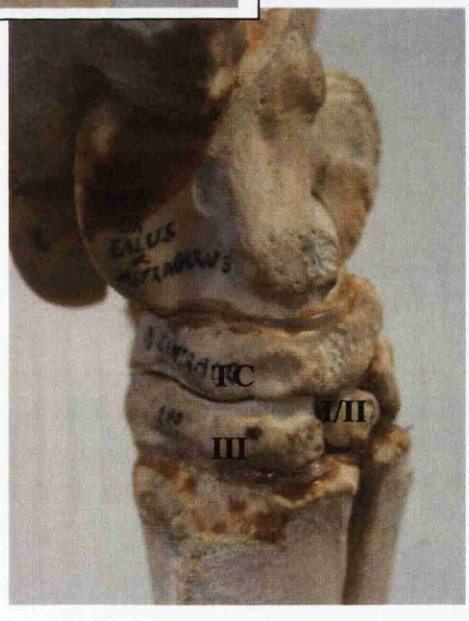
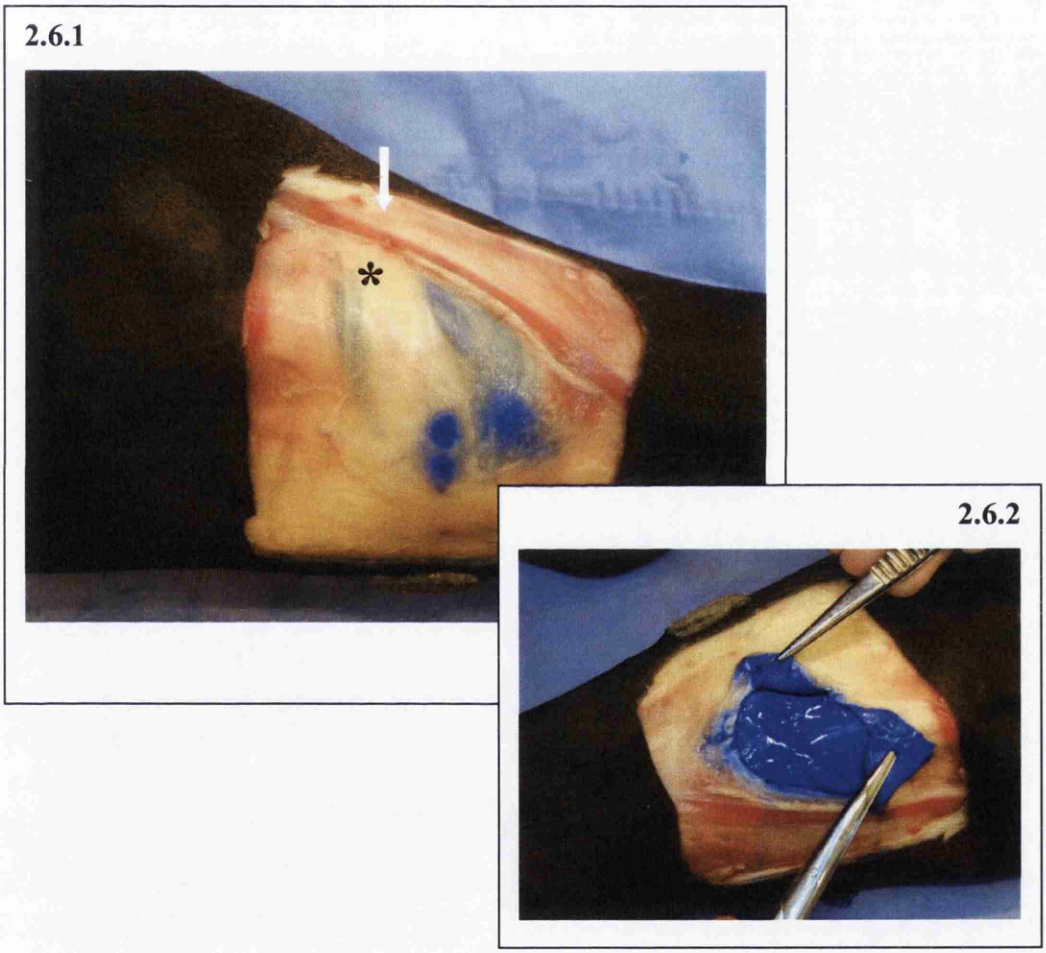


Figure 2.4: Dorsal view of the tarsus **Figure 2.5:** Dorsomedial view of the tarsus

III=3rd tarsal bone, IV=4th tarsal bone; TC=central tarsal bone; C=calcaneus; T=talus; I/II=fused 1st and 2nd tarsal bone

Figure 2.6.1: Medial aspect of the DTJ showing the cunean bursa (in blue following injection with dye), the cunean tendon (*) and the saphenous vein (arrow)

Figure 2.6.2: The bursa has been exposed by tenotomy of the cunean tendon and then opened.



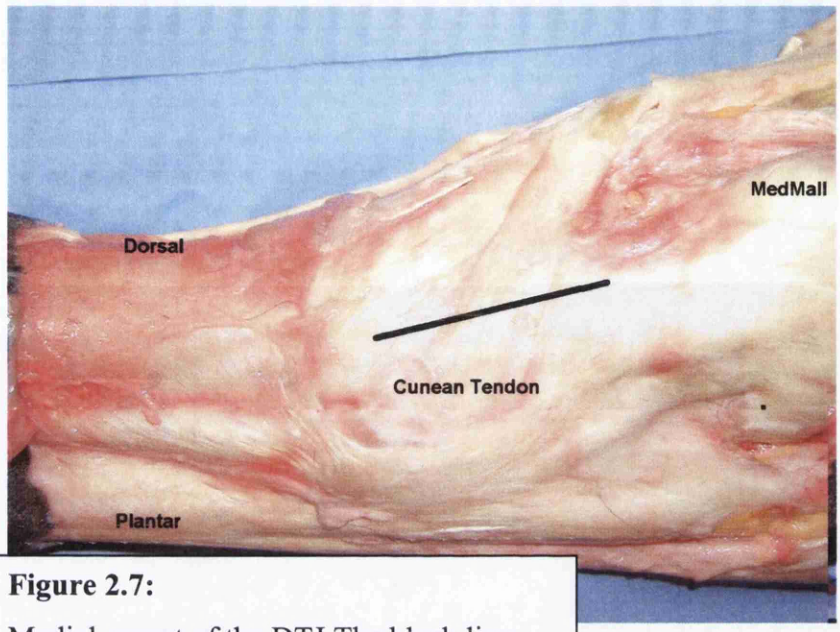


Figure 2.7:
Medial aspect of the DTJ.The black line indicates the approximate proximal to distal extent of the cunean bursa.

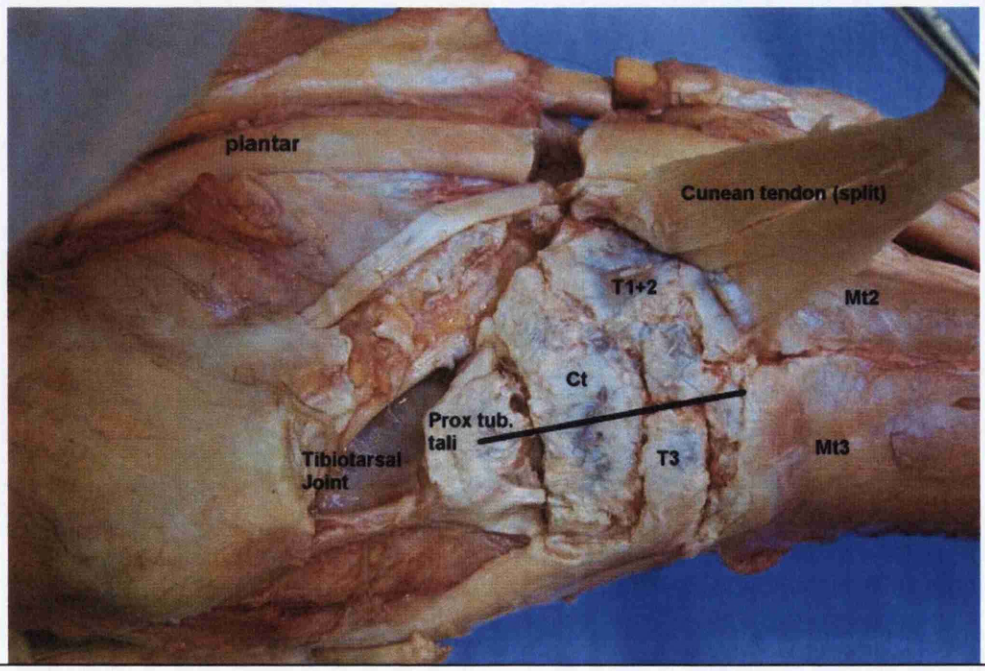


Figure 2.8: Medial aspect of the DTJ after the cunean tendon was elevated, the cunean bursa and collateral ligaments were resected and arthrotomy of the PIT, DIT and TMT joint was performed. The black line indicates the proximal to distal extent of the cunean bursa (Ct=central tarsal bone; T1+2=Fused 1st and 2nd tarsal bone, T3=third tarsal bone)

CHAPTER 3
LITERATURE REVIEW

CHAPTER 3:
LITERATURE REVIEW

3.1. Introduction

Osteoarthritis (OA) of the distal tarsal joints (DTJ) has been a commonly recognized cause of hindlimb lameness in horses since the 13th century when "spavanus" was first mentioned in the literature (Thomas, 1912). Spavanus is a Greek term meaning "cramp" or "pull" and forms the basis of the disease's name in many languages: "spavin" in English, "spat" in German and Dutch; "spavenio" in Italian; "éparvin" in French; "esparavan" in Spanish; and "spatt" in Swedish (Barneveld, 1983b). It has also been claimed that spavanus is a Latin word, derived from the old German word "sparve" ("sparrow") which is used colloquially to refer to a round swelling (Silbersiepe *et al.*, 1986). Bones of Icelandic horses found in heathen graves in Iceland and dated around the 8th or 9th century showed evidence of DTJ OA, suggesting that bone spavin has also been a longstanding problem in Icelandic horses (Bjornsdottir *et al.*, 2004b).

Baxter *et al.* (2003b) suggested that the syndrome of DTJ OA encompasses three separate clinical pathologies. "Tarsitis", a frequent cause of lameness in Standardbred horses, localized to the periarticular soft tissue structures of the distal tarsus (Gabel, 1983), "juvenile DTJ OA", which develops in young horses and may be caused by developmental abnormalities of the small tarsal bones (Bohanon, 1998), and adult-onset distal tarsal OA, developing subsequently to chronic repetitive trauma and conformational abnormalities (Barneveld, 1983b).

The most important recent work regarding DTJ OA was produced by Professor Barneveld (1983b), which culminated in the submission of a PhD thesis in 1983, and a group of Swedish and Icelandic researchers, resulting in many research papers on DTJ OA in Icelandic horses (Axelsson *et al.*, 1998; Eksell *et al.*, 1998; Bjornsdottir *et al.*, 2000a; Bjornsdottir *et al.*, 2000b; Axelsson *et al.*, 2001; Bjornsdottir *et al.*, 2003; Bjornsdottir *et al.*, 2004a).

3.2. Aetiology/Epidemiology

"Tarsitis" and "adult onset DTJ OA" are thought to be caused by repetitive trauma to the DTJ. The trauma takes the form of shear and torsional forces and is predisposed to by abnormal conformation, most commonly in the form of sickle hocks (Gabel, 1983; Barneveld, 1983b; Eksell *et al.*, 1998; Gough and Munroe, 1998; Axelsson *et al.*, 2001; Baxter *et al.*, 2003b). In a study by Eksell *et al.* (1998), horses with sickle hocks had a 42% prevalence of radiographic evidence of DTJ OA that was significantly higher than for horses with straight (20%) or normal (19%) hindlimb conformation.
Barneveld (1983b) presented evidence that horses were at greater risk of developing DTJ OA if they showed a gait abnormality that he referred to as "billarderen" (at the time of foot placement and the beginning of the stance phase the calcaneus moves laterally)

In Dutch Warmblood horses and Icelandic horses hereditary influences have been shown to play an important role in the expression of the disease (Barneveld, 1983b; Bjornsdottir *et al.*, 2000a; Axelsson *et al.*, 2001; Barneveld, 2004). This may also explain why hereditary traits such as conformational abnormalities appear to affect the prevalence of DTJ OA. Twenty three percent of 379 Icelandic horses in Sweden (Eksell *et al.*, 1998) and 30% of 614 Icelandic horses in Iceland (Bjornsdottir *et al.*, 2000b) had radiographic evidence of DTJ OA. In contrast only four percent of 402 three year old German Warmblood mares showed radiographic evidence of DTJ OA (Willms *et al.*, 1996).

Although osteochondrosis has been incriminated as the cause of juvenile DTJ OA (Watrous *et al.*, 1991; Bohanon, 1998), this is controversial (Barneveld and van Weeren, 1999). Early osteoarthritic changes have been described as cartilage fibrillation and chondronecrosis affecting lateral and medial aspects of the DIT joint (Barneveld, 1983b; Laverty *et al.*, 1991; Bjornsdottir *et al.*, 2004a). As evidence of classical osteochondrosis lesions is lacking (Barneveld and van Weeren, 1999) it may be that these early changes have been erroneously interpreted as signs of osteochondrosis (Watrous *et al.*, 1991). In Barneveld and van Weeren's study (1999) different exercise regimens had no effect on the development of articular surface lesions in the TMT or DIT joint of Dutch Warmblood foals. The effect of exercise on the development of DTJ OA was also investigated in Icelandic horses and again no evidence was found for an effect of training intensity on the development of lesions (Axelsson *et al.*, 2001). Based on the recognition of histological findings consistent with early DTJ OA in young Icelandic horses, Bjornsdottir *et al.*

(2004a) similarly concluded that the expression of the disease is unlikely to correlate with the initiation of ridden exercise.

Tarsitis has been incriminated as representing an early stage of DTJ OA when no radiographic changes have yet developed but inflammation of the periarticular soft tissues on the medial aspect of the DTJ causes pain and hindlimb lameness (Bogner *et al.*, 1998). In this respect, Bogner *et al.* (1998) have shown an association between radiological findings consistent with DTJ OA and histopathological findings consistent with chronic inflammation of the cunean bursa. However, the cunean tendon and its insertion site were unaffected, which was similar to Burtscher's observations (1994).
Gabel has described the clinical presentation of horses with tarsitis extensively and from his publications it can be concluded that tarsitis is different to DTJ OA, and therefore should be regarded as a separate condition (Gabel, 1979a/b, 1983).

3.3. Clinical signs

Horses presenting with DTJ OA have been reported to be below 10 years of age (Barneveld, 1983b; Driesang and Boehm, 1993; Burtscher, 1994). In Icelandic horses a significant association between the horses' age and the prevalence of DTJ OA has been identified: the older the horses are, the more likely radiographic evidence of DTJ OA is identified (Eksell *et al.*, 1998; Axelsson *et al.*, 2001). Gough *et al.* (1998) commented that in their experience bone spavin was more commonly recognized in the middle aged to old horse. Discrepancies between the reported ages of horses with DTJ OA may however, be caused by different proportions of juvenile DTJ OA in the study groups.

Osteoarthritis of the DTJ more commonly affects both hindlimbs than a single limb (Barneveld, 1983b; Bjornsdottir *et al.*, 2000b; Baxter *et al.*, 2003b) and horses diagnosed with DTJ OA may suffer from concurrent back problems. An abnormal gait, characterized by the leg swinging medially during the cranial phase of the stride and the foot landing laterally in a stabbing motion may be seen in horses with DTJ OA (Platt, 1997; Gough and Munroe, 1998). However, in an experimental study creating DTJ pain by injection of *E.coli* endotoxin in the DIT and TMT joint and performing kinematic gait analysis pre- and post-injection, no specific gait abnormalities were detected (Kramer *et al.*, 2000), as described by Platt (1997) and Gough *et al.* (1998) in horses with DTJ OA. Only nonspecific characteristics of hindlimb lameness, such as asymmetric tuber coxae

extension, and decreased limb protraction were identified during the study (Kramer *et al.*, 2000).

In advanced cases of DTJ OA an abnormal shape to the medial aspect of the DTJ may be identified, which is formed by fibrotic and thickened periarticular soft tissues (Platt, 1997; Axelsson *et al.*, 1998; Gough and Munroe, 1998; Baxter *et al.*, 2003b).

3.4. Diagnostic Tools

3.4.1. Flexion tests (Spavin test)

Although horses with DTJ OA may show an increase in lameness following proximal hindlimb flexion, this response is not specific for DTJ OA (Platt, 1997; Gough and Munroe, 1998; Baxter *et al.*, 2003b). Barneveld (1983b) highlighted the unreliability of flexion tests for localization of lameness. In his study the response to distal limb flexion was similar to proximal limb flexion in 36% horses with DTJ OA, and greater in 23% of horses.

In a population of 379 Icelandic horses in Sweden flexion tests were positive in 25% of the cases while 23% had radiographic evidence of DTJ OA (Axelsson *et al.*, 1998). These authors identified a significant relationship between palpable abnormalities at the medial distal tarsus, positive proximal limb flexion, lameness and radiographic signs consistent with DTJ OA. In horses with a positive response to proximal limb flexion, 45% were affected with bone spavin, whereas in the horses with no response, 86% had no radiographic evidence of DTJ OA. In an epidemiological survey including 614 Icelandic horses Bjornsdottir *et al.* (2000b) found 32.4% of the horses to be lame following proximal limb flexion, but only 6.7% of these horses had exhibited lameness prior to flexion. Horses with radiographic evidence of DTJ OA were four times more likely to be lame following flexion of the proximal limb.

On the basis of the above studies, Icelandic horses are more likely to be lame following proximal limb flexion if they have radiographic evidence of DTJ OA. However, horses without baseline lameness may show a positive response to limb flexion suggesting that this test can not predict lameness. It is conceivable that these observations are valid for other breeds as well as Icelandic horses.

Barneveld (1983b) investigated if the radiographic features of DTJ OA were associated with the response to hindlimb flexion but found no evidence for this.

While uncommon in Europe, a Churchill test is routinely performed in North America for diagnosis of DTJ OA. The aim of the test is to provoke pain/lameness by applying pressure over the medial aspect of the DTJ (Baxter *et al.*, 2003b). While clinical findings suggest this test to be useful for diagnosis of DTJ OA (Ross, 2003) no hard evidence is available to support this.

3.4.2. Intra-articular analgesia

Diagnosis of DTJ OA may include the use of local anaesthetics for intra-articular analgesia of the DIT and/or TMT joint (Dabarainer *et al.*, 2003). An anatomical communication between the DIT and TMT has been reported in 18% (Barneveld, 1983a), 26% (Bell *et al.*, 1993), 35% (Dyson and Romero, 1993), 38% (Kraushansen *et al.*, 1992) and 100% of the tarsi investigated (Friker *et al.*, 2000). Gough *et al.* (2002) investigated the diffusion of local anaesthetic agents between the TMT and DIT joint (functional communication). In all tarsi following injection of the DIT joint with mepivacaine, local anaesthetic was detected in the TMT joint and vice versa. Mepivacaine was also found to diffuse to the tarsocrural joint following TMT (92%) or DIT joint injection (88%) (Gough *et al.*, 2002). These findings indicate that a positive response to intra-articular analgesia of the TMT or DIT joint may not be specific for pain in a single synovial compartment in the tarsus. TMT joint analgesia may also affect the sensation in the distal limb as a result of diffusion of local anaesthetic towards the plantar nerves (Dyson and Romero, 1993).

3.4.3. Radiography

Radiographic abnormalities consistent with DTJ OA have been well described (Roethlisberger and Ueltschi, 1989; Verschooten and Schramme, 1994; Butler *et al.*, 2000; Sullins, 2002): narrowing and/or irregularities of the joint space; subchondral bone remodeling; osteosclerosis of the third/central tarsal bone; entheseophytosis at the foramina interossea; periosteal new bone on the periphery of the small tarsal bones; osteophytosis; subchondral bone lysis and ankylosis. Assessment of foramina interossea (synovial fossae) has been recommended by a limited number of authors only (Roethlisberger and Ueltschi, 1989; Burtscher, 1994; Verschooten and Schramme, 1994)

Four radiographic projections are used when imaging the tarsus in horses with DTJ OA: dorsoplantar (DPl), dorsolateral plantaromedial oblique (DL-PlMO), dorsomedial-plantarolateral oblique (DM-PlLO) and lateromedial (LM) projections (Butler *et al.*, 2000). Verschooten and Schramme (1994) stated that the DL-PlMO view is the most informative

of the radiographic projections. Other investigators have presented evidence that the plantarolateral-dorsomedial oblique (PlL-DMO) view (Eksell *et al.*, 1999), the LM view for moderate to severe and the DL-PlMO view for mild osteoarthritic changes (Roethlisberger and Ueltschi, 1989), and the LM view (Burtscher, 1994) are the most useful projections for making a radiographic diagnosis. Given that these studies were conducted in different populations (Icelandic horses, Warmblood horses, Trotters) it is conceivable that the horses' breeds are directly responsible for the differences in localization of radiographic changes. When single radiographic projections were read independently, the PlL-DMO view resulted in a sensitivity of 95% and a specificity of 97% for radiographic evidence of DTJ OA in Icelandic horses (Eksell *et al.*, 1999). The lowest sensitivity, 80%, resulted from reading the DPl view only. If the PlL-DMO view was combined with the other radiographic projections then a sensitivity of 100% was achieved.

Laverty *et al.* (1991) compared the sensitivity of conventional radiography with high detail radiography in cadaver limbs for detection of radiographic abnormalities consistent with DTJ OA. The authors found that subchondral bone plate irregularities and joint margin changes were frequently underestimated using conventional radiography. Using kappa statistics for measurement of agreement between the two modalities, good agreement was not found for any radiographic abnormalities. Prominent osseous spurs at the dorsoproximal third metatarsus were not found to be associated with significant articular surface lesions.

Radiographic abnormalities consistent with DTJ OA are often identified in the absence of lameness. In 134 young trotters radiographed prior to commencing training only 50% had normal tarsal radiographs whilst the remainder had radiographic evidence of DTJ OA (Hartung *et al.*, 1983). Nearly a quarter of these horses showed radiographic signs consistent with moderate to severe DTJ OA. In 141 trotters with lameness due to DTJ OA more than 50% did not have radiographic evidence of the disease (Hartung *et al.*, 1983). On the basis of the above observations the authors concluded that radiographic signs of DTJ OA may be present without lameness.

In Icelandic horses, however, a significant correlation has been identified between radiographic evidence of DTJ OA and lameness (Axelsson *et al.*, 1998; Bjornsdottir *et al.*, 2000b). Bjornsdottir *et al.* (2004a) have shown that small defects in the subchondral bone, seen on high detail radiographs, were significantly associated with the important histopathological finding of chondronecrosis. This histopathological finding is thought to

represent an early stage of OA. They also concluded that subchondral bone sclerosis was unlikely to represent a primary factor in the aetiopathogenesis of DTJ OA, rather it was likely to develop secondarily to an uneven distribution of biomechanical forces within the joint.

Radiographic signs indicative of DTJ OA are more commonly identified in the DIT than in the TMT joint (Barneveld, 1983b; Roethlisberger and Ueltschi, 1989; Axelsson *et al.*, 1998; Eksell *et al.*, 1999).
Barneveld (1983b) found that in horses showing radiographic evidence of subchondral bone lysis, lameness was unlikely to improve with treatment by orthopaedic shoeing and cunean tenotomy. Horses with subchondral bone lysis that underwent surgical arthrodesis however, had a similar outcome to those without. Dyson (2004) reported a poor outcome following the use of intra-articular corticosteroids in horses with subchondral bone lysis of the DTJ, in contrast to treatment outcome in horses with peri-articular osteophyte formation. There is however only anecdotal evidence to support this statement.

3.4.4. Nuclear scintigraphy

The scintigraphic appearance of the DTJ joints has recently been qualitatively and quantitatively described for normal horses and horses with DTJ OA (Murray *et al.*, 2004; Murray *et al.*, 2005). Increased radiopharmceutical uptake (IRU) was expressed as the ratio between the mean uptake in the DTJ and the distal tibia. The mean radiopharmaceutical uptake for both regions of interest (distal tibia and DTJ) was adjusted for background radiation. In addition to the analysis of regions of interest, profile analysis of radiopharmaceutical uptake was used. The mean ratio of radiopharmaceutical uptake for the DTJ in lateral scintigraphic images of normal horses was 1.62. A significant effect of work activity on radiopharmaceutical uptake was seen as IRU ratios were different for elite jumping horses (1.77) and horses exercised at low level (1.55). No association between age and radiopharmaceutical uptake was detected. Horses with distal tarsal joint pain but no radiographic evidence of DTJ OA had 1.75 times more radiopharmaceutical uptake in the region of the DTJ than in the region of the distal tibia. In horses with radiographic evidence of DTJ OA radiopharmaceutical uptake was 2.41 times greater.

Driesang and Boehm (1993) reported the radiographic and scintigraphic findings in 80 horses with DTJ OA. No correlation between the degree of lameness, the radiographic findings and increased radiopharmaceutical uptake was found. Similarly to Murray *et al.*

(2004; 2005) analysis of regions of interest was performed but the ratios of radiopharmaceutical uptake were calculated by comparison of the mean uptake in the DTJ region and the mean uptake in three regions of interest (distal tibia, calcaneus, proximal metatarsus). In 35 horses without radiographic evidence of DTJ OA, scintigraphic examination detected increased radiopharmaceutical uptake. This is consistent with the findings of Murray *et al.* (2005) and suggests that scintigraphy is a more sensitive imaging modality than radiography for DTJ OA.

3.4.5. Additional and alternative imaging modalities

In a post mortem study magnetic resonance imaging was found to be a sensitive diagnostic tool for the detection of a variety of pathologic abnormalities consistent with DTJ OA, involving ligaments, articular cartilage and subchondral bone, which were not evident on radiographic examination (Branch *et al.*, 2003).

The use of computed tomography has been described in the veterinary literature for diagnosis of bony and tendinous lesions (Garcia-Lopez, 2003) however the author of this thesis is unaware of any reports of the computed tomographic findings in horses with DTJ OA.

Thermography has been investigated for detection of subclinical DTJ OA (Vaden *et al.*, 1980). Normal thermographic patterns were established in a group of 20 Standardbred yearlings before and after exercise. One of the 20 horses showed an area of increased skin temperature at the medial aspect of the DTJ and subsequently radiography identified changes consistent with DTJ OA in this region. During follow up, four of the 20 horses dropped in performance and all of these horses showed an abnormal thermographic pattern of the skin at the medial aspect of the DTJ. Despite this weak evidence, the authors concluded that thermography is a useful technique for detection of subclinical DTJ OA.

3.5. Treatment

Management options for DTJ OA consist of conservative and surgical treatments (Baxter *et al.*, 2003a). Conservative treatment may comprise palliative management with nonsteroidal anti-inflammatory drugs (Clegg and Booth, 2000; Dyson, 2004), restricted exercise (Gough and Munroe, 1998; Baxter *et al.*, 2003a), corrective foot trimming and shoeing (Platt, 1997), intra-articular medication (Baxter *et al.*, 2003a), extracorporeal shock wave therapy (McCarroll and McClure, 2002), administration of nutraceuticals

(Platt, 2001), and various surgical techniques (Imschoot *et al.*, 1990; Jansson *et al.*, 1995; Dowling *et al.*, 2004; Zubrod *et al.*, 2005).

3.5.1. Intra-articular treatment

Despite this form of treatment being widely performed (Clegg and Booth, 2000) only anecdotal evidence is available of the results of i.a. treatment of the DIT and /or TMT joint with corticosteroids (Platt, 1997; Gough and Munroe, 1998; Clegg and Booth, 2000; Schramme, 2000; Baxter *et al.*, 2003a). Horses with subchondral bone lysis allegedly respond poorly to i.a. treatment in contrast to horses with peri-articular osteophyte formation, however this is a personal observation rather than robust evidence (Dyson, 2004).

Serena *et al.* (2005) have recently provided evidence that i.a. medication of the TMT joint with methylprednisolone acetate (MPA) leads to therapeutic concentrations of the agent in the DIT joint. The authors concluded that direct intra-articular medication of the DIT joint may not be necessary in horses with DTJ OA since MPA diffuses freely from the TMT into the DIT joint. This is important because local anaesthetic behaves similarly and therefore involvement of the DIT joint can not be excluded in horses with DTJ OA that show a positive response to analgesia of the TMT joint. Although treatment of the DIT and the TMT joint is often performed in these horses, Serena *et al.*'s (2005) observations indicate that this may be unnecessary.

3.5.2. Surgical treatment

Imschoot *et al.* (1990; 1995) described partial tibial neurectomy and neurectomy of the deep peroneal nerve for treatment and pain relief in ten horses with bone spavin. Seven horses were working normally at 12-28 months postoperatively. In the authors' opinion a short period of convalescence (horses started light riding exercise at 2 months post surgery) and good comfort levels post operatively represented advantages of this technique over other surgical procedures.

In his PhD thesis on bone spavin, Barneveld (1983b) described a technique for surgical arthrodesis of the DIT and TMT joint which involved creation of three 4.5 mm diverging drill tracts. Horses were box rested for one month post-operatively and then allowed pasture turn out for four months before being re-evaluated and allowed ridden exercise. Of 25 horses operated 86% returned to training. In a separate study comprising five horses in

which the DIT joint was drilled and the tracts packed with cancellous bone, outcome appeared worse, as only two of five were able to return to exercise.

Wyn-Jones and May (1986) compared four different surgical techniques for arthrodesis of the DTJ. The surgical techniques were a three to six drill tract technique and methods of internal fixation, using transarticular lag screw fixation of the DTJ or T and finger plates bridging the medial aspect of the DTJ. If the PIT joint was affected it was included in the athrodesis. Fourteen/18 horses (78%) with involvement of the DIT and TMT joint and six/11 horses (55%) with the PIT joint involved became sound following surgery when assessed using an owner questionnaire.

The results of using a similar technique to Barneveld (1983b) reported by Adkins *et al.* (2001) indicated a less successful outcome. Surgery, consisting of three diverging 3 cm long and 3.2 mm wide drill tracts, was performed in 27 hocks. Treatment success was defined on the basis of post-operative examinations, client feedback and analysis of racing performance. In 71% of the operated horses the procedure was considered successful. This represented 85% of the horses undergoing unilateral and 60% of the horses undergoing bilateral surgery.

In a more recent study, use of a three drill tract technique (3.2 - 4.5 mm) for arthrodesis of the distal tarsal joints in 54 horses, resulted in 59% having a successful outcome, 11% improving and 30% not improving in lameness at a median of 44 months post surgery (Dechant *et al.*, 2003). No significant evidence was found that the presence of subchondral bone lysis or the severity of radiographic abnormalities in horses that underwent surgery affected the treatment outcome but there was a trend for horses with severe radiographic abnormalities to have a less successful outcome. On post operative radiographic examinations the distal tarsal joint spaces frequently remained visible even after clinical signs had resolved. The authors argued that this technique may only lead to incomplete arthrodesis of the joints but by creating focal areas of immobilization, or "spot welds", pain is alleviated.

In the German literature Stanger *et al.* (1994) have reported the treatment outcome in 32 horses following surgical arthrodesis of the DTJ using the technique described by Barneveld (1983b). Horses were box rested for 14 days following surgery and then gradually re-introduced to light exercise. Mean convalescence time ranged from 5.3

months for ponies to 7.3 months for Warmblood horses. When the owners were interviewed, it was found that 81% of the horses were judged to have a positive outcome.

An experimental study on the effects of three different methods for arthrodesis of the distal intertarsal and tarsometatarsal joints in healthy horses was recently published (Zubrod *et al.*, 2005). When the effects of diode laser surgery, surgical drilling and intra-articular sodium monoiodoacetate (MIA) were compared in 15 horses, significantly more joint space was bridged by bone at six and 12 months post-operatively following the use of MIA and after surgical drilling compared to when laser facilitated arthrodesis was performed. Laser surgery facilitated arthrodesis however resulted in less post operative pain and discomfort compared to the other techniques. Following all three procedures horses were box rested for two weeks and then gradually returned to exercise. Both MIA and surgical drilling more frequently caused subchondral bone lysis than laser facilitated arthrodesis. Scruton *et al.* (2005) have shown similar effects of laser facilitated arthrodesis. In their study articular changes following laser treatment were more localized and resulted in less evidence of arthrodesis compared to when surgical drilling was performed.

Using a fenestration technique of the proximal third metatarsus, central and third tarsal bone in 56 horses with DTJ OA a positive outcome was reported for 50% of the horses (Jansson *et al.*, 1995). Treatment success was determined by owners as a return to previous levels of performance. The authors stated that this technique had been the surgical treatment of choice for DTJ OA at the Danish Veterinary Faculty since 1973. They argued that increased juxta-articular bone pressure at the distal tarsal joints is responsible for the sensation of pain and that decompression may be achieved by fenestration.

Cunean tenotomy/tenectomy is another surgical technique which has been propagated for treatment of DTJ OA and tarsitis. Eastman *et al.* (1997) reported the treatment outcome in 175 horses following cunean tenectomy for treatment of bone spavin. Treatment success was defined by the owner's satisfaction and the horse's ability to perform following surgery. Full work was resumed in horses at six weeks post surgery. Owner satisfaction was excellent in 62%, good in 21%, fair in 8% and poor in 9% of the cases. The horses' performance improved in 80% of the cases and 83% of the owners stated that they would select the treatment for a horse in the future. The author attributed the success to decreased shearing and rotational forces at the distal tarsal joints.

Gabel (1979b) found no significant difference in treatment outcome following cunean tenotomy in 22 horses when compared to the outcome in 29 horses treated conservatively. This may have been due to bridging of the ends of the cunean tendon by granulation tissue following tenotomy. Eastman *et al.* (1997) argued that this was the probable cause for their results following tenectomy being much better than following tenotomy. In Burtscher's (1994) study, the majority of Standardbred horses were treated with tenotomy of the cunean tendon combined with chemical blistering of the skin at the DTJ. This resulted in a poor outcome as only 37% of the operated horses showed an increase in racing performance at 2 years post operatively.

Cunean tenotomy as described by Gabel (1979b) can be regarded as a modification of the Wamberg procedure, which was first described in 1953. Tenotomy of the cunean tendon is included in the Wamberg procedure, but a rhomboid incision through the periosteal tissues is also made to section the local nerve supply of the joint capsule (Wamberg, 1953).

Bogner *et al.* (1998) have questioned the efficacy of cunean tenotomy/tenectomy for treatment of DTJ OA as the results of their study indicated that the cunean tendon did not play a primary role in the disease process. Baxter *et al.* (2003a) and Platt (1997) have also questioned the benefit of this surgical technique.

Intra-articular administration of MIA, a technique for chemical arhrodesis of the DTJ (Bohanon *et al.*, 1991; Sammut and Kannegieter, 1995; Dowling *et al.*, 2004) causes acute chondrocyte death by interference with chondrocyte glycolysis (Bohanon, 1998). This technique has been reported to inflict severe post injection pain (Bohanon, 1998; Dowling *et al.*, 2004) and treatment outcome can be unpredictable (Schramme, 2000). Communication of the TMT or DIT joint with the PIT joint may lead to inadvertent administration of MIA in to the PIT and tarsocrural joint and therefore contrast arthrography is indicated prior to MIA administration (Bohanon, 1998).
Success rates for the treatment of DTJ OA with MIA vary greatly: 22% (Schramme, 2000); 2/5 horses (Sammut and Kannegieter, 1995), 75% (Bohanon *et al.*, 1991); and 85% (Dowling *et al.*, 2004).

In conclusion, the outcome with surgical treatment is variable as it depends on the technique performed and in addition is likely to be affected by the horses' intended use. The reported success rates range from 37% with cunean tenotomy in Standardbred trotters

(Burtscher, 1994) to 86% with use of a three drill tract technique in a diverse group of horses (Barneveld, 1983b).

3.5.3. Other forms of treatment

Extracorporeal shock wave therapy has been proposed as a treatment of DTJ OA (McCarroll and McClure, 2002). This study reported an 80% chance for a one grade improvement in lameness on the AAEP rating scale (AAEP, 1999) following a single treatment. Horses were placed under general anaesthesia and under fluoroscopic control the location of radiographic abnormalities was mapped onto the skin surface. A single treatment with 2000 pulses at 0.89 mJ/mm^2 per joint was performed. At 90 days post treatment, 18% were sound, 38% improved by one grade and 42% by two grades. In 20% of horses lameness did not improve. The authors suggested that the positive effect of this treatment was due to strengthening of the subchondral bone, despite follow up examinations not finding any radiographic evidence for this.

The findings of a preliminary study of the use of cryosurgery for the treatment of DTJ OA suggested that this modality can be effective (McKibbin and Paraschak, 1985).

Corrective foot trimming and remedial shoeing are frequently advocated as adjuncts to conservative or surgical treatment of DTJ OA (Platt, 1997; Baxter *et al.*, 2003a). The aim is to cause the foot to land more squarely on the ground during walk and trot, and to facilitate break over at the toe. Shoes are often squared at the toe and have raised heels. If an abnormal foot flight is apparent (Platt, 1997; Gough *et al.*, 1998), the orthopaedic shoe often incorporates a lateral trailer or extension (Ferrie and Lentelink, 2002). It is assumed that this may help the horse to redistribute load on the tarsus to improve comfort either by rotating the foot or by helping the horse bear weight on the lateral aspect of the foot (Wilson *et al.*, 2001).

When the kinetics of horses with DTJ OA exercised at the trot in a straight line were investigated (Boswell *et al.*, 2000) it was found that the point of zero moment (PZM) is more plantar and lateral than in normal horses, confirming that these horses change their gait to unload the painful medial aspect of the tarsus. After analyzing the kinetic effects of lateral trailers and extensions in horses with DTJ OA, it was concluded that neither the PZM or the clinical lameness score changed significantly, rendering the use of such shoes questionable (Wilson *et al.*, 2001).

The use of oral disease-modifying agents, such as glucosamine and chondroitin sulphate, in the management of equine degenerative joint disease has become very popular, however very little evidence exists on the benefits of using such feed supplements for supportive treatment of DTJ OA (Platt, 2001). Clayton *et al.* (2002) presented the results of a double blinded placebo controlled study performed to evaluate the effects of a commercially available nutraceutical called "Cortaflex™" on gait in horses with DTJ OA. Kinetic analysis, including analysis of ground reaction forces, net joint torques and mechanical energy generation and absorption across a joint, was used to study the effects of Cortaflex™ [9] on lameness in eight horses. Based on a rapid improvement in the gait quality in these horses following initiation of administration, the authors concluded that the use of commercially available nutraceuticals was beneficial for management of DTJ OA.

Other alternative management options have been described for treatment of DTJ OA, such as acupuncture, low-energy light therapy lasers, magnetic therapy or therapeutic ultrasound, however evidence supporting their clinical use is lacking (Baxter *et al.*, 2003a).

3.6. Use of radiographic rating scales

The use of rating scales that have been tested for reliability has been reported for assessment of radiographic changes consistent with OA in human patients (Kallman *et al.*, 1989; Gunther and Sun, 1999; Kessler *et al.*, 2000)

Gunther and Sun (1999) evaluated the reliability of commonly used radiographic measures in hip and knee OA using intraclass correlation coefficients (ICC). Three readers evaluated radiographic images of 100 hip and knee joints in patients with radiographic evidence of OA twice at an interval of three months. The presence and severity of joint specific radiographic features (osteophyte formation and joint space narrowing at different sites, cysts, subchondral bone sclerosis, bony deformity and chondrocalcinosis) were assessed. The severity rating for each radiographic feature was different for the hip (rating on an ordinal 0-3 scale) and the knee joint (rating on an ordinal 0-4 scale). In this study the reliability of the radiographic features was different for the hip and knee joint and the reader's professional experience had an important effect on the rating, with the most experienced assessor being the most reliable for the majority of features. Reliability of repeated assessment of subchondral bone sclerosis in the hip and knee joint was unacceptable (ICC=0.11-0.44). In general, reliability was lower between than within

assessors. The authors concluded that the use of rating scales had to be practiced in order to make them a reliable tool. Rating of radiographic abnormalities in clinical studies should therefore be performed by the same individual or group of assessors, both of whom need to be familiar with the rating scale.

Kallman *et al.* (1989) reported on the reliability of rating hand OA using ICC analysis in participants of the Baltimore longitudinal study on aging. For 50 subjects a number of radiographic features consistent with OA of the hand (osteophytes, joint space narrowing, subchondral bone sclerosis, subchondral bone cysts, lateral deformity and cortical collapse) was recorded. Osteophytes and joint space narrowing were given one of three ratings while the other features were noted as absent or present. Four assessors read 200 hand radiographs on two occasions at a 1-2 month interval. Except for the assessment of subchondral bone cysts, inter and intra-observer reliability was acceptable for the radiographic features. The ICC ranged from 0.56 to 0.70, except for subchondral bone cysts for which it was 0.29. The average percent agreement between pairs of assessors was highest for the dichotomous (absent/present) variables, ranging from 96% to 99%. Of the scales with multiple categories, readers agreed most frequently on the scores for osteophytes (86%).

Kessler *et al.* (2000) adopted a different approach to rating of hand OA. Radiographic abnormalities were graded dichotomously as absent or present. Fifty pairs of hand radiographs were assessed by two investigators on two occasions at a one month interval. Both raters were able to exactly reproduce their first ratings on the second assessment and agreed frequently on the presence of radiographic abnormalities (kappa coefficient 0.52-0.92). The reliability between assessors was found to be different for individual joints.

To the author's knowledge only two radiographic rating scales have been tested for their reliability in veterinary orthopaedics (Eksell *et al.*, 1999; Innes *et al.*, 2004).

Innes *et al.* (2004) describing the radiographic progression of osteoarthritis of the canine stifle joint also reported on the within and between observer variation when the radiographic evidence of OA was graded. Four experienced veterinary radiologists graded forty paired sets of stifle radiographs in a blinded fashion. Each observer independently scored each joint subjectively for several parameters using discontinuous ordinal scales. The parameters assessed were "global score for overall disease severity" (0-3), "joint

effusion" (0-2), "osteophytosis" (0-3), "intra-articular mineralization" (0-2) and "tibial subchondral sclerosis" (0-1). Only one observer repeated the assessment after an interval of more than two weeks to investigate intra-observer reliability. Inter- and intra-observer agreement was analysed using unweighted kappa statistics. Results of the reliability study suggested that "global score", "effusion", "osteophytosis" and "intra-articular mineralization" were all features that had acceptable reliability (κ ranged from 0.56 – 0.78) but "subchondral sclerosis" did not ($\kappa = 0.388$).

Eksell *et al.* (1998) reported the specificity and sensitivity of four standard radiographic views of the tarsus in 98 Icelandic horses with DTJ OA. As part of this study the authors investigated the reliability of a radiographic rating scale. Radiographic abnormalities consistent with DTJ OA (periarticular osteophytes, irregular widening of the joint space, subchondral bone lysis and narrowing or collapse of the joint space) were recorded as absent or present and graded according to their severity. For each reading the consensus opinion of the authors was used. Radiographic signs of bone spavin involving a total of half an intertarsal joint space or less were graded as mild, more then half but not more than one joint space as moderate, and more than one joint space as severe. Radiographs were read on two occasions - on the first assessment in sets of four radiographs per horse and on the second assessment all views independently and in random order. Agreement on extent and presence of radiographic signs consistent with DTJ OA was calculated using kappa statistics. In this study the level of agreement between readings on the two assessments ranged from 0.7 to 0.8. The disagreement was mainly caused by 19 tarsi that were classified as normal on the first assessment but on the second were interpreted as showing evidence of DTJ OA. The authors concluded that the opportunity to read all radiographic projections available for a horse at one time had an effect on the rating of radiographic changes consistent with DTJ OA.

In studies analysing the agreement of repeated measurements the seemingly interchangeable use of terms such as agreement, reproducibility, repeatability, reliability, validity and consistency can make it difficult to compare and contrast results. Reliability can be understood as an index of proportional consistency among measurements when using the same scale or tool. Agreement describes the interchangeability of measurements among assessors. The fact that these two terms do not describe the same statistical condition may lead to the paradox that results may show high correlation and therefore good reliability but low agreement at the same time (Tooth and

Ottenbacher, 2004). Statistical tests such as a Pearson correlation test may be used to show an association between repeated ratings, however this test should not be interpreted as an indicator of agreement. A negative Pearson correlation would represent an important finding as it would mean that repeated measurements produced random values.
The term "consensus" is interchangeable with "agreement" and "consistency" is identical to "reliability" (Tooth and Ottenbacher, 2004). "Validity", also termed correctness, accuracy or conformity, differs in its definition from "reliability" as it refers to how close any values obtained are to the true value rather than how closely associated repeat measurements are when using the same scale or tool. If however, the use of a new scale or tool is compared to a gold standard technique, the reliability and validity can be assessed at the same time (White and van den Broek, 2004). Repeatability and reproducibility are commonly used as synonyms for intra and inter-observer reliability respectively as shown in the study by Polito *et al.* (2005).

A number of radiographic rating systems have been used for equine research purposes without testing their reliability. These include systems that use complex verbal descriptive ratings for radiographic abnormalities (Barneveld, 1983b), numeric scores attributed to Barneveld's verbal ratings (Dik, 1983), and systems with simple, verbal qualitative ratings, such as "none", "mild", "moderate" or "severe", according to the lesions' size or severity (Laverty *et al.*, 1991). Eksell *et al.* (1999), Bjornsdottir *et al.* (2000b) and Dechant *et al.* (2003) used simple verbal qualitative ratings according to the number and/or extent (amount of joint surface affected) of radiographic abnormalities. Simple (Scruton *et al.*, 2005) and complex (Burtscher, 1994) quantitative rating scales have been developed that attribute a numeric score to radiographic abnormalities according to their perceived severity. Burtscher (1994) used a system in which the numeric score, expressing the perceived severity, was different for individual radiographic features. This was based on the author's interpretation that certain radiographic abnormalities were more important than others (e.g. subchondral bone lysis versus joint space narrowing).
Zubrod *et al.* (2005) in their research on surgical techniques for arthrodesis of the DTJ opted to use a simple dichotomous rating scale, recording radiographic abnormalities as absent or present.

Despite there being a number of examples of the use of radiographic rating scales tested for reliability in man, none has been developed for use in equine orthopaedics that is known to be reliable when applied clinically by a single assessor. In canine orthopaedics,

in contrast, a radiographic rating scale has been developed that has been investigated for reliability (Innes *et al.*, 2004).

3.7. Qualitative research methods-Delphi consultation process

The first mention of the Delphi technique was by the RAND corporation in the late 50's. The RAND corporation is a non-profit organization which aims to improve policy and decision making through research. The Delphi method as described by Gordon, Helmer and Dalkey (1964) was initially designed to serve as a defense research method for the US Air Force. In this report (1964) the authors assessed the direction of long term trends in science and technology development and covered topics such as scientific breakthroughs, population control, automation, space progress, war prevention and weapon systems.

The use of qualitative research methods, like the Delphi consultation technique, has been extensively reported in human health related sciences (Jones and Hunter, 1995; Bowles, 1999; Hasson *et al.*, 2000; Powell, 2003).

Jones and Hunter (1995) provide an informative review of qualitative research methods including consensus methods for medical and health services. Consensus methods provide another means of synthesizing information, when published information is inadequate or non-existent. Two consensus methods are commonly adopted in medical, nursing and health services research – the nominal group technique and the Delphi process. The Delphi process takes its name from the Delphic oracle's skills of interpretation and foresight. The aim of the Delphi process is to assess the extent of agreement on a given subject (consensus measurement) and to resolve disagreement (consensus development). Characteristic features of the technique are anonymity of participants and responses to avoid dominance or bias, iteration of the consultation process to allow individuals to change their response, and controlled feedback to show the distribution of the group's and the experts' responses.

Each of the persons invited to participate in the consultation process must be a justified "expert" on the matter under discussion. In multiple rounds (iteration) these experts are interviewed on the subject matter using a questionnaire format. The results from the previous round are included in the questionnaire, thus allowing the individual expert to assess his response relative to the group and to change it if he so wishes. As soon as an agreement is reached the process is stopped. The term agreement encompasses two issues,

firstly the extent to which each expert agrees with the issue under consideration, and secondly to the extent to which experts agree with each other. A clear definition of what is considered an acceptable agreement is imperative for the process to be successful.

Hasson *et al.* (2000) discussed possible limitations of the Delphi consultation process. It remains unknown if this technique is a reliable tool, i.e. if the same information were given to two or more panels, would the same result be obtained? In addition the results' validity can not be determined - consensus on a subject matter does not mean that the correct answer, opinion or judgment has been found.
Bowles (1999) mentioned that this method may be unattractive to today's researcher who prefers methods that support clinical effectiveness and the production of evidence, for example randomized controlled trials, meta analyses and systematic reviews.

To the author's knowledge there has been only one veterinary application of a Delphi consultation process prior to this study. Hotchkiss (2004) used the technique as part of studies designed to identify and quantify estimates for the important historical and clinical signs associated with recurrent airway obstruction in horses. Hotchkiss described the use of an electronic questionnaire, which in his opinion speeded up the response time. Hotchkiss concluded that the modified Delphi process proved to be an efficient and productive way of consulting an expert panel to answer a question that could not be directly answered from the information available.

CHAPTER 4

DESIGN AND RELIABILITY OF A QUANTITATIVE RADIOGRAPHIC RATING SCALE FOR BONE SPAVIN IN HORSES

CHAPTER 4:

DESIGN AND RELIABILITY OF A QUANTITATIVE RADIOGRAPHIC RATING SCALE FOR BONE SPAVIN IN HORSES

4.1. Introduction and aims of the study

Osteoarthritis (OA) of the distal tarsal joints (DTJ) is a common cause of hindlimb lameness in horses, affecting the tarsometatarsal (TMT), distal intertarsal (DIT) and much less frequently the proximal intertarsal (PIT) joint. Diagnosis is based on the findings of clinical examination and diagnostic imaging (Baxter *et al.*, 2003b). Radiographic changes, which have been reported to be consistent with DTJ OA are irregular subchondral bone, subchondral bone sclerosis, poor corticomedullary definition, irregularly enlarged and narrowed joint space, ankylosis, osteophytosis or bony spurs, periarticular bony bridge formation, subchondral bone lysis (Dik, 1983; Barneveld, 1983b; Roethlisberger and Ueltschi, 1989; Verschooten and Schramme, 1994; Butler *et al.*, 2000; Sullins, 2002) and indistinct or sclerotic synovial fossae/foramina interossea (Roethlisberger and Ueltschi, 1989; Verschooten and Schramme, 1994). While radiographic features such as subchondral bone lysis, are generally accepted indicators of DTJ OA, other features, such as bony spurs on the dorsoproximal aspect of the third metatarsal bone (Mt 3), may not reflect the disease (Laverty *et al.*, 1991; Butler *et al.*, 2000). Geographical location may also play a role in the radiographic interpretation of DTJ OA, as the assessment of synovial fossae/foramina interossea appears more common practice in certain countries (Switzerland, Austria, Belgium) than elsewhere (Roethlisberger and Ueltschi, 1989; Burtscher, 1994; Verschooten and Schramme, 1994).

Despite the poor correlation between the severity of radiographic changes of DTJ OA and lameness (Hartung *et al.*, 1983; Burtscher, 1994; Butler *et al.*, 2000), they are used to monitor disease. This is of particular importance when the outcome of surgical treatments, aiming to promote arthrodesis of the DTJ, is assessed in clinical or research cases (Dechant *et al.*, 2003; Zubrod *et al.*, 2005). Various radiographic rating systems for DTJ OA in horses have been described (Barneveld, 1983b; Laverty *et al.*, 1991; Burtscher, 1994; Eksell *et al.*, 1999; Dechant *et al.*, 2003; Bjornsdottir *et al.*, 2004a; Zubrod *et al.*, 2005) but to the author's knowledge the reliability of only one has been investigated (Eksell *et al.*, 1999). They reported the diagnostic value of four standard radiographic projections used for the detection of DTJ OA in Icelandic horses. The rating system was associated with a coefficient of agreement which made it a useful tool for the purpose of that study.

However, as this rating system does not allow radiographic changes to be graded in detail for each joint independently, it is unlikely to be an appropriate tool for disease monitoring. The use of radiographic rating systems for assessment of osteoarthritic changes has been common practice in human medicine for many years (Kellgren and Lawrence, 1957) and multiple studies investigating their reliability have been performed (Kallman *et al.*, 1989; Gunther and Sun, 1999; Kessler *et al.*, 2000).

Efforts to investigate the reliability of radiographic rating scales for osteoarthritic changes have also been made in canine orthopaedics (Innes *et al.*, 2004).

This study was undertaken to develop and investigate the reliability of a radiographic rating scale for use in horses with DTJ OA. A questionnaire and modified Delphi consultation process (Jones and Hunter, 1995) was used to collect information on radiographic interpretation and to develop a consensus of specialists on the diagnostic value of various radiographic features, indicative of DTJ OA. Based on the questionnaire results, a radiographic rating scale was designed, and the scale was then tested for its reliability.

4.2. Materials and Methods

4.2.1. Selection of experts

Seventeen international experts were invited to participate in a "Delphi" consultation process. They were considered experts by virtue of their professional qualifications (recognized specialists in large animal diagnostic imaging or equine orthopaedics) and publication record. At the time of the study these experts were employed in 11 countries on two continents: in Europe, in the UK, Germany, Belgium, Finland, Austria, France, Switzerland, Sweden, the Netherlands, in the United States and Canada. Fourteen of 17 experts were working at academic institutions. Experts were sent a postal invitation to participate in the consultation process and a request to confirm their wish to participate in an e-mail to the author **(Accompanying material: Letter to experts, p105)**. Postal addresses were found on the internet, or taken from the register of the relevant national professional body.

4.2.2. Delphi consultation process

In a compromise between achieving a degree of consensus and reducing the experts' compliance, the consultation process was predetermined to last for two rounds, during which experts were interviewed twice on the same subject matter using a questionnaire. In

the 2nd round of the process, the results from the 1st round were included with the questionnaire, allowing each expert to assess his/her previous response in relation to the group and to reconsider his/her stand point. The consultation process was conducted so that each expert's identity remained unknown to the other participants. The author's role in this process was to act as a facilitator. Expert – facilitator interactions to provide technical assistance with the questionnaire were permitted but discussion or explanation of specific aspects of the questionnaire was not allowed.

4.2.3. Questionnaire design and distribution

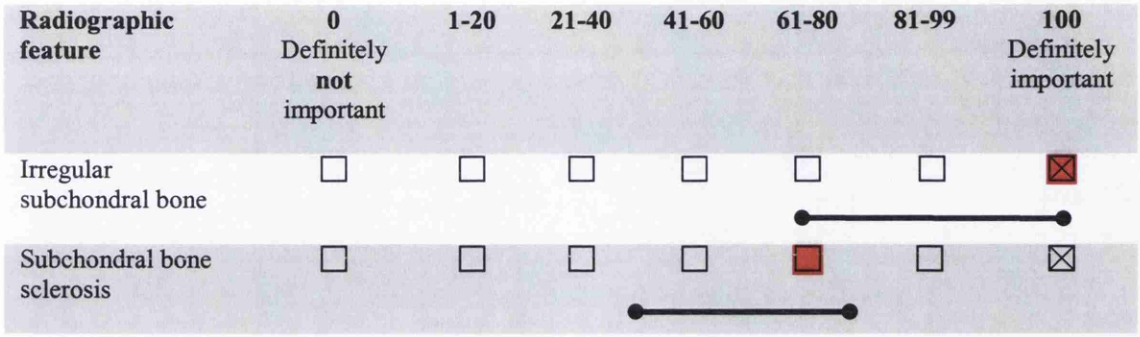
The following radiographic features were incorporated in the questionnaire: irregular subchondral bone; subchondral bone sclerosis; poor corticomedullary definition; enlarged joint space; narrowed joint space; ankylosis; osteophytes; bony spur on dorsoproximal Mt 3; periarticular bony bridge formation; indistinct or sclerotic synovial fossae and subchondral bone lysis.

An electronic questionnaire was designed to ask the expert to grade the importance of each radiographic feature when making a radiographic diagnosis of DTJ OA. Seven ordinal groups, covering a range of importance were available for rating of each feature: 0 or definitely not important (group a); 1-20 (group b); 21-40 (group c); 41-60 (group d); 61-80 (group e); 81-99 (group f); and 100 or definitely important (group g). This rating process was completed for the tarsometatarsal, distal intertarsal and proximal intertarsal joint. Additional space was provided to allow comments to be made.

The questionnaire was designed so that it could be distributed as an electronic document and filled in by the expert using a personal computer. Areas designated for the experts' response allowed tick marks or comments to be entered, whereas the rest of the document was protected from changes. E-mail addresses were obtained from the experts' message confirming participation.

In the 2nd round, each individual questionnaire indicated the group's and the expert's own response from the first round. To summarise central tendencies and dispersions of the responses, the results were expressed as the median and interquartile range for each radiographic feature. A red box was used to indicate the position of the median and a bar to display the interquartile range. To the expert, his/her response from the 1st round was marked by an "X" in the relevant tick box. A section of a 2nd round questionnaire is shown in **Figure 4.1**.

Figure 4.1: Excerpt of Expert 1's second round questionnaire. The "X" indicates this expert's response in the 1st round; the red box illustrates the position of the median and the bar the interquartile range of the group's response in the 1st round.



In addition to, but separate from, the Delphi consultation, experts were invited during the first round to comment on their preferred radiographic technique for obtaining lateromedial (LM), dorsoplantar (DPl), dorsomedial-plantarolateral (DM-PlLO) or dorsolateral-plantaromedial oblique (DL-PlMO) radiographic views of the tarsus for the diagnosis of DTJ OA.

During the second round experts were asked whether they gave combinations of certain radiographic features more importance than when the features occurred in isolation, and whether they thought features were more important clinically when they were identified in more than one radiographic projection or when they were present at a specific location in the joint. **(Accompanying material: 1st round questionnaire (p106), 2nd round questionnaire of Expert 1 (p111))**

4.2.4. Development of a quantitative radiographic rating scale for DTJ OA

It was decided to develop a quantitative rating scale based on radiographic features for which a consensus on their diagnostic importance was achieved during the Delphi process. Radiographic features for which the upper three quartiles of responses from the 2nd questionnaire were not less than goup d (41-60) were identified as being sufficiently important for use in a rating scale.

The radiographic rating of each selected radiographic feature consisted of the value obtained from a visual analogue rating scale, multiplied by a weighting factor. The visual analogue scale value was determined by measuring the distance of a mark placed on a

100mm long scale from the origin. This value indicated the severity of a radiographic feature perceived by an assessor (0 = not present, 100 = most severe presentation possible). The weighting factor was based on the calculated median response from the 2nd questionnaire for the radiographic feature. A weighting of 1 represented a median in group d (41-60), a weighting of 2 meant the median was in group e (61-80), 3 in group f (81-99), and a weighting of 4 represented a median in group g (100).
When the radiographic ratings were summed for each joint, for all radiographic features and for all four projections, the result was a total rating, representing the radiographic severity of OA of each joint.

4.2.5. Experiment to test the reliability of the quantitative radiographic rating scale
Four radiographic projections (LM, DM-PlLO, DL-PlMO, DPl view) of three DTJ were selected by the author from the hospital's radiographic database **(Appendix p119)**. These 12 radiographs were considered to display radiographic abnormalities representative of findings in horses with DTJ OA. Nine veterinarians working at two separate academic institutions participated in the experiment. The assessors were all active clinicians (university lecturer, registrar or resident) and all regularly interpreted tarsal radiographs. They were presented with the test radiographs on two separate occasions, a minimum of six weeks apart and asked to score the radiographs using the rating scale developed as a result of the Delphi process. To facilitate the rating process, the assessors were provided with an evaluation form for each projection and joint, containing the 0-100 mm scale for each radiographic feature. The radiographic rating, representing the product of the visual analogue rating and the weighting factor, was calculated by the author at a later stage. Each assessor was asked to identify his evaluation form with a personal code name only to ensure that his or her identity remained anonymous **(Accompanying Material: Evaluation form and instructions, p116).**
In addition to the visual analogue rating, the participants were asked to use a 3 point verbal rating scale ("mild", "moderate" and "severe") to assess the severity of OA of each joint (based on all projections).

4.2.6. Statistical analysis
The visual analogue rating (mm) rather than the calculated radiographic rating (product of visual analogue rating and weighting factor) was used for statistical analysis. This was to facilitate graphical analysis and had no statistical effect on the assessment of reliability. Bland-Altman plots (Bland and Altman, 1995) were used to illustrate the mean rating

versus the difference in rating between the two assessments for each assessor, radiographic feature, joint and radiographic view. Upper and lower 95% agreement limits were calculated and included with the graphs. A Pearson correlation test was used to compare 1st and 2nd ratings (Bland, 2000).

To illustrate further the scale's reliability, the joints were ranked on the basis of their total rating on both assessments, which was graphically displayed using box and whisker plots (Bland, 2000). Verbal descriptive ratings ("mild", "moderate" and "severe") for each joint were plotted against the joints' rank, using the same graphical format. This allowed comparison of the verbal descriptive with the visual analogue rating system.

Analysis of variance using a forward inclusion technique was used to identify statistically significant interactions (Bland, 2000). Variables were "assessor", "assessment", "joint" "view" and "horse".

4.3. Results

4.3.1. Results of the Delphi consultation process

Of the 17 invited experts, 9 confirmed their participation and returned the questionnaire in the 1st and 2nd round. Only 5/9 experts altered their initial response during the 2nd round. The combined results for the 1st and 2nd round of the consultation process can be seen in **Figures 4.2.1** (p133), **Table 4.1** (p163) and **4.2** (p164) in the Appendix. **Table 4.3** shows the results of the 2nd and final round of the consultation process, expressed as the interquartile range and median response for each radiographic feature. The weighting factors for the radiographic features for which the upper three quartiles of responses were not less than group d (41-60) (bold), are shown in the table.

Table 4.3: Results of the 2nd and final round of the consultation process. The interquartile range and median is shown, expressed as the goups of importance they include. 0 (group a); 1-20 (group b); 21-40 (group c); 41-60 (group d); 61-80 (group e); 81-99 (group f); and 100 (group g). Radiographic features for which responses were higher or equal than the cut off value (group d) are in bold.

Tarsometatarsal joint	Interquartile range	Median	Weighting
Irregular subchondral bone	e f g	f	3
Narrowed joint space	d e f	e	2
Osteophytes	e f	e	2
Periarticular bony bridge	f g	g	4
Subchondral bone lysis	g	g	4
Partial ankylosis	f g	g	4
Subchondral bone sclerosis	c d e	d	
Corticomedullary definition	c d	c	
Enlarged joint space	a b c d e	d	
Bony spur on Mt3	b c	b	
Indist/sclerotic synovial fossa	a b c d	c	
Distal intertarsal joint			
Irregular subchondral bone	e f g	f	3
Subchondral bone sclerosis	d e f	e	2
Narrowed joint space	e f	f	3
Osteophytes	e f g	f	3
Periarticular bony bridge	e f g	g	4
Subchondral bone lysis	g	g	4
Partial ankylosis	f g	g	4
Corticomedllary definition	c d	d	
Enlarged joint space	a b c d	c	
Indist/sclerotic syovial fossa	a b c d	b	
Bony spur on Mt3	a b c	a	
Proximal intertarsal joint			
Irregular subchondral bone	f g	g	4
Subchondral bone sclerosis	d e	e	2
Narrowed joint space	e f g	f	3
Osteophytes	f g	g	4
Periarticular bony bridge	f g	between group f and g	3.5
Subchondral bone lysis	g	g	4
Partial ankylosis	g	g	4
Corticomedullary definition	b c d e	c	
Enlarged joint space	a b c d	c	
Bony spur on Mt3	a	a	
Indist/sclerotic synovial fossa	a b c d	b	

4.3.2. Results from the enquiry on radiographic technique

When taking LM radiographic views, four of nine experts prefer a radiographic beam with slight proximal to distal angulation. Three of these experts prefer a 5-10 degree angle, with the centre of the beam at the level of the DTJ and one expert preferentially chooses a horizontal beam, centered at the lateral malleolus of the tibia, to create a diverging x-ray beam at the level of the DTJ.

Expert 1 attributes the greatest diagnostic value to the LM view and states that he routinely uses a grid for obtaining tarsal radiographs. Expert 9 emphasizes that the DM-PlLO projection has particular diagnostic value in horses with DTJ OA.

When obtaining DPl views, two experts prefer to acquire two images per limb, one with a horizontal and one with a 5-10 degree proximal to distal angulation. Expert 8 routinely uses a distal to proximal orientation of the beam.

Two experts prefer a slight proximal to distal angulation of the x-ray beam when acquiring oblique radiographs (DM-PlLO, DL-PlMO).

Expert 8 routinely obtains both oblique projections and Expert 5 only the DL-PlMO view for investigation of DTJ OA. Expert 3 routinely obtains DL-PlMO views at a 35 degree angle, while all other experts preferred to obtain oblique views at a 45 degree angle to the sagittal plane.

All of the experts emphasized that images of good radiographic quality are obtained by positioning the metatarsus perpendicular to the ground surface. Expert 9 mentioned that he routinely images the contra-lateral hindlimb for comparison, even if lameness is unilateral.

4.3.3. Results from the enquiry on complex radiographic interpretation

Eight of nine experts thought that the importance of a radiographic feature is greater when it is seen in combination with other radiographic abnormalities. Seven of nine experts are convinced that radiographic signs are of greater significance when they are seen in more than one view. However, the group was split over whether the significance of radiographic features varies between locations in the joint. **Table 4.4** shows the answers given during the 2nd round of the consultation process.

Table 4.4: Answers to questions asked during the 2nd round of the consultation process

Questions	No	Don't know	Yes
Question 1: Do you attribute greater importance to a radiographic feature when it is present together with other features rather than in isolation?	1	0	8
Question 2: Do you attribute greater importance to radiographic features when they are seen in more than one radiographic view?	2	0	7
Question 3: Do you attribute greater importance to a radiographic feature when it is present at a specific location in the joint?	4	1	4

Although the majority of experts considered the significance of minor radiographic changes to increase if other abnormalities were present at the same time, the opinion that some radiographic abnormalities would always be important regardless of being present alone or together with other changes (e.g. subchondral bone lysis, joint space narrowing) was also aired.

Experts 1 and 6 mentioned that the significance of osteophytes will depend on their radiographic appearance, as in their experience the presence of smooth rounded, "inactive" osteophytes has not been of clinical importance.

The majority of the group of experts thought that a radiographic feature would be of greater importance if it was visualized in multiple rather than a single view as this confirmed its presence or indicated disease severity or progression. This contrasts with one expert's argument that radiographic abnormalities may not be recognized in every view due to variations in radiographic technique, suggesting that the difference in detection of radiographic abnormalities is not necessarily disease-related.

With respect to a feature's location in a joint affecting its importance, Expert 4 pointed out that spurs at the dorsoproximal border of Mt 3, which are frequently seen in LM views, are mostly insignificant. However the presence of an osteophyte at the medial aspect of the TMT joint has often been of great importance in this expert's experience.

Expert 7 commented that the joint affected may be more important than the location of a radiographic feature within a joint, as abnormalities in the PIT joint carry a poorer prognosis than OA of the DIT or TMT joint.

4.3.4. Results from the use of a quantitative radiographic rating scale

Table 4.5 shows the 95% agreement limits (mean difference ± 1.96 x Stdev; mm) and correlation coefficients for 1st and 2nd visual analogue rating. On average ratings from the 2nd assessment were lower than ratings from the 1st assessment.

Table 4.5: Use of radiographic rating scale. 95% agreement limits (mm) and correlation coefficients for 1st and 2nd visual analogue rating. The most reliable assessor and radiographic feature in the different groups is indicated in bold. (Group I = assessors with lower repeatability, Group II = assessors with higher repeatability)

Assessor/Vet	**Mean difference ± (1.96xStdev)**	**Mean difference ± (1.96xStdev)**		**Corr (R) / P-value**	**Corr (R) / P-value**
		Group I	**Group II**	**GroupI**	**GroupII**
Assessor 1	11.858 ± 25.1272	8.74 ± 34.678	2.984 ± 21.793	R=0.831 P=0.000	R=0.871 P=0.000
Assessor 2	4.506 ± 28.261				
Assessor 3	3.17 ± 32.104				
Assessor 4	0.431 ± 21.653				
Assessor 5	8.96 ± 37.181				
Assessor 6	15.21 ± 42.453				
Assessor 7	**-1.121 ± 17.399**				
Assessor 8	7.279 ± 23.341				
Assessor 9	5.346 ± 19.617				
Radiographic feature (for all assessors and projections)	**Mean difference ± (1.96xStdev)**	**Mean difference ± (1.96xStdev)**		**Corr (R) / P-value**	**Corr (R) / P-value**
		Group I	**Group II**	**GroupI**	**GroupII**
Irregular subch bone	6.080 ± 30.977	9.53 ± 36.710	1.774 ± 18.727	R=0.783 P=0.000	R=0.852 P=0.000
Narrowed joint space	7.62 ± 32.191	10.5 ± 37.867	4.024 ± 21.364	R=0.810 P=0.000	R=0.869 P=0.000
Subch bone sclerosis	6.41 ± 30.850	9.54 ± 34.770	2.51 ± 23.069	R=0.856 P=0.000	R=0.881 P=0.000
Osteophytes	7.346 ± 30.709	10.44 ± 34.692	3.472 ± 22.796	R=0.824 P=0.000	R=0.874 P=0.000
Subch bone lysis	**4.647 ± 25.683**	**7.44 ± 29.066**	**1.153 ± 18.649**	R=0.848 P=0.000	R=0.881 P=0.000
Periarticular bony bridge	4.613 ± 31.369	5.77 ± 35.593	3.17 ± 24.950	R=0.826 P=0.000	R=0.874 P=0.000
Ankylosis	6.63 ± 28.911	8.23 ± 32.967	4.628 ± 22.353	R=0.871 P=0.000	R=0.877 P=0.000
Radiographic feature-LM projection (for all assessors and joints)	**Mean difference ± (1.96xStdev)**	**Mean difference ± (1.96xStdev)**			
		Group I	**Group II**		
Irregular subch bone	5.59 ± 35.142	5.59 ± 35.142	1.85 ± 22.853		
Narrowed joint space	6.62 ± 32.653	6.62 ± 32.653	5.15 ± 23.480		
Subch bone sclerosis	5.37 ± 34.907	8.75 ± 39.396	1.15 ± 26.832		
Osteophytes	8.79 ± 35.456	8.79 ± 35.456	3.29 ± 20.756		
Subch bone lysis	**3.28 ± 26.185**	**5.17 ± 29.831**	**0.931 ± 20.227**		
Periarticular bony bridge	3.41 ± 31.242	3.47 ± 33.653	3.35 ± 28.42		
Ankylosis	5.58 ± 32.046	6.36 ± 37.142	4.61 ± 24.637		
Radiographic feature-DL-PlMO projection (for all assessors and joints)	**Mean difference ± (1.96xStdev)**	**Mean difference ± (1.96xStdev)**			
		Group I	**Group II**		

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Irregular subch bone	6.48 ± 32.124	10.43 ± 39.253	1.54 ± 15.758
Narrowed joint space	7.19 ± 31.281	11.46 ± 35.672	1.85 ± 20.834
Subch bone sclerosis	6.46 ± 30.948	8.85 ± 34.280	3.48 ± 25.734
Osteophytes	6.25 ± 30.536	7.68 ± 36.769	4.47 ± 20.217
Subch bone lysis	5.02 ± 27.636	7.97 ± 32.144	1.33 ± 18.698
Periarticular bony bridge	0.914 ± 29.811	1.70 ± 39.317	**-0.069 ± 9.017**
Ankylosis	**4.96 ± 22.794**	**6.76 ± 24.676**	2.71 ± 19.658
Radiographic feature-DM-PILO projection (for all assessors and joints)	**Mean difference ± (1.96xStdev)**	**Mean difference ± (1.96xStdev)**	
		Group I	**Group II**
Irregular subch bone	6.02 ± 25.009	10.06 ± 29.066	**0.986 ± 13.680**
Narrowed joint space	8.57 ± 30.713	12.32 ± 35.985	3.88 ± 19.247
Subch bone sclerosis	6.32 ± 31.006	10.12 ± 34.829	1.58 ± 23.088
Osteophytes	8.38 ± 31.36	12.97 ± 31.928	2.64 ± 27.067
Subch bone lysis	**3.85 ± 21.112**	**5.24 ± 23.50**	2.1 ± 17.15
Periarticular bony bridge	8.12 ± 30.536	9.22 ± 32.026	6.75 ± 28.792
Ankylosis	8.08 ± 31.144	10.87 ± 37.749	4.6 ± 18.463
Radiographic feature-DPI projection (for all assessors and joints)	**Mean difference ± (1.96xStdev)**	**Mean difference ± (1.96xStdev)**	
		Group I	**Group II**
Irregular subch bone	6.23 ± 31.301	9.03 ± 36.573	2.72 ± 21.658
Narrowed joint space	8.12 ± 34.456	10.43 ± 41.591	5.22 ± 21.893
Subch bone sclerosis	7.49 ± 26.636	10.43 ± 31.791	**3.81 ± 16.209**
Osteophytes	**5.96 ± 24.696**	**7.94 ± 25.342**	3.49 ± 23.304
Subch bone lysis	6.44 ± 27.381	11.39 ± 29.321	0.25 ± 18.992
Periarticular bony bridge	6.00 ± 32.575	8.68 ± 35.848	2.65 ± 27.048
Ankylosis	7.90 ± 28.772	8.94 ± 30.948	6.60 ± 26.028
Tarsometatarsal joint (for all radiographic features and assessors)	**Mean difference ± (1.96xStdev)** 6.007 ± 27.479		
Distal intertarsal joint (for all radiographic features and assessors)	**Mean difference ± (1.96xStdev)** 8.206 ± 38.012		
Proximal intertarsal joint (for all radiographic features and assessors)	**Mean difference ± (1.96xStdev)** 4.307 ± 21.901		

Figure 4.3 shows the results of the reliability experiment for each assessor and all radiographic features. On the basis of this analysis the assessors were divided into two groups of different reliability. Group I, represented veterinarians who had used the scale with lower repeatability between the 1st and 2nd occasions (Vet 1, 2, 3, 5 and 6; 8.74 ± 34.678 mm difference) and Group II, included veterinarians who had used the scale with higher repeatability (Vet 4, 7, 8 and 9; 2.984 ± 21.793 mm difference) **(Figure 4.4)**.
For the most reliable assessor (Vet 7) the mean difference between 1st and 2nd rating was 1 mm and in 95% of the assessments 2nd ratings were between 16 mm higher and 18 mm lower than 1st ratings. For the least reliable assessor (Vet 6) the mean difference was 15 mm and 95% of 2nd ratings were between 57 mm higher and 27 mm lower than 1st ratings.

For a member of Group II (Group I values in parentheses) the mean difference was 3 mm (8.7 mm) and in 95% of 2nd ratings these were between 24 mm (43 mm) higher and 18 mm (25 mm) lower than the 1st assessment.

A significant correlation was found between 1st and 2nd rating for all assessors and all radiographic features.

The most reliable radiographic feature when all views, joints and assessors were combined was "subchondral bone lysis". When the ratings were analyzed for joint and radiographic projection, "subchondral bone lysis" was the most reliable feature in the LM view for all assessors and in the DM-PlLO view for the assessors of Group I. For Group II, the most reliable feature in the DM-PlLO view was "irregular subchondral bone".

For Group I assessment of "ankylosis" was most reliable in the DL-PlMO and "osteophytes" in the DP view. For Group II this was "periarticular bony bridge formation" in the DL-PlMO and "subchondral bone sclerosis" in the DPl view **(Table 4.5)**.

(A table containing all of the results, additional Bland-Altman plots and further graphical displays can be found in the Appendix/ Figures 4.2.2 p151).

All nine joints were considered independent variables in the analysis of variance as in a preliminary screening the interaction "horse and joint" was significant (P< 2.2e-16). Consequently the variable "horse" was not included in the main analysis. The results of univariable analysis of variance indicated that the effect of "joint", "assessor" and "assessment", but not "radiographic view", on the reliability of radiographic interpretation was significant. When "radiographic view" was excluded from multivariable analysis, the interactions "joint and assessor" and "assessor and assessment" were significant. The combination of "joint and assessment" did not account for a significant proportion of variance (**Table 4.6**: Analysis of variance). The majority of variance was caused by the differing severity of OA in the joints.

Table 4.6: Radiographic rating scale. Analysis of variance

	Df	Sum Sq	Mean Sq	F value	Pr(>F)	
joint	8	267291	33411	510.5308	< 2.2e-16	***
assessor	8	42467	5308	81.1130	< 2.2e-16	***
assessment	1	6174	6174	94.3388	< 2.2e-16	***
joint:assessor	64	40266	629	9.6136	< 2.2e-16	***
assessor:assessment	8	4120	515	7.8694	4.729e-10	***
Residuals	558	36518	65			
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1						

Figure 4.3: Use of radiographic rating scale. Bland-Altman plots showing the results of visual analogue rating for all assessors (vets)

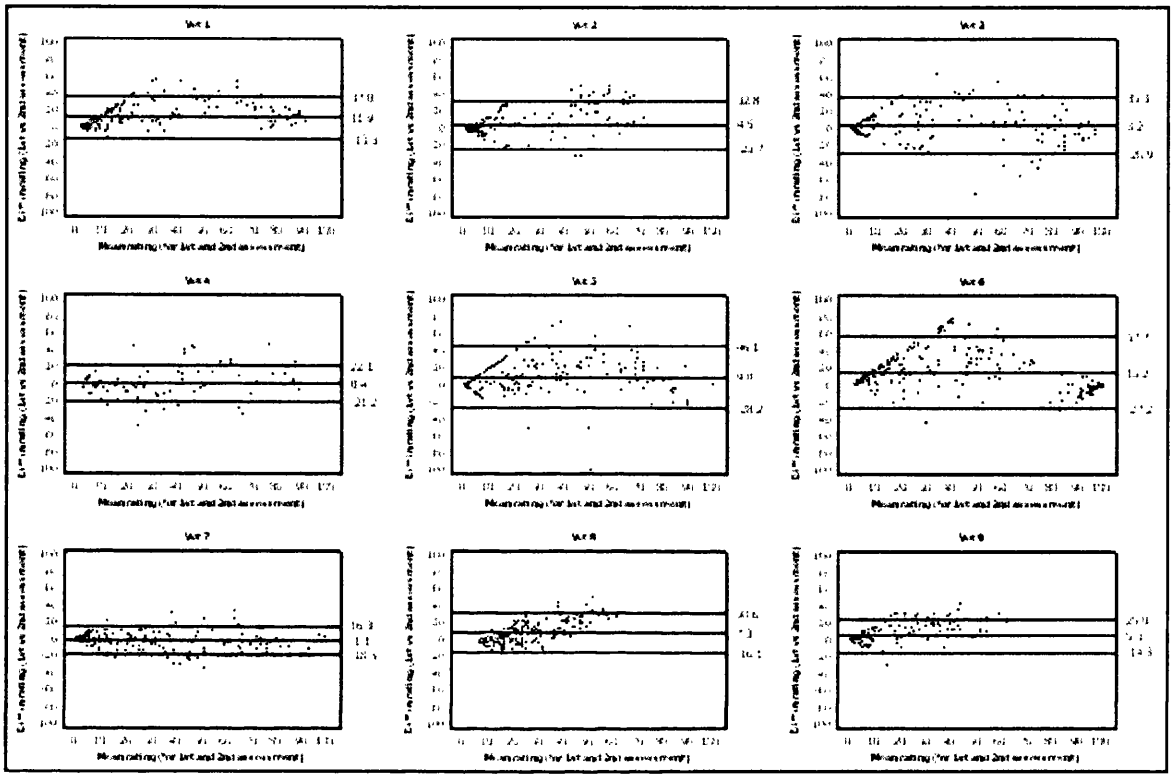
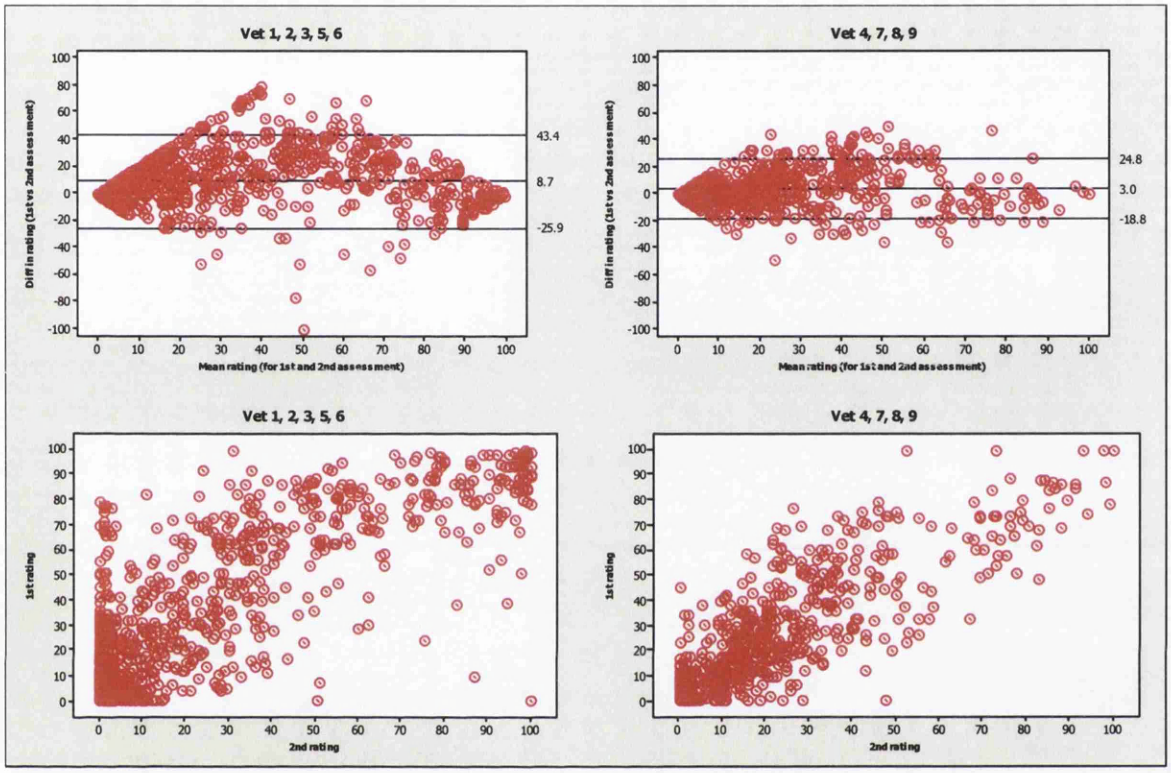


Figure 4.4: Use of radiographic rating scale. Bland-Altman plots showing the results of rating for two groups of different repeatability (Group I = Vet 1, 2, 3, 5, 6; Group II = Vet 4, 7, 8, 9)



The nine joints were ranked (1^{st} - 9^{th}) based on each assessor's total rating at 1^{st} and 2^{nd} assessment (**Figure 4.5** and **4.6**). Four joints were rated reliably on two occasions. Two joints were ranked very high (8^{th} or 9^{th} rank for SET1DIT and SET2DIT) and two very low (1^{st} or 2^{nd} rank for SET2PIT) **(Figure 4.5)**. One of the joints reliably ranked 6^{th} (SET2 TMT). The joint rank based at the 1^{st} assessment was compared to the joint rank at the 2^{nd} assessment, which shows the results clustered along the line of equality (**Figure 4.6**). Use of the joints' rank for assessing the reliability of the total joint rating facilitated comparison of the visual analogue rating scale with the verbal descriptive rating scale.

Figure 4.5: Radiographic rating scale. Joint rank based on the assessors' total visual analogue rating at 1st and 2nd assessment (DIT = distal intertarsal joint, TMT = tarsometatarsal joint, PIT = proximal intertarsal joint; SET 1, 2 or 3 refers to the 4 standard radiographic views for each of the three horses)

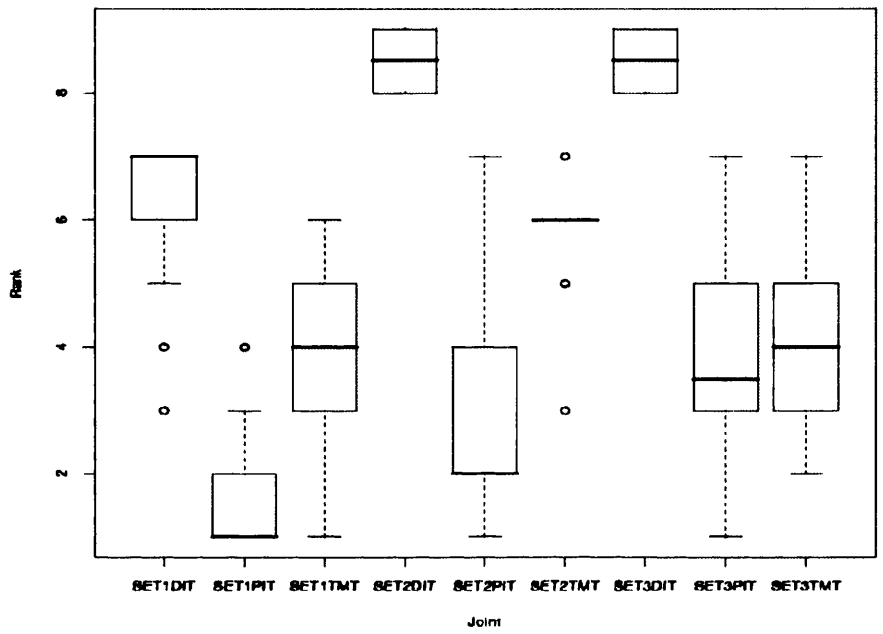
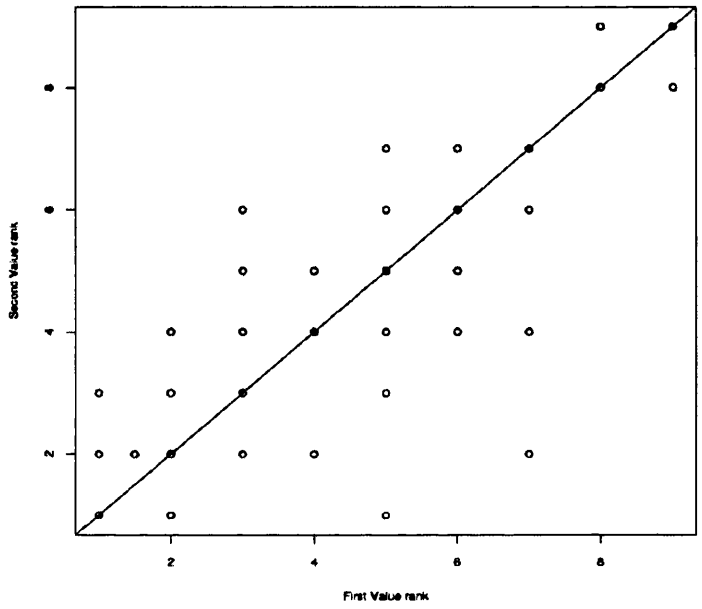


Figure 4.6: Radiographic rating scale. Joint rank at 1st and 2nd assessment using visual analogue rating scale



4.3.5. Results from the use of a qualitative radiographic rating scale

The reliability of the verbal descriptive rating was illustrated for each assessor by plotting the difference in verbal rating between 1st and 2nd assessment (**Figure 4.7**). Vet 7 was the only assessor who gave the same verbal descriptive assessment on both readings. When ratings were different, they were on average less on the 2nd assessment. The frequency of each rating per joint can be seen in **Figure 4.8**. Plotting the joint ranks determined from the visual analogue rating scale against their verbal assessment (**Figure 4.9**), showed that there was good correlation between the two rating scales.

Figure 4.7: Radiographic rating scale. Reliability of verbal descriptive rating ("mild", "moderate", "severe")

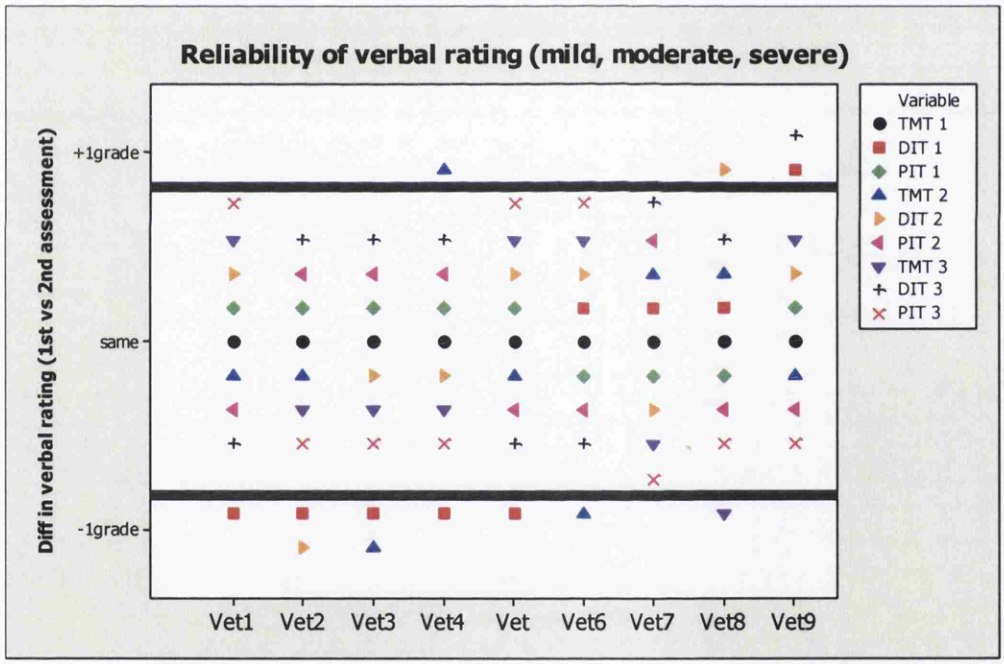


Figure 4.8: Radiographic rating scale. Frequency of verbal descriptive ratings per joint

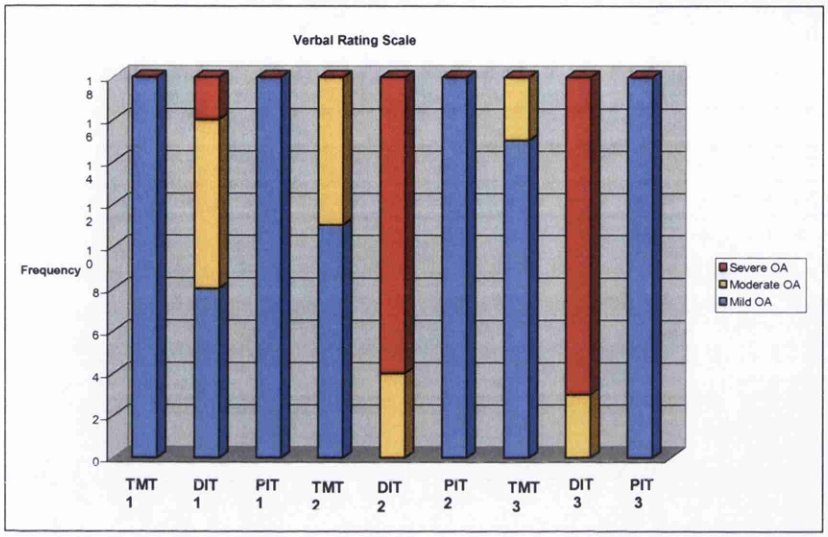
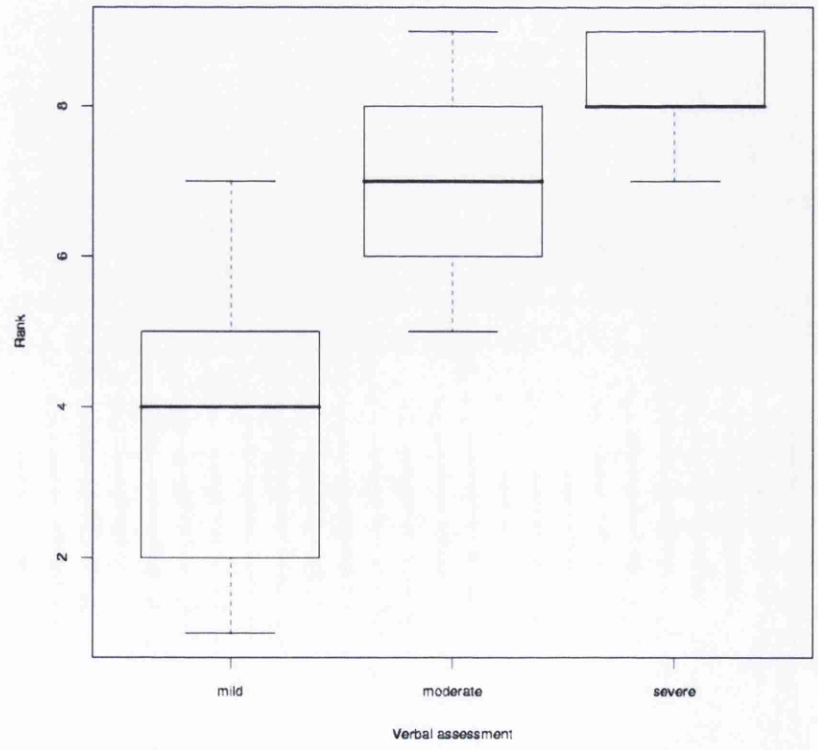


Figure 4.9: Radiographic rating scale. Joint rank versus verbal descriptive ratings



4.4. Discussion

To the author's knowledge, this is the second report of a veterinary application of a Delphi consultation process for qualitative research (Hotchkiss, 2004). In Hotchkiss' study, which investigated historical information and clinical signs associated with recurrent airway obstruction in horses, 19 of 26 invited experts (73%) agreed to participate. In this study, nine of 17 invited experts (53%) participated, giving a lower questionnaire return rate. Qualitative consensus methods are preferable means of investigation when published information is inadequate and quantitative data, for example based on meta-analysis, is lacking. Characteristic features of consensus methods are anonymity of the participants' responses, iteration of the process and controlled feedback (Jones and Hunter, 1995). The Delphi consultation process combines all of the above principles. In addition it is characterized by the consultation process being conducted by questionnaire. Its advantage over other consensus methods is the anonymity of the process which guarantees that the knowledge of other experts participating has no influence on the decision making process. The iterative nature together with the controlled feed back of the group's and the individual's response allows the participant to reconsider his/her response. This may result in the development of a consensus or in less dispersion of the initial results. In the consultation process used here, for 16 of the 33 radiographic features considered, the interquartile range, a measure of dispersion, became narrower by one ordinal group of radiographic importance over the two rounds. Thus as a result of five experts changing their response, the group's opinion became more unanimous.

For the purpose of this study it was not necessary to achieve complete agreement on the exact clinical radiological importance of each feature but rather to identify which ones would generally be of higher importance, so that they could be carried forward and used in the development of a rating scale. Radiographic features for which the interquartile range started in or above group d (41-60), were considered sufficiently important for this purpose.

Features which consistently showed a wide interquartile range spanning four or more groups of importance were "enlarged joint space" and "indistinct or sclerotic synovial fossae". With respect to the assessment of synovial fossae (foramina interossea), it appears that despite some uncertainty over the feature's exact importance as an indicator of DTJ OA, the experts agreed that it was of low importance compared to the other features. A possible explanation for the large interquartile range could be that the assessment of

synovial fossae is not commonly practiced by all experts. This is consistent with two experts' comments that they did not recognize the terminology. Nevertheless, all of the radiographic features used in the questionnaire for the Delphi consultation process have been described in the veterinary literature (Dik, 1983; Barneveld, 1983b; Roethlisberger and Ueltschi, 1989; Verschooten and Schramme, 1994; Eksell *et al.*, 1999; Sullins, 2002). Unfortunately confusion over terminology may have affected evaluation of the importance of "synovial fossae" (Roethlisberger and Ueltschi, 1989; Burtscher, 1994) because this radiographic feature may have been better known to some experts as "foramina interossea" (Verschooten and Schramme, 1994), a term that was not used in the questionnaire. A similar situation may also have led to the large interquartile range for the feature "enlarged joint space". "Enlarged joint space", "subchondral bone lysis" and "irregular subchondral bone" describe, to a degree, different aspects of a similar radiographic appearance. "Irregular subchondral bone" and "subchondral bone lysis" both received similarly high ratings, suggesting that the experts may have recognized an overlap between these features. In contrast, responses for "enlarged joint space" were different and the very wide interquartile range, especially during the first round of the process (group a-f), may have reflected differences in the experts' definition of this feature. Overlap in radiographic interpretation could also have occurred for "subchondral bone sclerosis" and "poor corticomedullary definition" as these features arguably describe different aspects of a similar radiographic appearance. The assessments for these two features however, were different, implying that they were interpreted as two separate entities. One of the experts did specifically address the potential overlap by commenting that she did not appreciate a difference in the features' radiographic appearance.
The author intended to investigate possible intercontinental differences in the radiographic interpretation of DTJ OA, but the low number of participants from North America unfortunately prevented this.

The Delphi questionnaire was designed so that the same radiographic features were listed for each joint. It was interesting to observe that some experts attributed radiological importance to a bony spur at the dorsoproximal aspect of Mt 3 (i.e. a bony spur adjacent to the TMT joint) when assessing OA in the DIT (three experts) or PIT joint (two experts). The author anticipated that this feature would only be considered relevant to assessment of the TMT joint. Although the result may have been due to operator error it is conceivable that the results reflected a true difference in radiographic interpretation between experts.

Despite concerns over the understanding of terminology, the consultation process established which radiographic features are considered important indicators of DTJ OA by a group of international experts. The findings supported the commonly expressed opinion that subchondral bone lysis is a very important radiological finding (Dyson, 2004), as this feature had the highest agreement in the consultation process. The radiological importance of subchondral bone lysis has recently been confirmed, as histopathology has identified small areas of lysis were found to be associated with cartilage defects in Icelandic horses with DTJ OA (Bjornsdottir *et al.*, 2004a). In the same investigation subchondral bone sclerosis was not found to be an early feature of OA of the DIT joint. This contrasts the experts' opinion that subchondral bone sclerosis is an important radiographic feature for the assessment of OA in the DIT and PIT joint.

From the results of the survey of radiographic technique used by the experts it is obvious that differences exist in regard to the use of grids, angulation of the x-ray beam and which projections are obtained routinely. Of particular interest was that one expert attributed greater diagnostic importance to the LM view, while a different expert judged the DM-PlLO view to be a superior projection. Verschooten and Schramme (1994) stated that the DL-PlMO is the most informative projection for assessment of DTJ OA. Roethlisberger and Ueltschi (1989) found the LM projection to be most useful for interpretation of moderate to severe OA changes, while the DL-PlMO view had a higher diagnostic value in cases with mild changes. When the diagnostic value of LM and DPl projections in horses with DTJ OA was compared, the LM was the more useful (Burtscher, 1994). Eksell *et al.* (1999) compared all four standard tarsal projections in a group of Icelandic horses with DTJ OA and found that the highest proportion of radiographic abnormalities were identified in the PlL-DMO, and not in the DL-PlMO view as suggested by Verschooten and Schramme (1994). Given that the findings outlined above were from studies of populations with different breed compositions (Burtscher made his observations in Standardbred trotters, Eksell in Icelandic horses, and Roethlisberger and Ueltschi in a population that was mostly Warmbloods), it is likely that there are breed differences in the localisation of radiographic signs consistent with DTJ OA. As a consequence the diagnostic value of each radiographic projection may be determined by the type of horse being examined. It is evident however, that early OA changes are not localized to specific regions of the DIT joint (Barneveld *et al.,* 1983b; Bjornsdottir *et al.,* 2004a) and therefore differences in the diagnostic value of radiographic projections may reflect inconsistencies in radiographic quality between projections and the sensitivity of radiography for

identifying OA (Laverty *et al.*, 1991). Although no differences were found between radiographic projections when the visual analogue rating scale was used in this study, the design of the study prevented analysis of the reliability of the different projections. As the three sets of radiographs, each comprising four projections, were made available to each assessor simultaneously, the rating of each radiographic projection was likely to be influenced by comparison of radiographic abnormalities between the projections. This bias is avoided by randomizing the order in which the radiographs are evaluated and only allowing one radiograph at a time to be evaluated as done by Eksell *et al.* (1999).

From the experts' comments it was clear that minor radiographic changes would be considered to be more important if they were found in combination with other changes but that certain radiographic features were always important even when present in isolation.

Burtscher (1994) proposed the use of a weighted quantitative radiographic rating scale for horses with DTJ OA in which the weighting for each radiographic abnormality was based on its perceived importance. In pairs of decreasing order of importance, the features were: ankylosis and periarticular bony bridge formation; osteophytosis; subchondral bone lysis and indistinct synovial fossae/foramina interossea; sclerotic synovial fossae/foramina interossea and subchondral bone sclerosis; and narrow or enlarged joint space and irregular subchondral bone.

When developing the quantitative rating scale a weighting factor was incorporated to account for differences in the clinical significance of abnormalities which might appear to be of similar radiographic severity. Instead of assigning a random weighting, like Burtscher (1994), weighting factors for radiographic features were deduced from the median of their responses.

Features which were identified by the experts as not very important for making the diagnosis of DTJ OA were: corticomedullary definition; enlarged joint space; bony spurs on the dorsoproximal aspect of Mt 3; indistinct or sclerotic synovial fossae for all joints; and also subchondral bone sclerosis in the TMT joint. Three of these features formed part of Burtscher's rating scale.

The Delphi consultation process was an efficient means to obtaining expert information on the subject matter. To sustain expert compliance however, the process was modified by being predetermined to last for two rounds only, rather than until no further expert agreement was obtained between rounds. An introductory round, asking experts to define

the radiographic features of DTJ OA, was also omitted as this information was available in the literature. The consultation process enabled seven radiographic features to be identified, which the experts considered important for a radiographic diagnosis of DTJ OA, and then used in the design of a quantitative rating scale.

Various radiographic rating scales for use in horses with DTJ OA have been described in the literature. Examples are a complex qualitative verbal descriptive rating scale (Barneveld,1983), rating scales which attribute numeric scores to verbal descriptive ratings (Dik, 1983) and scales which assign qualitative verbal ratings according to the lesions' size and extent (Laverty *et al.*, 1991) or according to the number and/or extent of changes (Eksell *et al.*, 1999; Bjornsdottir *et al.*, 2000b; Dechant *et al.*, 2003). Burtscher (1994) and Scruton (2005) used a quantitative scale, attributing radiographic abnormalities a numeric score according to their perceived severity. Zubrod *et al.* (2005) proposed a dichotomous rating scale using ratings according to the presence of radiographic changes per joint and view (Zubrod *et al.*, 2005).
The basis of the radiographic rating scale developed in this study was a visual analogue rating scale, in which each assessor indicated the severity of each radiographic feature as he perceived it. The radiographic index was obtained by multiplying the actual measurement on the scale with the weighting factor.

The nine veterinarians who participated in the experiment investigating the reliability of the radiographic rating scale, represented different levels of veterinary experience, ranging from a first year resident[a] to a board certified radiologists. As can be seen from the Bland-Altman plots in **Figure 4.3,** repeatability between observers was very different. Professional experience however did not appear to have an effect as the person with the greatest repeatability was not the board certified radiologist but the most recently graduated veterinary surgeon and junior resident. The relationship between experience and repeatability observed for a simple ordinal rating scale for use in radiology in man (Gunther and Sun, 1999) did not appear to apply to this study.
From the graphs in **Figure 4.3** and **4.4,** one would assume that the reliability of the rating scale did not increase with use of extreme (close to 0 or 100) compared to midrange ratings, as all differences between first and second rating showed a similar distribution along the line of equality (zero difference).

[a] Senior clinical scholar in equine orthopaedics (three year post graduate training position in equine orthopaedics)

The fact that results cluster at the lower and upper end of the scale should not be mistaken for evidence of high repeatability as it is consequent to the graphical analysis, which uses the difference between ratings and the mean rating for illustration (Bland-Altman plot). However when the joints' rank from both ratings was graphically displayed, a higher reliability for joints with severe and very mild osteoarthritic changes was illustrated **(Figure 4.5)**.

Apart from Vet seven's results, 2nd ratings were lower than first, suggesting that recall of the first assessment may have influenced the second despite the 6 week interval, which was chosen subjectively but compares to other studies (Kallman *et al.*, 1989). Despite the interval being similar to the one used in other studies, it may have been too short to prevent assessors remembering the most severe OA changes from the first rating and subsequently comparing those to the OA changes seen on 2nd rating. Other investigations of the reliability of radiographic rating scales have used intervals of 3 months (Gunther and Sun, 1999) or two weeks (Innes *et al.*, 2004) between repeated assessments.

Following univariable analysis of variance, the observations from Bland-Altman plots that joints were graded differently, ratings were different between assessors and that ratings varied between the two assessments, were all found to be significant ($P < 0.000$).
Following multivariable analysis a significant difference in ratings was seen for the interaction "assessor and joint" ($P < 0.000$) and "assessor and assessment" ($P < 0.000$), providing evidence that assessors varied in their rating of joints and that assessors also differed in their change in rating at the 2nd assessment, suggesting that interobserver reliability of the rating scale was poor in use.
No significant difference was observed in ratings analysed according to "joint and assessment", which indicated that rating of OA was not a completely random event ($P=0.21$). A Pearson correlation test also illustrated a significant correlation between the assessors' 1st and 2nd rating, providing more statistical evidence that the ratings were not random.

With the use of this rating scale subchondral bone lysis was the most repeatable radiographic abnormality **(Table 4.5)**. It was of particular interest that "subchondral bone sclerosis", a feature which has been associated with very poor repeatability and reproducibility in the canine stifle (Innes *et al.*, 2004), was the most repeatable feature in

the DPl view for the group of assessors with high repeatability. For the other assessors "osteophytes" was the most repeatable feature in this projection.
The reliability of individual radiographic features is likely to vary with the joint affected. This has been shown for the assessment of OA of the hip and knee in man (Gunther and Sun, 1999), which suggests that comparison of the results of reliability studies for different joints, and probably different species, should be done with caution.

As mentioned earlier in this section, univariable analysis did not show a significant difference in rating for the four radiographic projections. This may have been caused by a potential flaw in the study's design, as all projections were made available to an assessor at the same time. Consequently assessment of a projection may have been influenced by the others in a set, leading to the over- or under interpretation of radiographic findings. In Eksell *et al.*'s (1999) study under interpretation appeared to occur. In 10 percent of evaluated tarsi no OA was detected when the four standard projections were read in combination, whilst when only one projection was assessed at a time evidence of OA was identified (Eksell *et al.*, 1999). Nevertheless, the result that "view" was not a significant variable (P=0.8518) may suggest that the tarsal radiographs may have been read in combination.

The main purpose of Eksell *et al.*'s (1999) paper was to investigate whether differences in diagnostic value for DTJ OA exist between the four standard tarsal projections and as such the study was not designed to investigate the reliability of a radiographic rating scale. Eksell *et al.* (1999) used three assessors but ratings appeared to have been performed on the basis of the group's consensus, thus only allowing the group's reliability to be evaluated. The rating of OA changes was based on the total amount of DTJ surface affected and the qualitative verbal rating (none, mild, moderate or severe) applied to the entire distal tarsus. If used clinically, this generalized assessment may not allow the progression of individual radiographic abnormalities to be monitored.

For statistical analysis of agreement, kappa (κ) analysis (Tooth and Ottenbacher, 2004) is frequently used (Eksell *et al.*, 1999; Kessler *et al.*, 2000; Innes *et al.*, 2004). In the study by Eksell *et al.* (1999), the use of κ-analysis for measurement of agreement may have been inappropriate as rating was performed on the basis of the group's consensus rather than independently (Tooth and Ottenbacher, 2004).

Kappa analysis was thought to be inadequate for the purpose of this study. The study's main purpose was not to investigate if an assessor was able to exactly reproduce his visual analogue rating, which would be unlikely, but rather to illustrate by how much radiographic ratings would differ, when they were repeated twice.

Based on the results of the most repeatable assessor (-1.121 ± 17.399 mm) it can be concluded that at best an assessor is able to differentiate between 5 or 6 degrees of severity. In contrast, the least repeatable assessor (15.21 ± 42.453 mm) in this study was only able to differentiate between two degrees. These findings suggest that whatever type of rating scale is used, it should not provide the operator with more than five choices and that this may even be too many for some assessors to differentiate between.
This statement is supported by the author's observation that the reliability of the qualitative verbal rating scale was much higher than the visual analogue scale **(Figure 4.7)**.
Comparison of the qualitative verbal with the quantitative rating scale illustrated a good correlation between the verbal ratings and visual analogue assessments **(Figure 4.9)**.

In man, depending on the way it is presented three to 11 dimensions of information can be processed to form a judgment reliably (Hoffman *et al.*, 1968; Slovic, 1969; Ebbesen and Konecni, 1975; Phelps and Shanteau, 1978) . This was supported by the finding from this study that information from seven radiographic features (dimensions) was used by the assessors to assess reliably if osteoarthritis of the DTJ was mild, moderate or severe.

In conclusion, the author does not advocate the use of the rating scale developed in this study unless each user first assesses his repeatability and obtains similar results as Vet 7 in this study. Dichotomous rating scales, assessing the presence, or absence, of osteoarthritic changes only (Zubrod *et al.*, 2005) or scales incorporating few ratings (Eksell *et al.*, 1999; Dechant *et al.*, 2003) may therefore be more repeatable, as has been shown for rating scales for OA in man (Kallman *et al.*, 1989; Kessler *et al.*, 2000) and the dog (Innes *et al.*, 2004).
This study has however, facilitated the identification of seven "important" radiographic features of DTJ OA through expert consensus. These may be of considerable assistance to the development of other rating scales for the radiographic interpretation of DTJ OA.

CHAPTER 5

A RETROSPECTIVE STUDY OF CONSERVATIVE TREATMENT OUTCOME IN 51 HORSES WITH OSTEOARTHRITIS OF THE DISTAL TARSAL JOINTS

CHAPTER 5:

A RETROSPECTIVE STUDY OF CONSERVATIVE TREATMENT OUTCOME IN 51 HORSES WITH OSTEOARTHRITIS OF THE DISTAL TARSAL JOINTS

5.1. Introduction and aims of the study

In distal tarsal osteoarthritis (OA), affecting the tarsometatarsal (TMT), distal intertarsal (DIT) and occasionally the proximal intertarsal (PIT) joint, three separate clinical presentations have been distinguished: tarsitis or lameness attributed to periarticular soft tissues; juvenile distal tarsal OA; and adult-onset distal tarsal OA (Baxter *et al.*, 2003b). In horses with tarsitis and adult-onset distal tarsal OA, repetitive overload, resulting in excessive compressive and rotational forces is responsible for the development of the disease (Gabel, 1979a; Baxter *et al.*, 2003b). Performance activity (Gabel, 1983), breed (Bjornsdottir *et al.*, 2000b), heritability (Axelsson *et al.*, 2001; Arnason and Bjornsdottir, 2003; Barneveld, 2004) and conformational defects (Barneveld, 1983b; Eksell *et al.*, 1998), have been identified as predisposing factors. Developmental disorders of the cuboidal tarsal bones, such as osteochondrosis or incomplete ossification, have been incriminated as causes of juvenile distal tarsal OA (Bohanon, 1998), however the role of osteochondrosis is controversial (Watrous *et al.*, 1991; Barneveld and van Weeren, 1999).

The diagnosis of OA of the distal tarsal joints (DTJ) is based on the presence of hindlimb lameness which improves with intra-articular (i.a.) analgesia of the TMT and DIT joint (Dabarainer *et al.*, 2003). Radiography (Butler *et al.*, 2000), nuclear scintigraphy (Murray *et al.*, 2004; Murray *et al.*, 2005) and magnetic resonance imaging (Branch *et al.*, 2003) are useful clinical imaging modalities. However, the presence of abnormal radiographic findings may be overlooked (Laverty *et al.*, 1991) and their severity does not correlate with the degree of lameness (Hartung *et al.*, 1983; Burtscher, 1994). Scintigraphy has been reported to be more sensitive than radiography for detecting bone pathology in horses with DTJ OA (Driesang and Boehm, 1993).

Management options range from medical or non-surgical treatment such as restricted exercise, corrective shoeing, systemic administration of nonsteroidal anti-inflammatory drugs (NSAIDs), i.a. medication and alternative therapies (e.g. acupuncture, magnetic therapy, therapeutic ultrasound, extracorporeal shock waves) to surgical treatment, like

neurectomy, cunean tenectomy or techniques facilitating arthrodesis or decompression of the distal tarsal bones (Platt, 1997; Baxter *et al.*, 2003a). While the outcome of surgical treatment is well reported in normal (Scruton *et al.*, 2005; Zubrod *et al.*, 2005) and affected horses (Wyn-Jones and May, 1986; Stanger *et al.*, 1994; Imschoot *et al.*, 1995; Jansson *et al.*, 1995; Sammut and Kannegieter, 1995; Eastman *et al.*, 1997; Adkins *et al.*, 2001; Dechant *et al.*, 2003; Dowling *et al.*, 2004), little objective information is available on the results of non-surgical treatment (Newman *et al.*, 2000; Clayton *et al.*, 2002; McCarroll and McClure, 2002) and the evidence for the outcome following i.a. medication is only anecdotal (Platt, 1997; Gough and Munroe, 1998; Clegg and Booth, 2000; Schramme, 2000; Baxter *et al.*, 2003b; Dyson, 2004).

The aim of this retrospective study was to document the immediate and long term treatment outcome in horses receiving i.a. corticosteroids such as methylprednisolone acetate (MPA; Depo-MedroneV[1]) and triamcinolone acetonide (TR; Adcortyl[2]) in combination with or without hyaluronic acid (HA; Hyonate[3]) for treatment of OA of the DTJ.

Hypotheses for this study were that there is improvement in lameness following the use of i.a. medication for treatment of OA of the DTJ, that there is a difference in improvement using i.a. TR (+/- HA) versus MPA, and that there is a difference in lameness following i.a. medication of DTJ showing diffuse versus focal increases in radiopharmaceutical uptake (IRUs) on scintigraphic examination of the tarsi.

5.2. Materials and Methods

5.2.1. Case selection

Horses were identified via a computer search of the 1998 to 2005 hospital data base, containing all case reports to referring veterinary surgeons. For this search the following key words were used:
"osteoarthritis - OA - bone spavin - TMT - DIT - tarsometatarsal joint - distal intertarsal joints - distal tarsal joints"

During this seven year period the same senior clinician was responsible for the lameness cases, thus all lameness examinations were conducted in a consistent manner.

Horses were included if hindlimb lameness improved by ≥50% following i.a. analgesia of the TMT and/or DIT joint and if joints had received i.a. medication with TR (+/- HA) or MPA.

If i.a. analgesia was performed in one limb only in horses with bilateral disease, the contra-lateral DTJ were required to show IRU on scintigraphic examination for the case to be included in the study. Contra-lateral hindlimb lameness, that only became apparent following i.a. analgesia, was not used for further analysis.
Horses were excluded if other causes of lameness in the same limb or neurological signs consistent with ataxia or weakness were identified at any examination.

5.2.2. Collection of data

The paper hospital records were reviewed, the name of the primary clinician recorded and the following information was extracted for each case: age; breed; sex; use; lameness at first and follow up examinations; gait characteristics; results of diagnostic analgesia; and the nature and response to initial and follow-up treatment.

5.2.3. Assessment of lameness

Lameness was assessed under standardised conditions: at the walk and trot in a straight line on a hard surface; and at the trot on the lunge on both reins on hard and soft surfaces. Lameness was graded according to a numerical rating scale based on the AAEP lameness score (AAEP, 1999), but allowing half grades (0 = not lame and 5 = not weight bearing). During follow up examinations lameness was assessed under the conditions which had enabled the lameness to be most clearly seen at the initial examination.

5.2.4. Radiographic assessment

Four radiographic views, dorsoplantar (DPl), dorsolateral-plantaromedial oblique (DL-PlMO), dorsomedial-plantarolateral oblique (DM-PlLO) and lateromedial (LM) views of all affected tarsi were assessed in a blinded fashion by one single viewer (Raphael Labens), who was experienced in radiographic interpretation. All of the images had been obtained according to standard radiographic technique (Butler *et al.*, 2000).

Following assessment of the DTJ in each of the four views, OA was graded as absent, mild, moderate or severe for each joint (DIT, TMT, and PIT). In addition radiographic changes - irregular and sclerotic subchondral bone, narrowed joint space, osteophytes,

periarticular bony bridge formation, subchondral bone lysis and ankylosis - were noted as absent or present in each joint.

5.2.5. Scintigraphic assessment

At 2 ½ to 3 hours post injection of technetium 99m-methylene diphosphonate (^{99m}Tc-MDP at 1GBq/100 kg bwt)[4], lateral and plantar images centered on the tarsi were obtained using a gamma camera with a 53 x 39 cm field of view, fifty-five photomultiplier tubes and low energy general purpose collimator[5]. Lateral bone phase images were acquired for 150 000 and plantar images for 300 000 counts using a matrix size of 256 x 256 x 16.

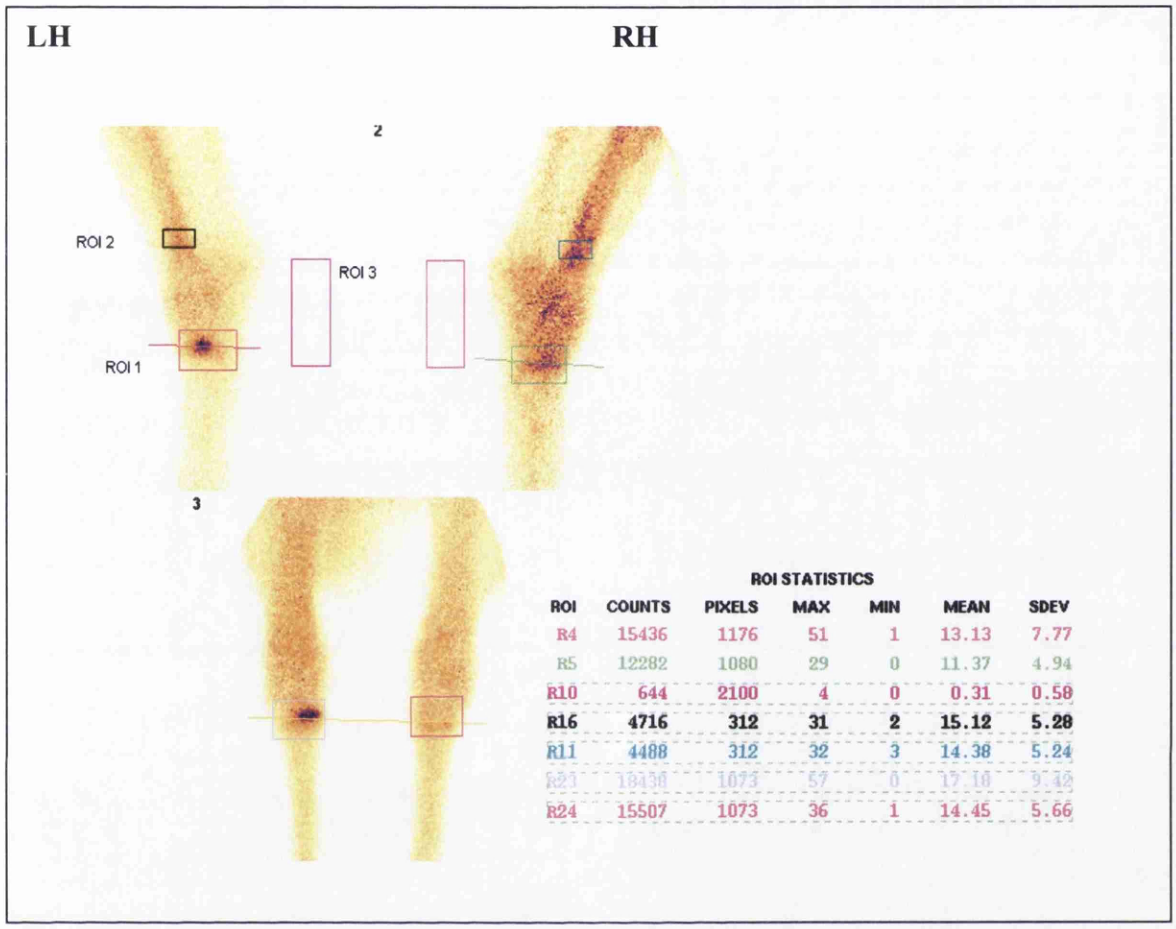
All scintigraphic images were assessed in a blinded fashion by six different veterinary surgeons, all of whom were experienced in the assessment of scintigraphic images. IRUs were described as diffuse or focal.

In horses in which a majority of observers ($\geq$4 people) identified focal IRU, the surface area of the focal uptake was measured in relation to the surface area of the DTJ on lateral or plantar scintigraphic images. To facilitate comparison with published data (Murray *et al.*, 2004) regions of interest were drawn on the scintigraphic images and the mean number of counts (MNC) for each region was calculated **(Figure 5.1)**. In lateral scintigrams the MNC for a region plantar to the DTJ (ROI_3), representing an area of background radiation, was subtracted from the MNC for the region of the distal tibia (ROI_2) and the DTJ (ROI_1) to derive MNCs adjusted for background.

An increase in radiopharmaceutical uptake for the DTJ was expressed as the ratio of the adjusted MNC for ROI_1 divided by the adjusted MNC for ROI_2.

In plantar images, which included both tarsi, the MNC for the DTJ region was directly compared to the value for the contra-lateral tarsus.

Figure 5.1: Scintigraphic images of the tarsi. Examples of focal (LH) and diffuse (RH) increased radiopharmaceutical uptakes (IRUs)



Surface area measurements were completed on digital images using the Universal Desktop Ruler® software program[6].

The analyses of radiopharmaceutical uptake were performed using dedicated nuclear medicine software[7].

5.2.6. Definition of treatment outcome

Short term treatment outcome following i.a. medication was assessed using the difference in lameness grade between initial and follow up examinations. This was only done in horses that were treated and re-examined by the same primary clinician.

Preferentially, only grades from examination at the trot in a straight line were analysed. If no obvious lameness was evident in a straight line, grades were obtained from examination on the lunge. In horses with bilateral lameness, the grade of the lamer limb, assessed at the trot in a straight line was used. The grade of the less lame 2nd limb was determined by the results of examination at the trot on the lunge.

In addition horses were classified as "lame" or "sound" based on information from each re-examination. Information from primary clinicians, who did not perform the previous assessment or treatment was allowed for this assessment.
Long term follow up was assessed by conducting an owner telephone survey. A positive treatment outcome was no lameness with the horse able to perform as intended without receiving oral NSAIDs. Horses that developed other health problems, preventing their return to exercise and horses that had been treated surgically following management with i.a. corticosteroids were excluded from further analysis.

5.2.7. Telephone follow-up

In a letter, addressed to the principal of each veterinary practice responsible for referring a study case, permission was asked to interview a horse's owner by telephone **(Accompanying material, p132)**. Owners for whom permission was obtained were contacted and asked the following questions in the exact order stated below:

- What is the horse's current workload?
- Did bone spavin alter what you can do with the horse?
- Does your horse suffer from any other health problems?
- Did you seek veterinary attention since your horse was last seen at the hospital?
- Are you giving your horse any medication or feed supplementation?
- Do you think your horse is lame?

The information obtained was used for analysis of long term treatment outcome.

5.2.8. Statistical analysis

The difference in lameness grade between examinations was tested using a Wilcoxon signed rank test. The change in lameness grade following the first i.a. treatment was compared between different groups using a Mann Whitney test. Group 1 were horses with moderate and severe radiographic evidence of OA of the DIT and TMT joints and Group 2 comprised horses with mild or no evidence of OA of the DIT and TMT joints. In each group, horses whose TMT and whose DIT and TMT joints were medicated with MPA or TR (+/-HA) were identified. Change in lameness grade was compared between groups for horses in which the same joint was medicated with the same agent and within groups for

horses with different agents or joints medicated. Significance for statistical tests was set at $P < 0.05$. All statistical tests were performed using Minitab Version 14 [8].

5.3. Results

5.3.1. Case details

The computer search of the 1998 to 2005 hospital database identified 113 horses in which the diagnosis of OA of the DTJ had been made. Nineteen horses were excluded from the study as they showed less than 50% improvement in lameness following i.a. analgesia of the TMT and/or DIT joint. Five horses were found to have causes of hindlimb lameness other than DTJ OA on initial or follow-up examinations and one horse showed neurological signs. These horses were also excluded. Of the remaining 88 horses, 51 horses were treated using i.a. medication and were re-examined at the hospital. These horses formed the study population.

Of the 51 horses, 35 were geldings, 15 mares and one was an intact male. Median age was 9 years (range 4 -18 years). There were 28 Thoroughbreds, Warmbloods or their crosses. Twenty-nine of 51 horses were used for general purpose riding (occasional jumping and/or dressage lessons, hacking, pony club activities), 10 for jumping, four for dressage, two for eventing and two horses were used for hunting.
In 18/51 horses a winging foot flight (Gough and Munroe, 1998) and in 14 mediolateral foot imbalance (Platt, 1997) of the hindlimbs was recorded. Twenty-five of 51 horses showed bilateral hindlimb lameness at the first examination and in nine horses bilateral hindlimb lameness became apparent at the follow-up examinations. In 22/51 horses concurrent forelimb lameness was noticed. **(Appendix Table 5.1)**

5.3.2. Intra-articular medication

Fifty-one horses received i.a. medication on ≥1 occasion, with a total of 59 hindlimbs being medicated (17 hindlimbs were treated with TR+HA, four with TR and 38 with MPA). In 19/59 hindlimbs, both the DIT and TMT joint were treated. Forty eight horses were treated and re-examined by the same primary clinician.

Forty-eight horses or 52 hindlimbs were first treated at the initial examination, four horses or four hindlimbs at the first re-examination and two horses or three hindlimbs at the second re-examination.

In 59 hindlimbs treated at least once, lameness improved in 34/59 hindlimbs (57.6%) and 15/59 (25.4%) were sound when re-examined after the first treatment. However, of the 51 horses receiving i.a. medication once, 46 remained lame at the next examination (90.2%) **(Appendix, Table 5.2, 5.9, 5.10** and **5.11).**
Median time between first i.a. treatment and next examination was 56 days (range 18-1436 days) **(Appendix, Table 5.4).**

Fourteen of 51 horses received i.a. medication ≥2 times. Twelve horses were treated and re-examined by the same primary clinician, resulting in 13 hindlimbs that received i.a. medication on two occasions (12 hindlimbs received MPA and one TR+HA). In five of 13 hindlimbs both the DIT and TMT joints were treated. **(Appendix, Table 5.3, 5.9, 5.10** and **5.11).**

Eight horses or 9 hindlimbs were treated for the second time at the first re-examination, two horses, or 2 hindlimbs, at the second and one horse, or one tarsus, at the third and fourth re-examination.

Of 14 horses receiving i.a. treatment for a second time, 14 remained lame at the next examination. In 13 tarsi receiving i.a. medication twice, lameness improved in seven hindlimbs (53.8%), one of which was sound when the horse was re-examined.

Median time between second i.a. treatment and next examination was 50 days (range 25-194 days).
Median time between first and second i.a. treatment was 69 days (range 35-1436 days).
Total median follow up time for 51 horses receiving i.a. medication was 95 days (range 18-1510 days).
Table 5.5 shows the number of re-examinations, the mean and median duration since first examination, the number of lame horses at each time point and the number of horses that had received i.a. treatment on the previous visit to the hospital.

Table 5.5: Time of re-examination and frequency of lameness (Tx = treatment)

	Median N° of days	**Mean N° of days**	**N° of horses**	**N° of lame horses**	**N° of horses with i.a. tx on previous examination**
1st re-exam	56	104	51	48	48
2nd re-exam	108	207	27	25	14
3rd re-exam	212.5	243	14	12	4
4th re-exam	271	442	2	2	1
5th re-exam	319	319	1	1	1

The mean dose of corticosteroid used per joint was 56.7 mg of MPA (median 55 mg; range 20-120 mg) and 9.8 mg of TR (median 9.8 mg; range 5-20 mg).

5.3.3. Exercise post i.a. treatment

Horses were routinely box rested for 2-3 days after i.a. medication, followed by a gradual increase in the duration of ridden exercise at the walk for 7-14 days and at the trot for an additional 3-4 weeks. During that time horses were allowed unlimited turn out.

5.3.4. Radiography

Forty-eight of the 51 radiographic series were available and reviewed. This resulted in information on 59 hindlimbs. All of the horses showed radiographic signs consistent with OA of the TMT and/or DIT joints. Eight of 48 horses had radiographic signs consistent with OA of the PIT joint (six mild, one moderate and one severe) **(Appendix, Table 5.12** and **5.13).**

Horses with a positive long term treatment outcome displayed moderate and severe osteoarthritic changes more often than horses with a negative long term outcome. Horses that were sound or improved by ≥2 grades following i.a. medication showed moderate and severe osteoarthritic changes relatively less frequently than the remainder of the population **(Figure 5.2** and **5.3, Table 5.6).** The frequency of each radiographic feature in this group

is shown in **Figure 5.7.** None of the horses that was sound or improved by ≥2 grades showed signs of OA of the PIT joint.

Table 5.6: Frequency of moderate and severe osteoarthritic changes in the tarsometatarsal (TMT) and distal intertarsal (DIT) joint

Horses	**TMT**	**DIT**
with positive long term outcome	14%	35%
with negative long term outcome	12%	27%
sound or better by ≥2 grades	11%	21%
remainder	15%	31%

OA changes were more severe and, except for osteophytes, individual radiographic features were more frequently seen in the DIT than in the TMT joints (**Figure 5.2, 5.3** and **5.4).**

Horses that had a positive long term treatment outcome had a tendency to display osteophytes, subchondral bone lysis more frequently and subchondral bone sclerosis less often in the DIT joint. TMT joint osteophytes were more frequently seen in these horses (**Figure 5.5** and **5.6).**

In the group of horses with the greatest short term improvement (sound or lameness improved by ≥2 grades), the DIT joints were less frequently medicated and showed fewer moderate and severe OA changes than in the rest of the population (**Figure 5.8, Table 5.7**).

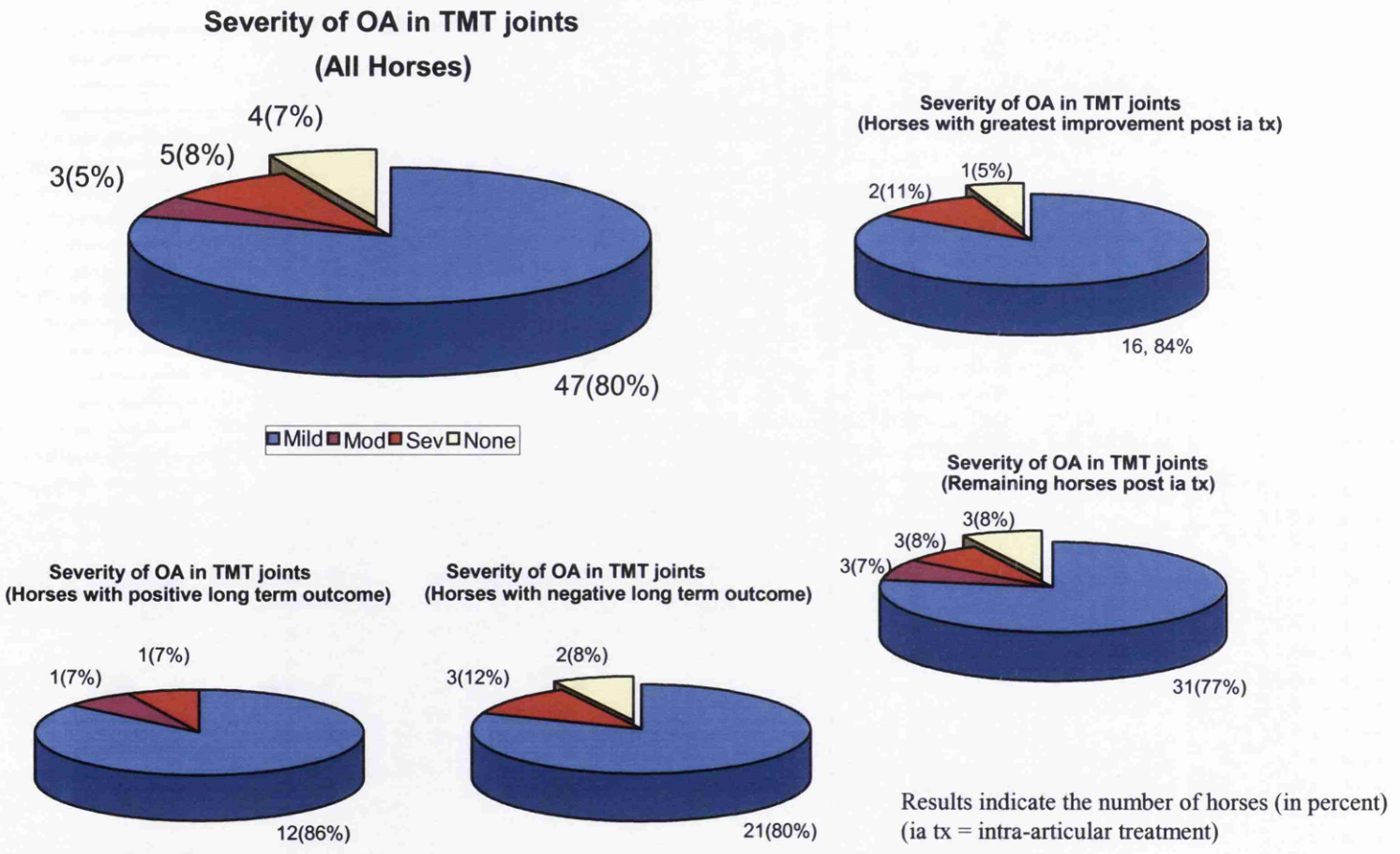
In 12 hindlimbs with diffuse IRU, 10 DIT and 12 TMT joints displayed radiographic evidence of mild OA while in two DIT joints no radiographic evidence of OA was detected.

In six of seven hindlimbs with focal IRU for which radiographic information was available, four DIT and TMT joints had radiographic evidence of mild, one TMT joint of moderate, and two DIT and one TMT joint of severe OA.

Table 5.7: Frequency of tarsometatarsal and distal intertarsal (TMT+DIT) joint medication vs. severity of distal intertarsal (DIT) joint osteoarthritis (OA)

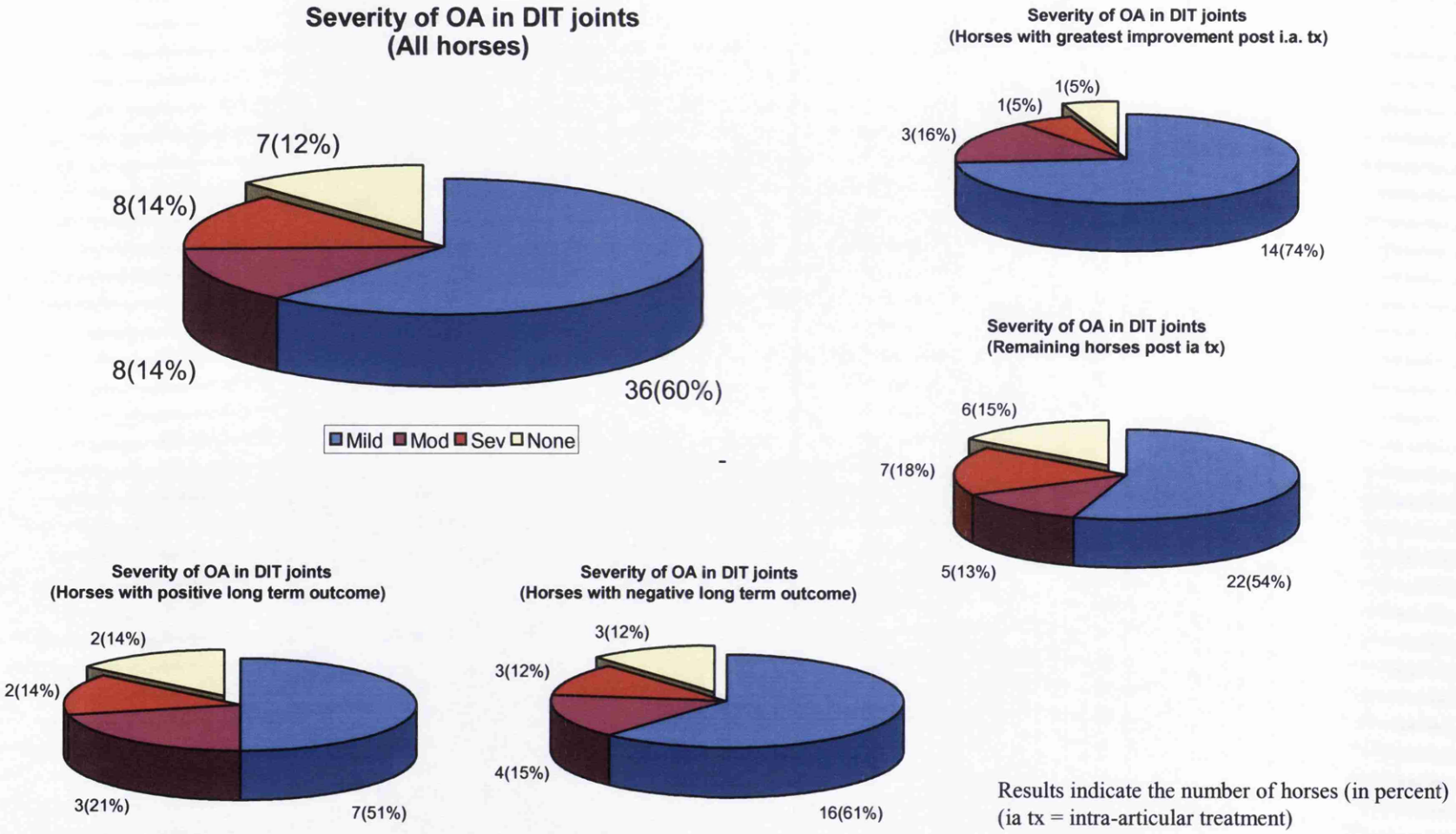
	Medication TMT+DIT	**Frequency of moderate and severe OA changes DIT**
Horses sound or improved in lameness by ≥2 grades	26%	21 %
Rest of the horses	38%	31%

Figure 5.2: Severity of osteoarthritis (OA) in the tarsometatarsal (TMT) joints



Results indicate the number of horses (in percent)
(ia tx = intra-articular treatment)

Figure 5.3: Severity of osteoarthritis (OA) in the distal intertarsal (DIT) joints



Results indicate the number of horses (in percent)
(ia tx = intra-articular treatment)

Figure 5.4: (TMT = tarsometatarsal; DIT = distal intertarsal; irreg subch bone = irregular subchondral bone; jt = joint)

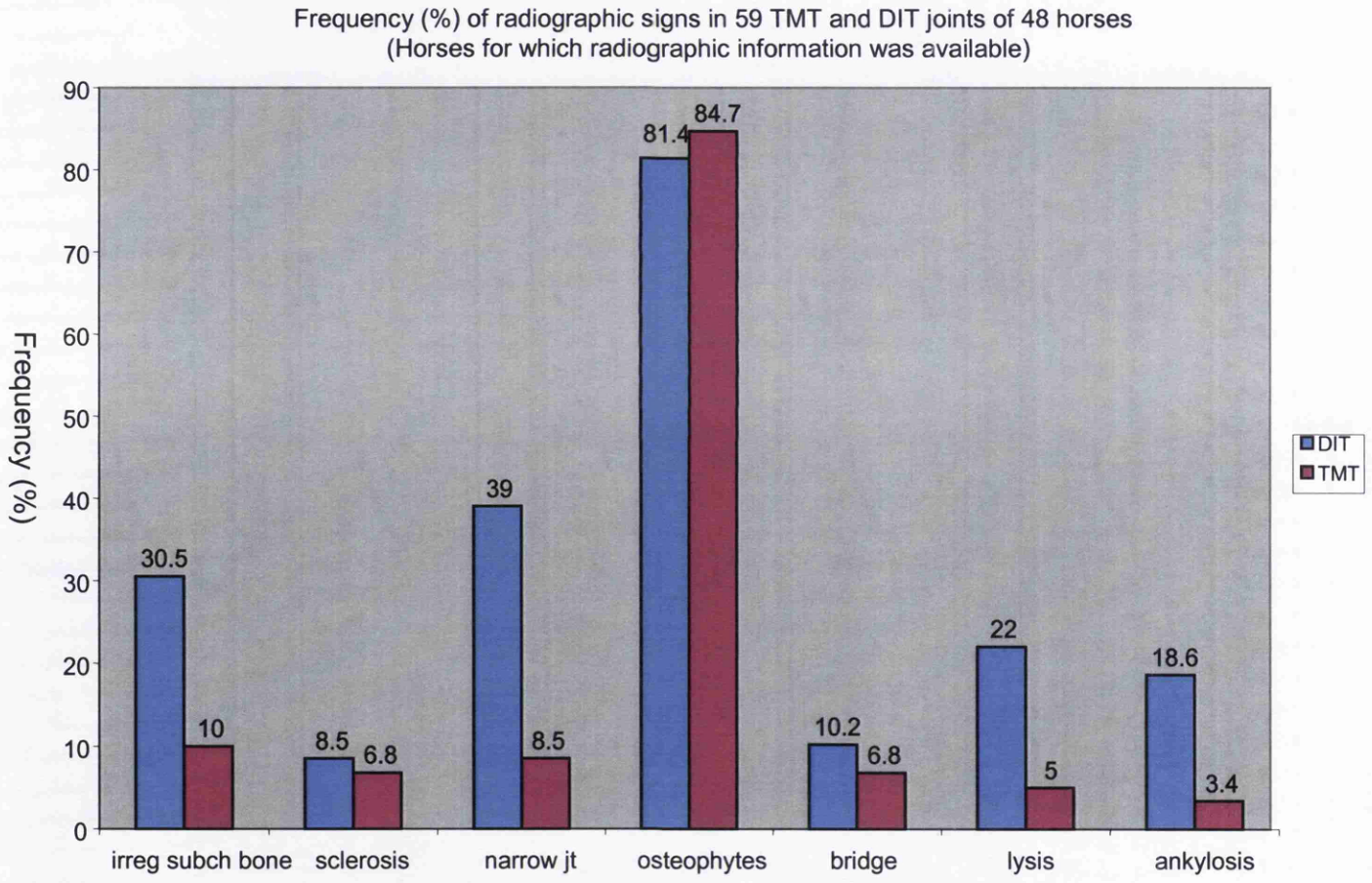


Figure 5.5: (TMT = tarsometatarsal; DIT = distal intertarsal; irreg subch bone = irregular subchondral bone; jt = joint)

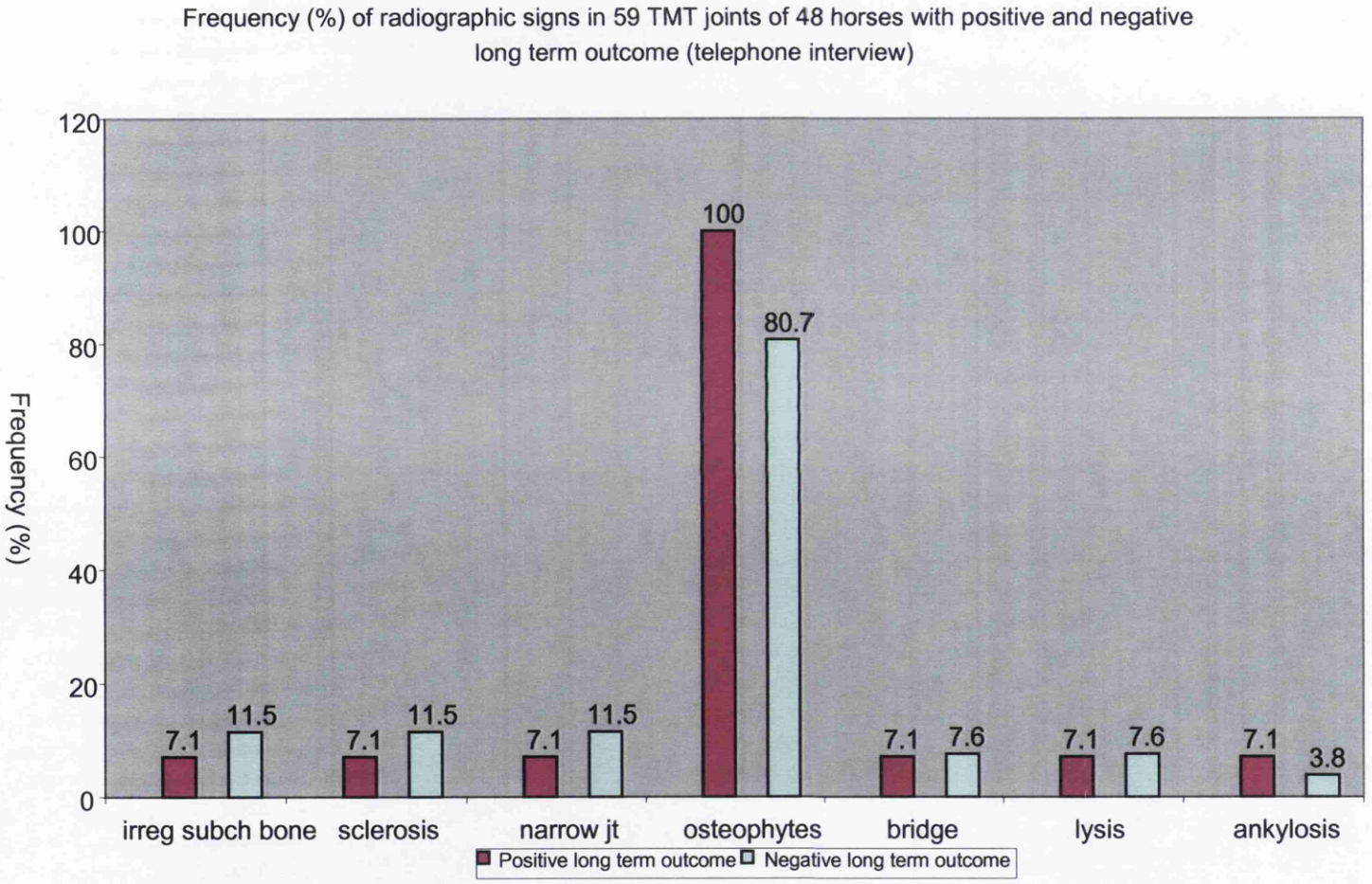


Figure 5.6: (TMT = tarsometatarsal; DIT = distal intertarsal; irreg subch bone = irregular subchondral bone; jt = joint)

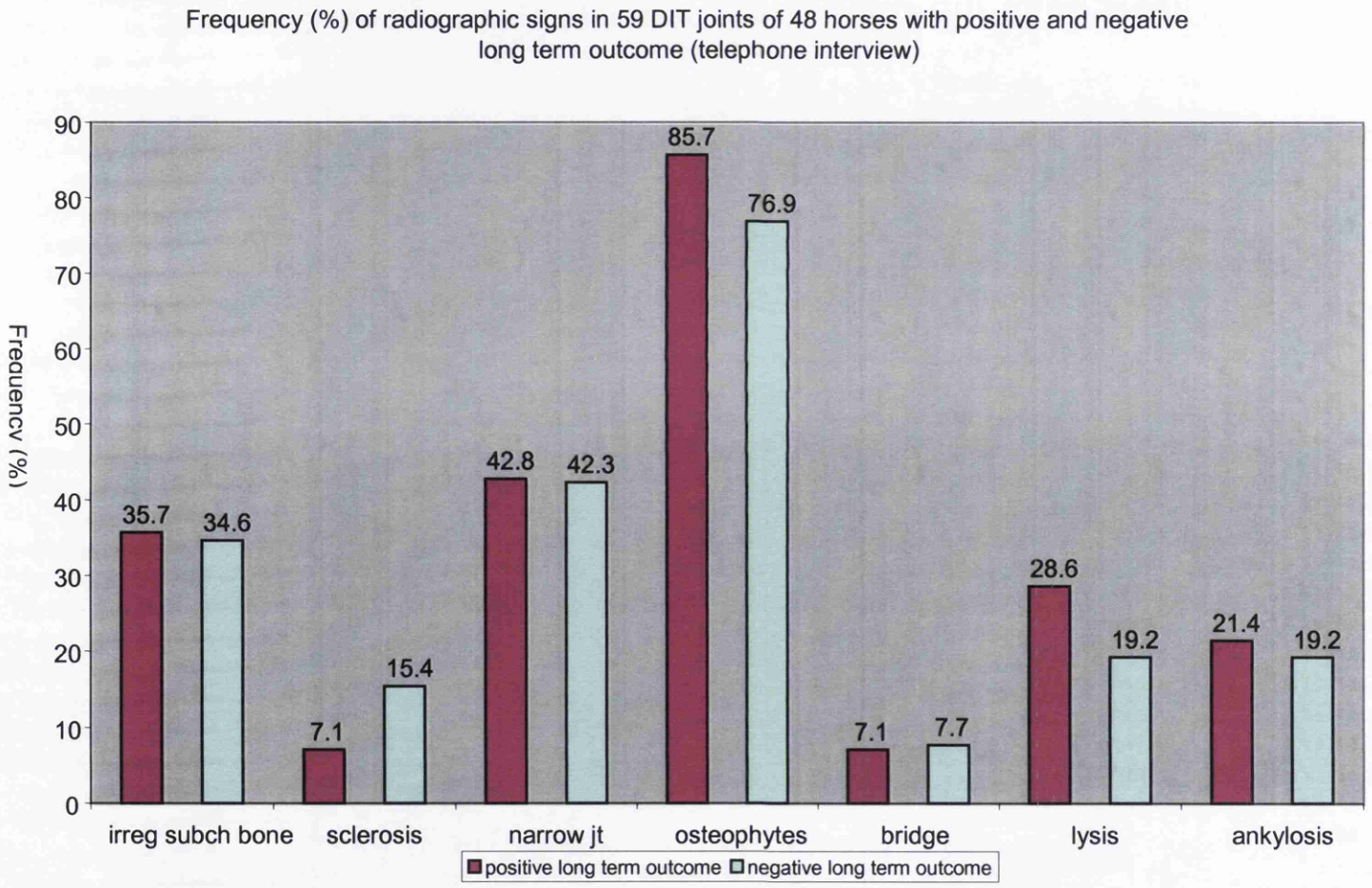


Figure 5.7: (TMT = tarsometatarsal; DIT = distal intertarsal; irreg subch bone = irregular subchondral bone; jt = joint)

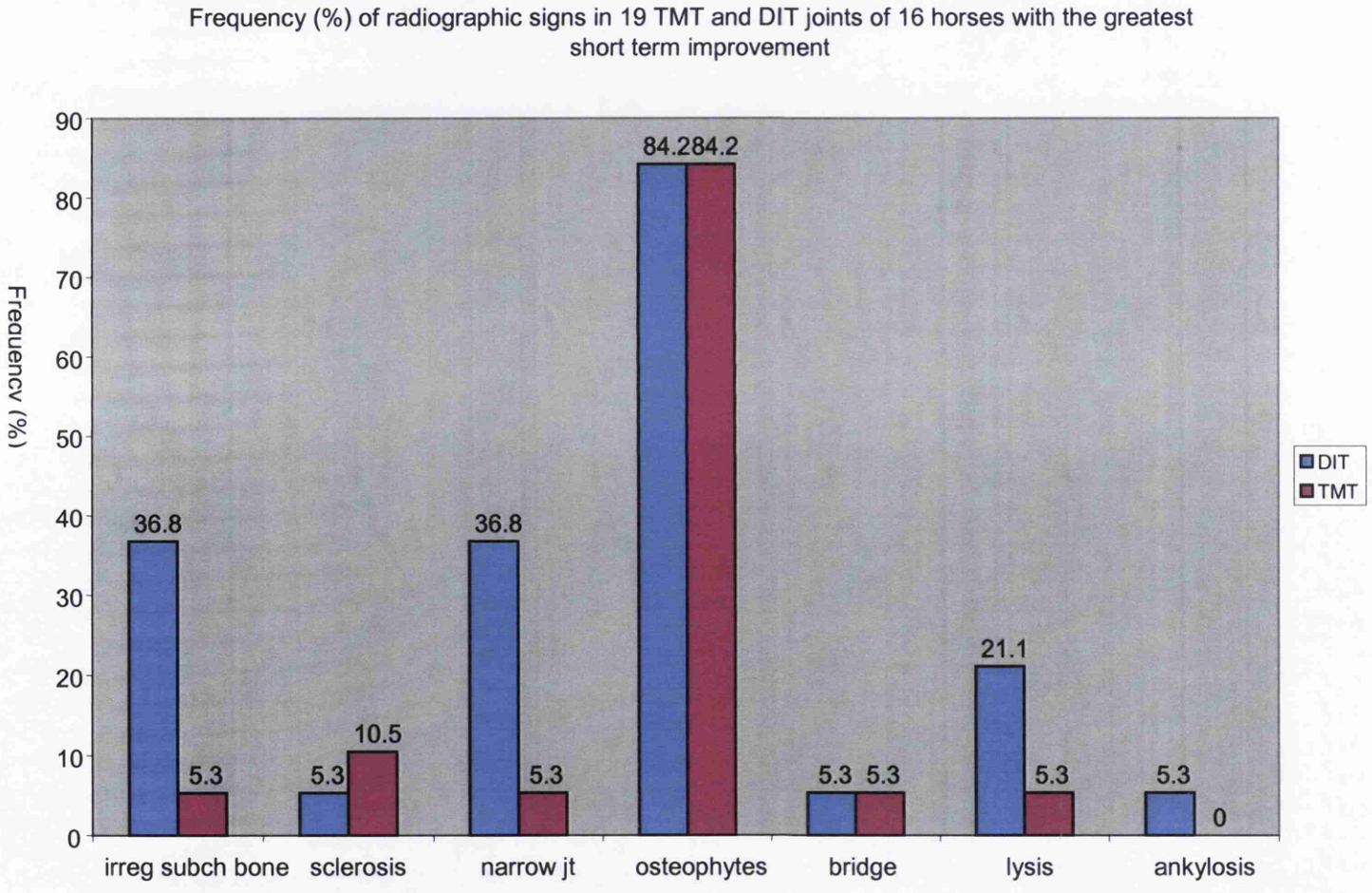
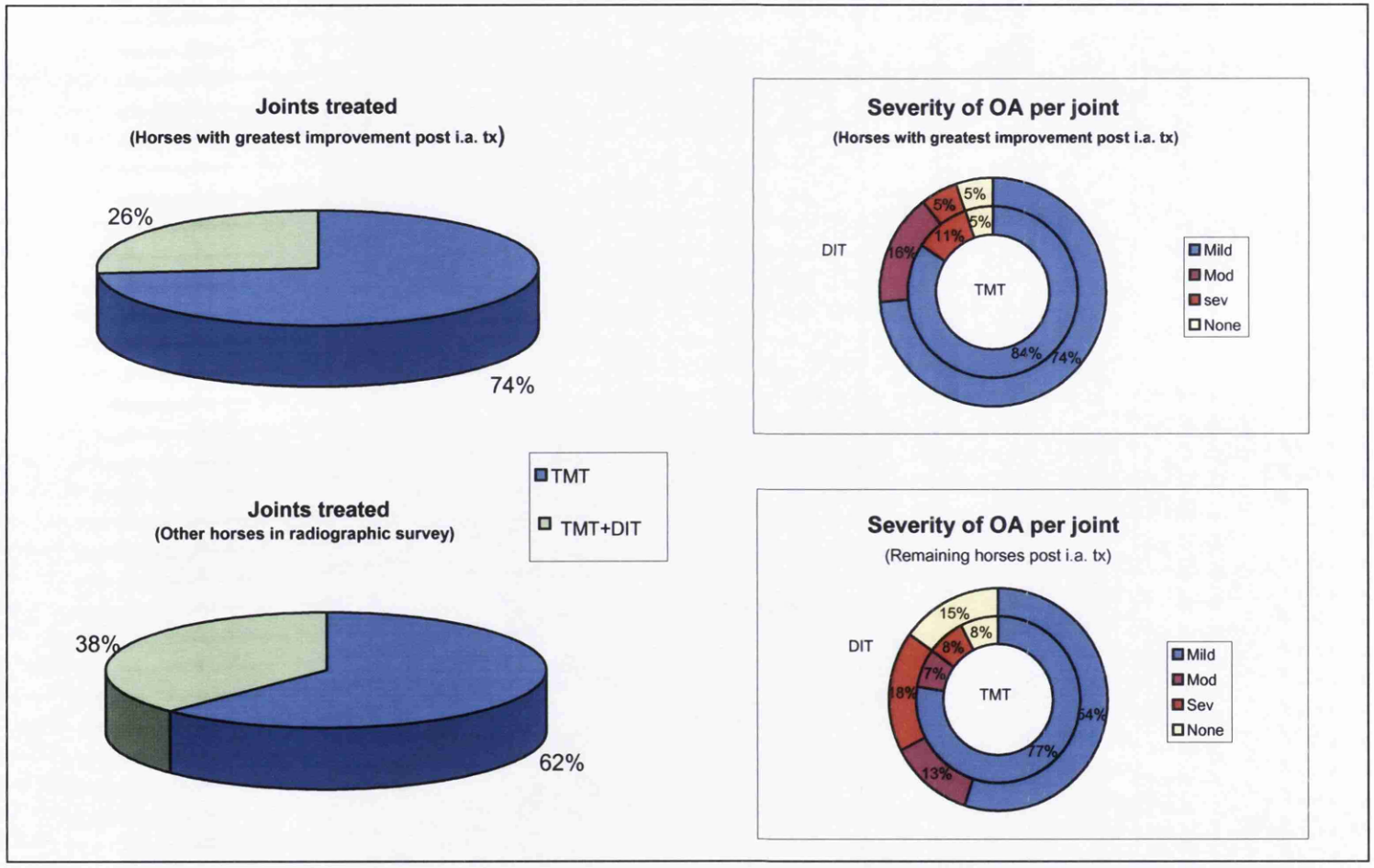


Figure 5.8: Severity of osteoarthritis (OA) in the tarsometatarsal (TMT) and distal intertarsal (DIT) joints of horses showing the greatest short term improvement in lameness compared to the remainder of the study population (graphs on the right). Frequency of joints treated in the same group of horses (graphs on the left).



5.3.5. Scintigraphy

In 13 of 51 horses, scintigraphy was performed as part of the lameness investigation. For 12 horses, scintigraphic images were available for review, resulting in 12 lateral and 11 plantar views of the tarsi.

In all 12 horses IRU of the DTJ was identified. A majority of the observers identified focal IRU in eight DTJ (7/8 hindlimbs were included in the analysis of lameness grades) and in 16 DTJ the uptake was diffuse (12/16 hindlimbs were included in the analysis of lameness grades) **(Appendix, Table 5.15)**

Focal IRU (as identified by the observers) covered < 25% of the surface area of the DTJ. Mean radiopharmaceutical uptake ratio (ROI_1 adj/ROI_2 adj) for the lame hindlimbs was 1.463 (range: 0.757 to 2.320); mean uptake ratio for lame hindlimbs with focal IRU was 1.658 (range: 0.866 to 2.321) and for lame hindlimbs with diffuse IRU 1.351 (range: 0.757 to 2.122) **(Appendix, Table 5.14).**

5.3.6. Statistical analysis of lameness grades

Twelve different primary clinicians were responsible for management of the 51 horses in the study. The distribution of veterinary surgeons responsible for horses showing an improvement in lameness of ≥2 grades is shown in **Table 5.8.**

Vet 1 – Vet 6, who had completed a residency program at the hospital during the study period, were considered at equal risk of encountering horses with OA of the DTJ. Two of six primary clinicians were not responsible for a single case amongst those showing the greatest short term improvement with i.a. treatment.

Table 5.8: Distribution of primary clinicians per horses with the greatest short term improvement

Primary Clinician	Horses with greatest short term improvement (relative to total horses seen)	N° of study horses seen
Vet 1	4 (40%)	10
Vet 2	4 (40%)	10
Vet 3	3 (37.5%)	8
Vet 4	3 (42.8%)	7
Vet 5	0	4
Vet 6	0	6
Vet 7	1 (100%)	1
Vet 8	0	1
Vet 9	0	1
Vet 10	0	1
Vet 11	1 (100%)	1
Vet 12	0	1

Intra-articular medication of the DTJ on one occasion resulted in a median improvement in lameness of 0.75 grades (range: -1.5 to 3 grades), which was significant ($P < 0.000$). Horses receiving i.a. medication twice did not show further significant improvement in lameness ($P=0.141$).

No significant difference in change in lameness was found between horses receiving triamcinolone acetonide (+/- HA) and methylprednisolone acetate, or triamcinolone acetonide (+ HA) and methylprednisolone acetate ($P_{TR(+/- HA) and MPA} = 0.8062$; $P_{TR(+ HA) and MPA} = 0.8154$).

The data available allowed comparison of the change in lameness between Group 1 (showing moderate and severe DTJ OA) and Group 2 (showing mild or no evidence of DTJ OA), for horses whose TMT and DIT joint were treated with MPA. No significant difference was seen ($P=0.0680$).
Within Group 2, change in lameness following treatment of the TMT or of both the TMT and DIT joint with MPA, and of the TMT joint following treatment with MPA or TR (+HA) was compared.

No significant difference in change in lameness was found for horses following treatment of the TMT joint with MPA or TR (+HA) (P=0.9347) or for horses whose TMT or TMT and DIT joints were treated with MPA (P=0.0964).
In contrast to horses with diffuse IRU of their DTJ, horses with focal IRU showed no significant improvement in lameness grade following i.a. medication on one occasion ($P_{focal} = 0.1$; $P_{diffuse} = 0.032$) **(Appendix: Analysis of lameness grades with Minitab Version 14, p179).**

5.3.7. Telephone follow up - Assessment of long term outcome

Follow up information was obtained by telephone interview for 42/51 horses, mean 787 days after the horses' last examination.
Four horses developed unrelated conditions preventing their return to exercise and four horses were treated surgically following failure to improve after i.a. medication. These eight horses were excluded from analysis of long term treatment outcome. A positive long term treatment outcome was recorded for 13/34 (38.2%) and a negative outcome for 21/34 (61.8%) horses. Three of the 16 horses showing the greatest short term improvement after i.a. medication also had a positive long term treatment outcome. For eight horses with OA of the DTJ, which affected the PIT joint, three had a positive and two a negative long term outcome (three were excluded from analysis of outcome)
Of 12 horses with IRU of the DTJ, information was available on long term outcome in nine. Five had a positive long term outcome (two horses had focal and two horses had diffuse IRU of the DTJ and one horse had bilateral IRUs of the DTJ, one described as diffuse and one as focal). Four horses had a negative long term outcome (two horses displayed diffuse, one focal and one horse had diffuse and focal IRUs of the DTJ, due to bilateral scintigraphic uptake) **(Appendix, Table 5.16).**

5.4. Discussion

The findings of this study demonstrate that horses treated once with i.a. MPA or TR (+/- HA) for OA of the DTJ, show a significant improvement in hindlimb lameness, when assessed after a median duration of 56 days. The median improvement was however, small (0.75 grades) and some horses were more lame on re-examination. No difference was identified between the use of MPA or TR (+/- HA).

Lameness in horses receiving i.a. medication on two occasions showed no further significant improvement when assessed at median 50 days after the second i.a. medication.

Lameness improved in 57% of all limbs receiving i.a. medication of the TMT and/or DIT joint on one occasion. One fourth of the limbs, but only 9.8% (5/51) of the horses, were sound when examined subsequently. This can be partly explained by a number of horses developing bilateral hindlimb lameness by the time of follow-up examination. In addition, the study design meant that horses whose primary lameness was not evident when re-examined under the same conditions as at the initial investigation, would be classified as lame if they were lame when assessed under different circumstances.

All of the horses that received i.a. medication on two occasions remained lame and only one of the hindlimbs that was re-medicated, was sound on re-examination. Median time between first and second i.a. treatment was 69 days. There was no evidence that this time span reflected the duration for which the first i.a. medication had a positive clinical effect; it is more likely to represent owner ability to detect lameness and logistics of returning the horse to the hospital.
Median number of days between first i.a. medication and re-examination was 56 and between second i.a. medication and re-examination 50 days. It is conceivable that short term outcome may have been different if horses were assessed before the anti-inflammatory effects of the corticosteroids waned significantly, e.g. within 39 days of i.a. treatment with MPA (Autefage *et al.*, 1986).

It appears logical to attribute the horses' improvement in lameness following i.a. treatment to the effects of the corticosteroid administered. However one has to remember that in a population of Standardbred trotters with traumatic arthritis i.a. injection of 2ml of 0.9% NaCl solution was shown to result in a significant improvement in lameness at 5-7 weeks post injection when compared to a control group subjected to rest only (Gaustad *et al.*, 1999). In this study however horses were affected by osteoarthritis, a degenerative joint disease which has a different aetiology compared to the traumatic arthritis seen by Gaustad *et al.* (1999). Nevertheless it should be considered that the corticosteroid agents administered may not have been exclusively responsible for the reduction in lameness and that an unknown effect of i.a. injection in addition to a possible clinicians' bias, as they were not "blinded" to the treatments performed, may have contributed to the outcome.

In horses that showed the greatest short term improvement in lameness following i.a. medication, OA was graded "moderate" or "severe" less frequently than in the remaining horses (**Figure 5.2** and **5.3**). This was especially distinct for the DIT joint, and was probably the reason why this joint received i.a. medication less frequently than the TMT joint. This finding suggests that horses improved more following i.a. medication when the DIT joint was less severely affected or did not need i.a. treatment (**Figure 5.8**). The reason for horses to improve less in lameness when the DIT joint was medicated may have been due to a lower success rate of DIT joint injection and i.a. administration of corticosteroids. In contrast to the TMT joint, injection of the DIT joint is technically more difficult and personal skills will determine if medication is deposited intra or peri-articularly (Baxter *et al.*, 2003b) Serena *et al.* reported that injection of the TMT joint in normal horses with MPA will lead to therapeutic levels of the drug in the DIT joint (Serena *et al.*, 2005). However this may not be the case in horses with pathology of the TMT and DIT joints, and therefore it may still be justified to medicate these joints separately.

On further analysis of the results for Group 1 and Group 2 horses, neither the severity of OA nor which joint was affected and medicated, seemed to significantly influence the degree of improvement following i.a. medication, which is consistent with the findings of Serena *et al.* (2005).

When comparing the results for horses with different radiographic severity of DTJ OA however, the cut off value for significance (Mann Whitney; $P = 0.0680$) was approached, suggesting that there was a trend for horses with less severe DTJ OA to show a greater improvement in lameness.

In horses showing the greatest short term improvement in lameness, two primary clinicians (Vet 5 and 6) were not represented by a single case. Possible explanations are that these clinicians may have been less skilled at i.a. injection, or less reliable when assessing treatment outcome in their horses, compared to others. Differences in reliability may have arisen because the clinicians defined the lameness grades differently.

Hewetson *et al.* (2006) have shown that a numerical rating scale for lameness assessment (as was used in this study) is of limited reliability. Inter and intra-observer agreement for lameness grades ranged from 56 to 60% of the assessments (Hewetson *et al.*, 2006). Despite some limitations of the study, such as the predominance of hindlimb lameness in the horses, the rating of lameness in horses seen on video tape and the inability to observe horses from the side when moving in a straight line, it clearly demonstrates that rating of

lameness can be variable. Therefore the author feels that in the present study, statistical results close to the cut off value for significance should be interpreted with caution. This particularly applies to the conclusion that severity of OA had no effect on the outcome following i.a. treatment and that horses with diffuse IRU of the DTJ did improve in lameness. Ideally assessment of lameness would include force plate gait analysis, which is likely to be more reliable. However kinetic analysis is infrequently used as a clinical tool (McLaughlin and Gaughan, 1998).

Radiographic signs of OA are generally more frequent in the DIT than in the TMT joint (Barneveld, 1983b; Roethlisberger and Ueltschi, 1989; Eksell *et al.*, 1999), which was also found in this study **(Figure 5.4)**. OA was also more commonly graded "moderate" or "severe", in the DIT compared to the TMT joint **(Figure 5.3)**. Axelsson *et al.* (1998) have found a similar trend in Icelandic horses for OA to be more severe in the DIT compared to the TMT joint. In horses with a positive long term treatment outcome, moderate and severe OA were more frequently identified **(Figure 5.2** and **5.3)** and osteophytes and subchondral bone lysis more frequently seen than in horses with a negative outcome **(Figure 5.5** and **5.6)**. According to his rating system, Barneveld (1983b) did not identify an association in outcome following cunean tenectomy and orthopaedic farriery with severity of DTJ OA. However horses in which subchondral bone lysis was present were less likely to have a positive outcome following tenectomy and farriery, in contrast to horses which underwent surgical arthrodesis (Barneveld, 1983b). Dechant *et al.* (2003) found no association between the presence of subchondral bone lysis and treatment outcome when using a three-drill tract technique for arthrodesis of the DTJ. From analysis of radiographic changes between cases in this study it appears that horses were more likely to have a positive long term treatment outcome when radiographic changes were more advanced, which contrasts Barneveld's (1983b) observations. Also the presence of subchondral bone lysis did not seem to affect outcome, because horses with a positive long term treatment outcome as well as horses that were sound or improved by $\geq$2 grades following i.a. medication had radiographic evidence of subchondral bone lysis **(Figure 5.6** and **5.7).** This contrasts the observations by Dyson (2004) who suggested that horses with subchondral bone lysis were less likely to improve following i.a. treatment.

Subchondral bone lysis was judged to carry a high diagnostic value for DTJ by a group of experts in equine diagnostic imaging and orthopaedics (Chapter 4). On the basis of the presented and other study results the clinical importance of this radiographic feature as a prognostic indicator for treatment outcome is questionable.

Various scales have been proposed for rating radiographic changes in horses with DTJ OA. (Barneveld, 1983b; Laverty *et al.*, 1991; Burtscher, 1994; Eksell *et al.*, 1999; Dechant *et al.*, 2003). The reliability of one of these scales has been reported (Eksell *et al.*, 1999) but this scale does not permit rating of individual radiographic changes in each of the DTJ. When a visual analogue and verbal descriptive rating scale was tested for reliability in horses with DTJ OA, the verbal descriptive scale, which used ratings such as "none", "mild", "moderate" or "severe", more consistently allowed each assessor to repeat his ratings and other assessors to reproduce the same rating. The reliability of a visual analogue rating scale for individual radiographic changes was unacceptable clinically (Chapter 4). For these reasons individual radiographic signs were assessed in the present study as "absent" or "present", and OA as "none", "mild", "moderate" or "severe".

Assessment of long term treatment outcome, after a mean of 787 days following the horses' last examination at the hospital, found that 38.2% were performing at their intended use, did not show hindlimb lameness and were not receiving NSAIDs. This information was collected from owners, which invariably carries the risk of hindlimb lameness being underreported. However the fact that these horses were able to perform at their intended use suggests that lameness, if present, was mild. This long term outcome is less than for surgical treatment (50% (Jansson *et al.*, 1995), 59% (Dechant *et al.*, 2003), 71% (Adkins *et al.*, 2001), 77% (Imschoot *et al.*, 1990), 80% (Eastman *et al.*, 1997), 81% (Stanger *et al.*, 1994), 86% (Barneveld, 1983b)), indicating that surgical treatment represents a superior option for long term management of DTJ OA.
Only three of 16 horses that showed the greatest improvement following i.a. medication, also had a positive long term treatment outcome, suggesting that ability to improve following i.a. medication as assessed by veterinary surgeons, does not predict a positive long term treatment outcome. For five out of eight horses with concurrent PIT joint OA, information on long term treatment outcome was available; three horses had a positive and two a negative outcome. In this study long term outcome in horses treated by i.a. medication did not appear to be affected by the presence of radiographic signs of PIT joint OA.

A considerable proportion of horses in this study displayed concurrent forelimb lameness at the first examination (43%). Although horses that developed additional health problems were excluded from analysis of long term treatment outcome, horses that were unable to

perform their intended use, due to unrecognized, persistent fore limb lameness could have been falsely included in the group of horses with a negative outcome despite an improvement in hindlimb lameness. Alternatively the successful management of fore limb lameness may have positively influenced the assessment of long term outcome.

When six veterinary surgeons, who were all routinely involved in acquisition and interpretation of scintigraphic images, were asked to evaluate the scintigraphic images available for 12 horses, focal IRU was identified by the majority of clinicians in eight and diffuse IRU in 16 DTJ. On average, focal uptake covered 15% of the surface area of the DTJ. When the ratio of radiopharmaceutical uptake for the ROI of the distal tibia and DTJ was compared with results published by Murray *et al.* (2005), it became evident that none of the lame limbs had DTJ IRUs above the reported mean ratio of 2.41 for horses with DTJ pain and radiographic signs of DTJ OA . Five of 22 lame DTJ reached the mean uptake ratio of 1.75, reported in horses with DTJ pain with no evidence of DTJ OA. Mean radiopharmaceutical uptake for the lame hindlimbs was 1.463 times more than for the ROI of the ipsilateral distal tibia, which is lower than the reported mean uptake ratio of 1.62 for a group of normal horses and lower than the mean uptake ratio of 1.53 for lower level riding horses. In four of 22 lame hindlimbs, in which diffuse IRU had been identified, the mean uptake was in fact less than for the ROI of the distal tibia. This may suggest that there is poor correlation between results of visual assessment of radiopharmaceutical uptake and analysis of ROI, that a concurrent increase in radiopharmaceutical uptake of the distal tibia was present or that placement of ROIs was flawed. Murray *et al.* (2004) describes the accurate placement of ROIs by superimposition of hock radiographs on the relevant scintigraphic image, which is different to the unassisted placement used in this study. Furthermore profile analysis of DTJ uptake was not performed in this study, which in horses with ratios lower than expected, may have identified evidence of abnormal uptake.

Mean uptake for ROI with focal IRU was on average 1.227 times more than for ROI with diffuse IRU. When short term treatment outcome following i.a. medication was assessed in horses with focal IRU no significant improvement in lameness was observed on re-examination, which contrasts with the significant improvement in horses with diffuse IRU. As mentioned previously in this section test results were close to cut off for significance. For seven tarsi with focal IRU, mean improvement in lameness was 0.78 grades and for these seven tarsi, two hindlimbs were sound on re-examination. For 12 tarsi with diffuse IRU, mean improvement in hindlimb lameness was 0.92 grades and 2/12 hindlimbs were

sound on re-examination. Dabareiner (2003) suggests that improvement with i.a. medication is generally poor in horses with intense IRU and that focal IRU may represent intertarsal ligament enthesiopathy (Dabarainer *et al.*, 2003).

All of the horses in this study with IRU showed radiographic abnormalities consistent with DTJ OA. Horses with IRU displayed radiographic evidence of mild, moderate and severe OA. However when radiographic evidence of moderate or severe OA was identified it was associated with focal IRU of the DTJ. Considering that horses with focal IRU did not significantly improve in lameness following i.a. medication and that these horses also displayed more advanced radiographic signs of OA may further support the assumption that radiographic severity of DTJ OA was a negative prognostic indicator for an improvement in lameness following i.a. medication (despite the non-significant statistical test results).

It has been the author's experience that focal IRU can also be seen with fracture of a prominent osteophyte, however no such abnormality was observed in the horses with focal IRU. On average focal IRU was more intense than diffuse IRU. The fact that horses with focal IRU showed no significant improvement in lameness following i.a. medication could also be related to the intensity, rather than the focal nature of the IRU.

Information from nine animals was used to assess the long term treatment outcome in horses with IRU of the DTJ. In this small group of horses, it appeared that IRU did not affect long term outcome, as horses with diffuse and focal IRU of the DTJ had a positive long term outcome.

When interpreting the results of this study, one needs to consider that the study population may be biased, as horses were selected by referring veterinary surgeons for investigation at a university hospital. The study's case inclusion criteria only admitted horses to the study which had at least one re-examination performed. This may have selected for horses which show poor improvement following i.a. medication on one occasion, as owners would be more inclined to re-present an animal if it did not improve, than if it did. However, owners are routinely asked to re-present their animal for re-examination following i.a. medication regardless of any perceived improvement and it has been the author's experience that this is well accepted.

In this retrospective study the author was able to confirm the hypothesis that there is a difference in lameness following the use of i.a. MPA or TR (+/- HA) and that there is a difference in the change in lameness following i.a. medication in horses with focal versus diffuse IRU of the DTJ. No evidence was found that the use of MPA or TR (+/- HA) would result in different treatment outcomes. A single treatment with intra-articular corticosteroids appeared to be a successful option for short term management of horses with DTJ OA. Positive long term treatment outcome was low (38%), rendering surgical treatment more valid for long term management of horses with DTJ OA.

CHAPTER 6
GENERAL DISCUSSION

CHAPTER 6:
GENERAL DISCUSSION

As part of this study a Delphi consultation process was performed to identify important radiographic features for use in a radiographic rating scale. The Delphi consultation was found to be a useful and very cost efficient tool for gathering information from experts in the field of equine diagnostic imaging and orthopaedics living in different geographical locations. Unfortunately less than 50% of the invited experts were willing to participate and returned their questionnaire. For some, this may have been because they did not recognize a need for this consultation process, as in their opinion the radiographic interpretation of distal tarsal joint OA was undisputed. From the results of the questionnaire however, it can be concluded that experts differed in the assessment of radiological importance of the features consistent with DTJ OA. This was particularly obvious for the interpretation of synovial fossae or foramina interossea. The unfamiliar terminology of some of the radiographic features may also have contributed to the low questionnaire return rate. All the radiographic features included in the questionnaire however, have been reported in the literature to be consistent with a radiographic diagnosis of distal tarsal joint OA. Time limitations may also have deterred a number of experts from participating in an iterative process.

If the author wished to improve the study, he would change the design of the rating scale in the Delphi consultation process. Instead of offering experts ordinal groups of importance (0; 1-20; 21-40; 41-60; 61-80; 81-99; 100) for rating, the author would use verbal descriptors (e.g. not important, marginally important, moderately important, very important) instead. This would simplify the rating process and facilitate a greater degree of consensus as each of the ratings would carry a more recognizable level of importance.

In retrospect it would have been advantageous to invite additional experts from North America to participate so that a comparison between the radiographic interpretation of distal tarsal joint OA in North America versus Europe was possible. At present however there is no indication that such a difference exists.

As with all forms of qualitative research one has to realise that results are based on personal opinion/experience and that in contrast to quantitative methods, statistical

validation of results is not possible. Establishment of an agreement or consensus within a group of experts does indicate that the group shares the same opinion on a specific subject but it does not imply that this is also the correct information. The group could express a consensus but be collectively wrong. In situations such as where there is either controversial information or no published evidence available, qualitative research methods do represent a valid approach (Jones and Hunter, 1995). Radiographic abnormalities in horses with DTJ have been well described and evidence on the clinical importance of some radiographic features, such as subchondral bone lysis, has been reported (Barneveld, 1983b; Dyson, 2004; Bjornsdottir *et al.*, 2004a). No information however is available on the radiographic importance of abnormalities when making a diagnosis of DTJ OA and certain radiographic abnormalities such as sclerotic or indistinct foramina interossea are not widely recognized indicators of distal tarsal joint osteoarthritis. Qualitative research, and in particular the Delphi consultation process, was thought to be appropriate to determine which radiological features are important indicators of DTJ OA.

The radiographic rating scale developed in this study, consisted of a visual analogue rating of radiographic features which were found to be important during the Delphi consultation process. The author adopted Burtscher's idea of a weighted radiographic rating scale (1994) as the Delphi consultation process indicated that the radiographic abnormalities included in the rating scale were not all of equal importance (e.g. joint narrowing vs. subchondral bone lysis).

The decision to use a continuous scale (the visual analogue rating scale) directly influenced the possibilities of statistical analysis. Kappa analysis, which has been widely used for the assessment of rater agreement, was not appropriate as the data were not categorical. Means of comparing continuous data were therefore necessary to investigate the assessors' reliability. In this study Bland Altman plots were chosen for that purpose. These plots compare the mean rating of two measurements against their difference and illustrate the 95% agreement limits for the repeated ratings. This analysis allows assessment of inter and intra-assessor reliability by reading the mean differences and 95% agreement limits, and comparing them between multiple assessors. In contrast to the statistical value derived from κ-analysis this form of analysis may appear less informative or naive. A clear advantage of κ-statistics over the measurement of agreement using Bland Altman plots is the fact that it accounts for chance agreement.

Although continuous data may also be suitable for κ-analysis after having been collapsed and categorized, clear and consistent definitions of the categories are necessary for

meaningful interpretation (Tooth and Ottenbacher, 2004). In regard to the present study the categorisation of the continuous data (0-100) would be based on random cut off points, making κ-statistics inappropriate.

The assessors' ability to read all radiographic projections at the same time and to compare abnormal findings between projections, may have confounded assessment of the projections. This would explain why no significant difference was found between the ratings of different radiographic views. Radiographic assessment of the tarsus using sets of four views represents normal clinical practice but evaluation of the scale's reliability would have been better performed if the order of radiographic projections had been randomised and only one radiograph at a time assessed, to exclude the possibility that radiographic projections were compared with each other.

When the reliability of the rating scale was assessed in a group of nine different veterinary surgeons it was obvious that inter and intra-observer reliability was different. Only the performance of the most reliable assessor would have permitted the radiographic rating scale to be applied clinically. If the author was to perform a second study on the reliability of a radiographic rating scale, based on the experience with this investigation, he would prefer to choose an ordinal or categorical scale and perform kappa statistics to investigate reliability.

In this study the reliability of repeated ratings was not affected by the assessors' professional experience. Other unrecognized factors such as the time each assessor set aside for completing the rating may have had an effect on the results but were not investigated or controlled for.

The retrospective clinical case study, determined clinical outcome in horses with DTJ OA following treatment with intra-articular corticosteroids. No studies of this kind have been published. Intra-articular treatment of the DTJ with MPA or TR (± HA) on one occasion was shown to be a successful means of treating lameness in horses with DTJ OA. Intra-articular medication of the DTJ is frequently performed and the results support the clinical rationale for their use.

The finding that no significant improvement over single treatment was achieved with repeat i.a. treatment of the DTJ raises the question of whether surgical treatment options for DTJ OA should be discussed with owners earlier in the management of cases. On the

basis of an owner questionnaire only 38% of the horses in this study had a positive long term treatment outcome. It is conceivable that if horses had been examined by veterinary surgeons at the time of telephone follow up, the long term outcome would have been worse. Previously the author has found it difficult to answer owners' enquiries about whether it would be possible to use their horse at the same performance level again. The results of this study enable evidence-based advice to be given to horse owners. Specifically, intra-articular treatment of the DTJ will improve the horse's lameness however, the horse is likely to remain lame. If first i.a. treatment fails to improve the horse's lameness, surgical treatment options should be discussed. Long term conservative management is likely to result in an animal fit for intended use in approximately one third of the cases. If focal IRU of the DTJ joint is detected at scintigraphy, improvement following i.a. treatment with corticosteroids is unlikely.

Unfortunately, due to the retrospective nature of the study there are a number of limitations inherent in its design. As shown by Hewetson *et al.* (2006) the rating of lameness can not be considered an exact science. The author tried to reduce the problem of high observer variability when assessing lameness by only including horses in the study which were consistently examined by the same clinician. Nevertheless, as only 60% of repeat assessments of lameness would be expected to be consistent, intra-observer reliability is not ideal. This means that despite having ensured that horses were examined by the same clinician throughout the follow up period, assessment of lameness, and therefore short term outcome, was likely to be subject to a degree of variability.

To facilitate analysis of radiographic findings, abnormalities were noted as absent or present and OA was graded as none, mild, moderate or severe for each distal tarsal joint. This decision was based on the observation that the verbal descriptive rating of DTJ OA was more reliable when compared to the visual analogue rating scale.

Unfortunately the author was not able to follow up horses using radiography or scintigraphy. Spontaneous ankylosis of the DTJ has been reported to occur infrequently (Verschooten and Schramme, 1994), nevertheless it would have been interesting to observe if radiographic abnormalities did progress in this group of horses. In horses with focal IRU, repeat scintigraphy together with radiography may have helped to understand this clinical presentation more, as radiographic findings may develop later at a stage, possibly to coincide with a loss of the further focal IRU.

A Wilcoxon signed rank and Mann Whitney test was used for statistical analysis of the change in lameness. Both are suitable for non-parametric data only. The Wilcoxon signed rank test will test if the median difference between two paired sets of data approaches nil. The Mann Whitney test assesses equality between two independent unpaired sets of data. The difference in lameness grade following i.a. treatment was tested using the Wilcoxon signed rank test as the data set consisted of paired values. The difference in lameness grade following i.a. treatment between groups was analyzed using a Mann Whitney test as the data were considered to be independent and unrelated to each other.

In this study no association was found between the outcome following i.a. treatment and the radiographic severity of OA, the agent administered and the joint treated. Ideally results from this retrospective study should be followed up in a prospective investigation to verify their accuracy. Double blinded, randomized clinical control studies would provide an ideal study design for this purpose, however, from a clinical stand point they are likely to be impractical as the compliance of owners is likely to be low when faced with the possibility of a placebo being administered to their animal.

From this study it became obvious that the majority of horses presented to the hospital for treatment of DTJ OA are used for general purpose or pleasure riding. This work load represents a low level and commonly irregularly performed form of exercise, which in general is representative of the intended use of horses referred to the hospital. From personal communications with veterinary surgeons in Europe and North America it appears that the outcome following i.a. treatment in horses with DTJ OA is lower at the hospital than elsewhere. The author is unable to fully explain this observation. It is possible however that limitations in the study's design were responsible for a failure to recognize improvement in lameness following i.a. treatment (on average an improvement of 0.75 grades was identified) or it may be that the nature of the horses' work load influenced outcome. When the IRUs of the DTJ were analysed in the group of horses that had scintigraphy performed as part of their lameness investigation it became obvious that the areas of IRU were consistently less intense than anticipated from the literature (Murray *et al.*, 2005). In the latter publication it has been shown that the intensity of IRU varies between horses with different work loads, suggesting that exercise may have a direct effect on the scintigraphic presentation of the disease and possibly also on the outcome following treatment. Eksell *et al.* (1998) found an increased frequency of radiographic abnormalities

consistent with DTJ OA in Icelandic horses intended for pleasure riding and trekking. This suggests that in addition to the predisposition of Icelandic horses for DTJ OA the type of exercise has also an important influence on the expression of disease. It is conceivable that on the basis of Murray *et al.*'s (2004, 2005) and Eksell *et al.*'s (1998) observations, the clinical presentation and outcome following treatment of the horses in this study was affected by the high proportion of animals engaged in pleasure riding and hacking.

In human medicine there is evidence that pain in patients with osteoarthritis and rheumatoid osteoarthritis is affected by weather variables such as temperature and humidity (Strusberg *et al.*, 2002). The author hypothesizes that a similar effect may also be experienced by horses with osteoarthritis. This, of course, could have a substantial effect on horses with DTJ OA in a region such as the one where the hospital is located, which has rain fall on 250 days per year and an average temperature of approximately 8°C. The influence of climate may therefore partly explain why the outcome following i.a. treatment of the DTJ differs between geographical locations. However the author would like to emphasize that this is only speculation.

One of the factors incriminated as playing a role in the development of DTJ OA is repetitive strain (in particular shear and torsional forces) at the level of the DTJ (Gabel, 1983). Individual differences have been reported in the insertion pattern of the medial branch of the tibialis cranialis muscle (cunean tendon) (Burtscher, 1994). This may lead to alterations in torsional forces and indirectly affect susceptibility to DTJ OA. In some clinical cases the author has examined the medial aspect of the DTJ ultrasonographically but found that visualisation of the insertion site of the cunean tendon was unreliable. It may be interesting to investigate if there indeed is a correlation between the presence of radiographic abnormalities consistent with DTJ OA and the insertion pattern of the cunean tendon. In the author's opinion this would however only be feasible on post mortem examinations.

The author is hopeful that other institutions will report the success rate of treatment of DTJ OA using intra-articular corticosteroids, as this would allow comparison with the results presented here. Comparison between studies may be helpful in identifying those factors which influence treatment success.

With respect to the use of radiographic rating scales, the evidence indicates that visual analogue rating scales are likely to be unreliable in use. Based on the author's observations

from this investigation, the use of a verbal descriptive rating scale is more reliable and a rating scale such as the one proposed by Zubrod *et al.* (2005) is likely to be more reliable. However, to ensure that conclusions in clinical cases or research projects are accurate it has to become second nature for veterinary clinicians/researchers to follow the example of human health professionals and to investigate the reliability of all rating scales used.

ACCOMPANYING MATERIAL

To
Mr/Mrs

UNIVERSITY
of
GLASGOW

Dear Mr/Mrs ----------,

Re: An Expert Panel Consultation Process on the Radiographic Diagnosis of Osteoarthritis of the Distal Tarsal Joints in Horses

We would like to invite you to participate in the above investigation. It is part of a study conducted by Raphael Labens, a Resident in Equine Surgery at Glasgow University, to investigate the use of radiography in clinical decision-making in horses with osteoarthritis (OA) of the low motion distal tarsal joints (i.e. bone spavin).

This questionnaire represents the first round of a consultation process based on the Delphi technique, which aims to establish a consensus in expert opinions on the radiographic diagnosis of bone spavin. Results from this consultation process will help develop a radiographic scoring system for osteoarthritis of the distal tarsal joints that is practical, can be used reproducibly and is clinically relevant.

In subsequent stages of the study, the reproducibility of the scoring system when used by non-experts will be determined and the correlation between radiographic score, clinical diagnosis and treatment outcome will be investigated.

Currently, there appears to be no consensus on the way in which the radiographic diagnosis of OA of the distal tarsal joints should be made. Radiographic interpretation is frequently entirely subjective but occasionally utilises scoring systems, which are based on the size or assumed clinical significance of radiographic features. To our knowledge none of the approaches has been validated.

We very much hope that you will find time to participate in this study. If you can, we will send you the questionnaire by e-mail so that you may complete the form electronically. Please send an e-mail confirming your participation, or to obtain further information, directly to Raphael Labens, R.Labens@vet.gla.ac.uk or Lance Voute, L.Voute@vet.gla.ac.uk.

All responses will be strictly confidential and any results obtained will be sent to you by e-mail during the subsequent rounds of the consultation process.

Sincerely,

Raphael Labens	Lance Voute	Prof. Sandy Love
Mag.Med.Vet; DEC, MRCVS	BVSc, Cert ES(Orth), MRCVS	BVMS, PhD, MRCVS
Resident	Lecturer in Equine Surgery	Head of Departement

An Expert Panel Consultation Process on the Radiographic Diagnosis of Osteoarthritis of the Distal Tarsal Joints in Horses

UNIVERSITY of GLASGOW

First Round

Conducted by the Weipers Centre for Equine Welfare
Division of Companion Animal Sciences
University of Glasgow Veterinary School
Bearsden Road
Glasgow G61 1QH
United Kingdom
Tel. : +44 (0) 141 330 5999

Instructions

- This is the first round of our consultation of experts on the importance of certain radiographic changes when making the **radiographic diagnosis of bone spavin.**
- When completing the questionnaire, please utilise your personal experience including your knowledge of the available literature, research you may have performed and clinical judgment in the field of osteoarthritis of the distal tarsal joints. In answering this questionnaire there should be no need to consult the literature.
- This questionnaire should only take about **10 minutes** to complete.
- Please indicate the most appropriate response to each and every question using your mouse for tick boxes. For written answers, mouse click over the appropriate yellow box and type your response.
  Once you have completed the survey please save it and e-mail the file, as an attachment, to me at R.Labens@vet.gla.ac.uk
- At the bottom of each section space has been provided for additional comments.
- All responses are **completely confidential** and will be identified by code numbers only.
- If you have any queries please do not hesitate to contact me using the above details or by e-mail at R.Labens@vet.gla.ac.uk

Thank you for your assistance

1. **How important are the following changes to you when making a radiographic diagnosis of osteoarthritis of the tarsometatarsal joint (Articulatio tarsometatarsalis) ?**

On a scale from 0 to 100, where 0 = Definitely not important, 100 = Definitely important

Radiographic feature	**0** Definitely **not** important	**1-20**	**21-40**	**41-60**	**61-80**	**81-99**	**100** Definitely important
Irregular subchondral bone	☐	☐	☐	☐	☐	☐	☐
Subchondral bone sclerosis	☐	☐	☐	☐	☐	☐	☐
Poor corticomedullary definition	☐	☐	☐	☐	☐	☐	☐
Enlarged joint space	☐	☐	☐	☐	☐	☐	☐
Narrowed joint space	☐	☐	☐	☐	☐	☐	☐
Ankylosis	☐	☐	☐	☐	☐	☐	☐
Osteophytes	☐	☐	☐	☐	☐	☐	☐
Bony spur on dorsoproximal Mt 3	☐	☐	☐	☐	☐	☐	☐
Periarticular bony bridge formation	☐	☐	☐	☐	☐	☐	☐
Indistinct/sclerotic synovial fossae	☐	☐	☐	☐	☐	☐	☐
Subchondral bone lysis	☐	☐	☐	☐	☐	☐	☐

Please type any comments on this section

click here

2. **How important are the following changes to you when making a radiographic diagnosis of osteoarthritis of the distal intertarsal joint (Articulatio centrodistalis) ?**

On a scale from 0 to 100, where 0 = Definitely not important, 100 = Definitely important

Radiographic feature	**0** Definitely **not** important	**1-20**	**21-40**	**41-60**	**61-80**	**81-99**	**100** Definitely important
Irregular subchondral bone	☐	☐	☐	☐	☐	☐	☐
Subchondral bone sclerosis	☐	☐	☐	☐	☐	☐	☐
Poor corticomedullary definition	☐	☐	☐	☐	☐	☐	☐
Enlarged joint space	☐	☐	☐	☐	☐	☐	☐
Narrowed joint space	☐	☐	☐	☐	☐	☐	☐
Ankylosis	☐	☐	☐	☐	☐	☐	☐
Osteophytes	☐	☐	☐	☐	☐	☐	☐
Bony spur on dorsoproximal Mt 3	☐	☐	☐	☐	☐	☐	☐
Periarticular bony bridge formation	☐	☐	☐	☐	☐	☐	☐
Indistinct/sclerotic synovial fossae	☐	☐	☐	☐	☐	☐	☐
Subchondral bone lysis	☐	☐	☐	☐	☐	☐	☐

Please type any comments on this section

click here

3. **How important are the following changes to you when making the radiographic diagnosis of osteoarthritis of the proximal intertarsal joint (Articulatio talocalcaneocentralis) ?**

On a scale from 0 to 100, where 0 = Definitely not important, 100 = Definitely important

Radiographic feature	**0** Definitely **not** important	**1-20**	**21-40**	**41-60**	**61-80**	**81-99**	**100** Definitely important
Irregular subchondral bone	☐	☐	☐	☐	☐	☐	☐
Subchondral bone sclerosis	☐	☐	☐	☐	☐	☐	☐
Poor corticomedullary definition	☐	☐	☐	☐	☐	☐	☐
Enlarged joint space	☐	☐	☐	☐	☐	☐	☐
Narrowed joint space	☐	☐	☐	☐	☐	☐	☐
Ankylosis	☐	☐	☐	☐	☐	☐	☐
Osteophytes	☐	☐	☐	☐	☐	☐	☐
Bony spur on dorsoproximal Mt 3	☐	☐	☐	☐	☐	☐	☐
Periarticular bony bridge formation	☐	☐	☐	☐	☐	☐	☐
Indistinct/sclerotic synovial fossae	☐	☐	☐	☐	☐	☐	☐
Subchondral bone lysis	☐	☐	☐	☐	☐	☐	☐

Please type any comments on this section

click here

4. **Please indicate how you would take or prefer radiographs of the hock to be taken to investigate OA of the distal tarsal joints (hard/soft exposure, angulation of beam, incidence, etc).**

Lateromedial view :

click here

Dorsoplantar view :

click here

Dorsomedial-plantarolateral oblique view :

click here

Dorsolateral-plantaromedial oblique view :

click here

Please type any comments on this section (such as if you would require additional views) :

click here

An Expert Panel Consultation Process on the Radiographic Diagnosis of Osteoarthritis of the Distal Tarsal Joints in Horses

UNIVERSITY of GLASGOW

1st Round Results and 2nd Round Questionnaire

Conducted by the Weipers Centre for Equine Welfare
Division of Companion Animal Sciences
University of Glasgow Veterinary School
Bearsden Road
Glasgow G61 1QH
United Kingdom
Tel. : +44 (0) 141 330 5999

Instructions:

Thank you very much for your participation in the 1st round of our specialist consultation process on the radiographic interpretation of osteoarthritis of the distal tarsal joints in horses. A total of 9 out of 17 experts contacted agreed to participate and returned their questionnaire. All of the participant's comments have been carefully considered. Your notes on radiographic technique will prove very valuable at a different stage of this project.

The responses from the 1st round on the importance of certain radiographic features have been summarized for each criteria and the results are shown in graphical form - see example below. The red box indicates the median and the black bar highlights the interquartile range (middle 50 percent) for the responses. Both the median and the interquartile range may lie in between groups in some instances due to the nature of the data.

Radiographic feature	**0** Definitely **not** important	**1-20**	**21-40**	**41-60**	**61-80**	**81-99**	**100** Definitely important
Irregular subchondral bone	☐	☐	☐	☐	☐	■	☒

The "X" identifies your response from the 1st round. The main purpose of the 2nd round of the consultation process is to give you the opportunity to modify your response in light of the responses of others. If you wish to modify your response from the 1st round please alter the position of the "X" as appropriate.
We were very grateful for the comments made on the 1st round questionnaire. Some of these prompted us to ask the three questions that are placed at the end of the 2nd round questionnaire. We would be very pleased if you could find time to answer those questions. Additionally in some instances comments that you made in the 1st round have been summarized and included on the questionnaire so that you have the opportunity to modify them.
We anticipate that this will be the final round of our questionnaire. Results from this round will also be made available to you by e-mail at a later stage.
Please find enclosed the questionnaire for the 2nd round of this consultation process.
(To view the document correctly please use the option "print layout" in your "view" box)
If you have any queries please do not hesitate to contact us either by telephone or by e-mail at R.Labens@vet.gla.ac.uk or L.Voute@vet.gla.ac.uk .

1. **How important are the following changes to you when making a radiographic diagnosis of osteoarthritis of the tarsometatarsal joint (Articulatio tarsometatarsalis) ?**

On a scale from 0 to 100, where 0 = Definitely not important, 100 = Definitely important

Radiographic feature	**0** Definitely **not** important	**1-20**	**21-40**	**41-60**	**61-80**	**81-99**	**100** Definitely important
Irregular subchondral bone	☐	☐	☐	☐	☐	■	☒
Subchondral bone sclerosis	☐	☐	☐	■	☐	☐	☒
Poor corticomedullary definition	☐	☐	☒	☐	☐	☐	☐
Enlarged joint space	☒	☐	☐	■	☐	☐	☐
Narrowed joint space	☐	☐	☐	☐	■	☐	☐
Ankylosis	☒	☐	☐	☐	☐	☐	■
Osteophytes	☐	☐	☐	☐	■	☐	☒
Bony spur on dorsoproximal Mt 3	☒	■	☐	☐	☐	☐	☐
Periarticular bony bridge formation	☐	☐	☐	☐	☐	☒	■
Indistinct/sclerotic synovial fossae	☐	☐	■	☐	☒	☐	☐
Subchondral bone lysis	☐	☐	☐	☐	☐	☐	☒

Please type any comments on this section

2. How important are the following changes to you when making a radiographic diagnosis of osteoarthritis of the distal intertarsal joint (Articulatio centrodistalis) ?

On a scale from 0 to 100, where 0 = Definitely not important, 100 = Definitely important

Radiographic feature	**0** Definitely **not** important	**1-20**	**21-40**	**41-60**	**61-80**	**81-99**	**100** Definitely important
Irregular subchondral bone	☐	☐	☐	☐	☐	■	☒
Subchondral bone sclerosis	☐	☐	☐	☐	■	☐	☒
Poor corticomedullary definition	☐	☐	☐	☒	☐	☐	☐
Enlarged joint space	☒	☐	☐	■	☐	☐	☐
Narrowed joint space	☐	☐	☐	☐	☐	■	☐
Ankylosis	☒	☐	☐	☐	☐	☐	■
Osteophytes	☐	☐	☐	☐	☐	■	☒
Bony spur on dorsoproximal Mt 3	■	☐	☐	☐	☐	☐	☐
Periarticular bony bridge formation	☐	☐	☐	☐	☐	☒	■
Indistinct/sclerotic synovial fossae	☐	■	☐	☐	☒	☐	☐
Subchondral bone lysis	☐	☐	☐	☐	☐	☐	☒

Please type any comments on this section

3. How important are the following changes to you when making the radiographic diagnosis of osteoarthritis of the proximal intertarsal joint (Articulatio talocalcaneocentralis) ?

On a scale from 0 to 100, where 0 = Definitely not important, 100 = Definitely important

Radiographic feature	**0** Definitely **not** important	**1-20**	**21-40**	**41-60**	**61-80**	**81-99**	**100** Definitely important
Irregular subchondral bone	☐	☐	☐	☐	☐	☐	☒
Subchondral bone sclerosis	☐	☐	☐	☐	■	☐	☒
Poor corticomedullary definition	☐	☐	☒	☐	☐	☐	☐
Enlarged joint space	☒	☐	☐	■	☐	☐	☐
Narrowed joint space	☐	☐	☐	☐	☐	■	☐
Ankylosis	☒	☐	☐	☐	☐	☐	■
Osteophytes	☐	☐	☐	☐	☐	☐	☒
Bony spur on dorsoproximal Mt 3	☒	☐	☐	☐	☐	☐	☐
Periarticular bony bridge formation	☐	☐	☐	☐	☐	☒	☐
Indistinct/sclerotic synovial fossae	☐	■	☐	☐	☒	☐	☐
Subchondral bone lysis	☐	☐	☐	☐	☐	☐	☒

Please type any comments on this section

Do you attribute greater importance to a radiographic feature when it is present together with other features rather than in isolation?
(If yes please give details)

No	Don't know	Yes
☒	☐	☐

Do you attribute greater importance to radiographic features when they are seen in more than one radiographic view?

No	Don't know	Yes
☒	☐	☐

Do you attribute greater importance to a radiographic feature when it is present at a specific location in the joint?
(If yes please give details)

No	Don't know	Yes
☐	☐	☒

Identification:

Validation Process of a Radiographic Rating Scale for Use in the Distal Tarsal Joints in Horses

UNIVERSITY of GLASGOW

Conducted by the Weipers Centre for Equine Welfare
Division of Companion Animal Sciences
University of Glasgow Veterinary School
Bearsden Road
Glasgow G61 1QH
United Kingdom
Tel. : +44 (0) 141 330 5999

Round one

Thank you for willing to participate in this validation process!

- Please find enclosed three different sets of radiographs for the radiographic evaluation of the distal tarsal joints. Each one contains four standard views (LM, DP, DL-PLMO and DM-PLLO view).

- For each joint (TMT, DIT and PIT joint) indicate along the bar the severity of the listed radiographic feature as you would perceive it. (0 = not present; 10 = worst possible presentation).

- Please indicate in the appropriate area at the end of this evaluation form whether you interpret the radiographic changes as evidence of mild, moderate or severe osteoarthritis.

- Please do not spend more time evaluating these images as you would normally do in a clinical situation.

- Mark this cover sheet in the identification box (top left corner) with a word of your choice that will allow you to remember it for the next round. This will also guarantee the anonymity of your response.

- When you have completed the evaluation please post your answer with the prepaid and addressed envelope directly to me.

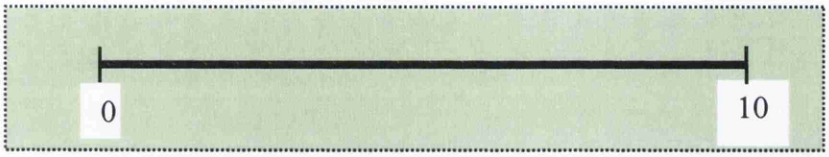
Thank You

SET:

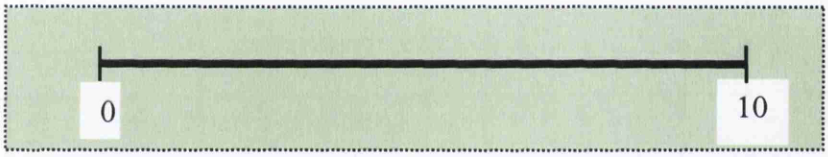
Tarsometatarsal joint (TMT)

Lateromedial view (LM)

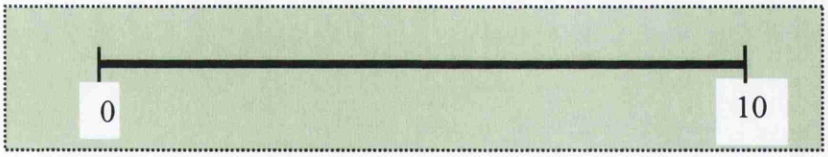
- *Irregular subchondral bone*



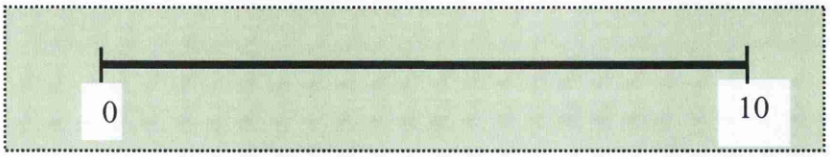
- *Narrowed joint space*



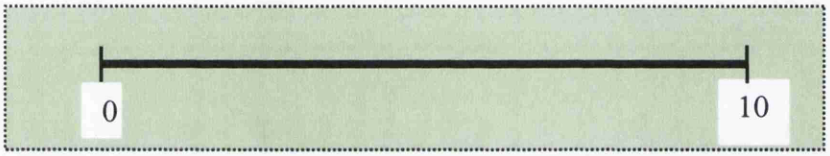
- *Osteophytes*



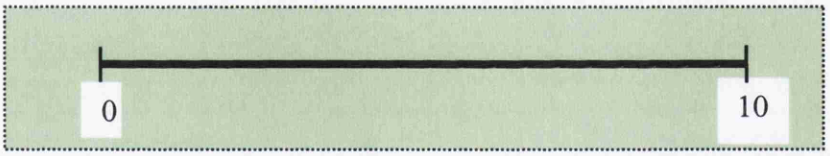
- *Periarticular bony bridge formation*

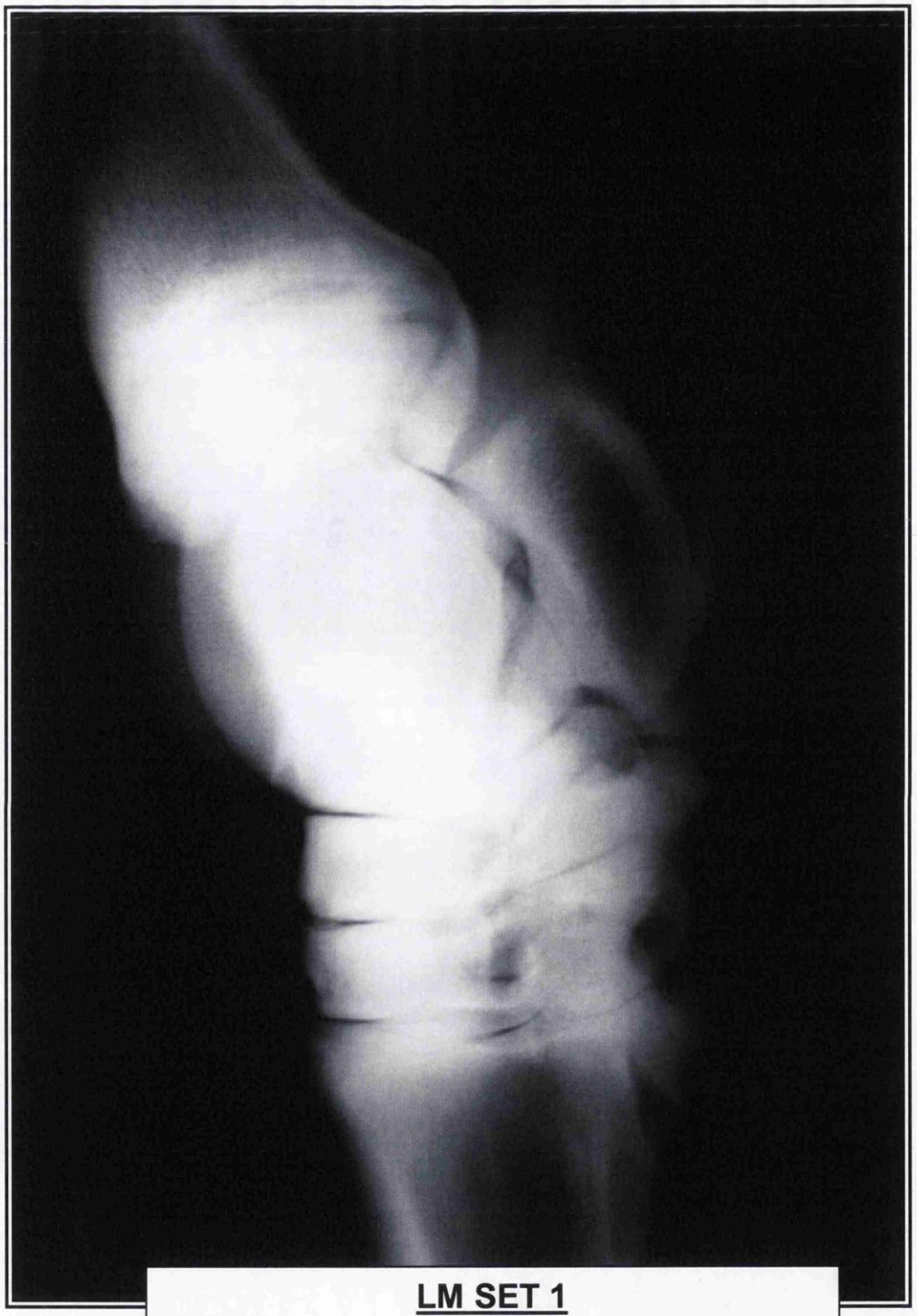


- *Subchondral bone lysis*

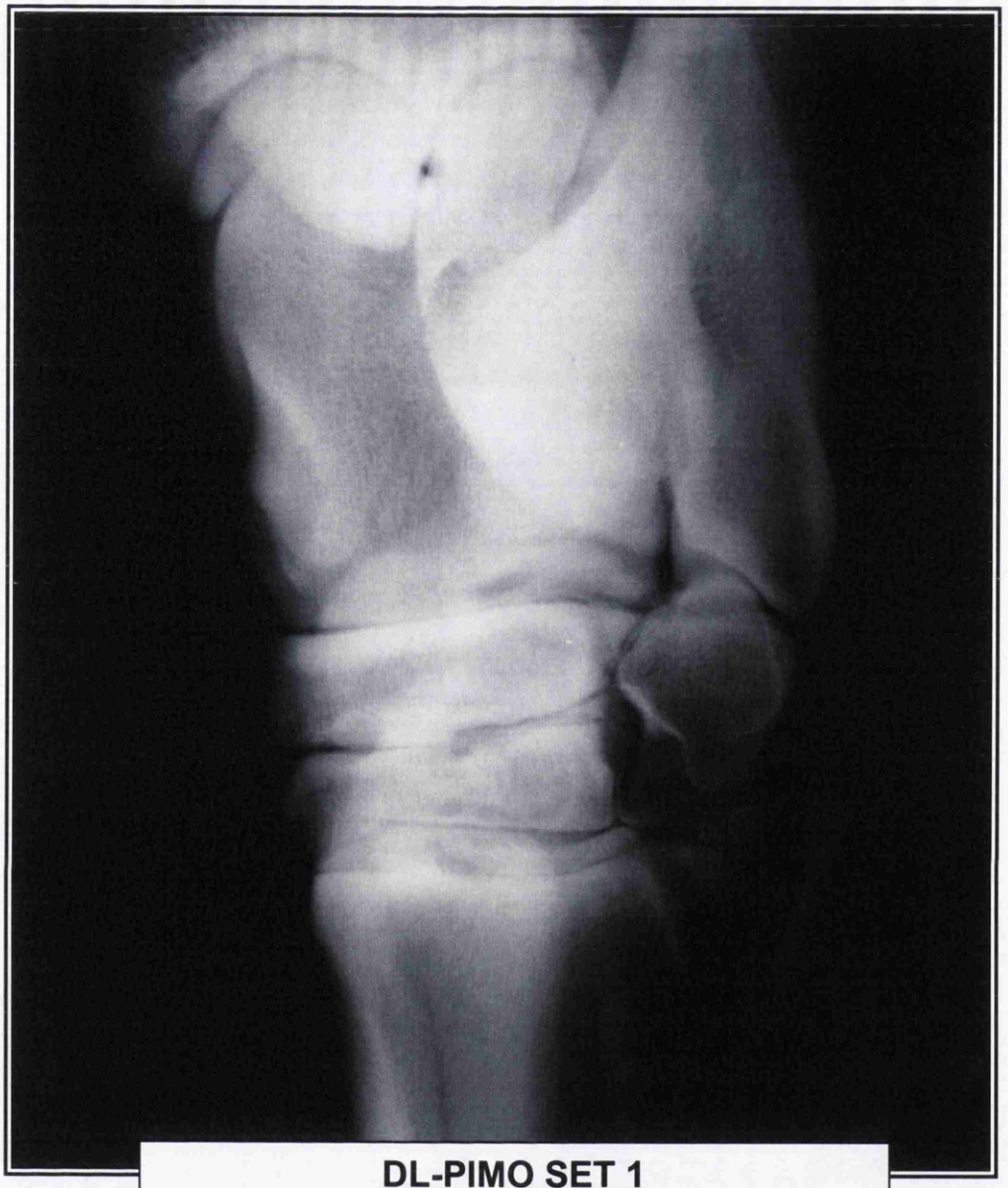


- *Partial ankylosis*

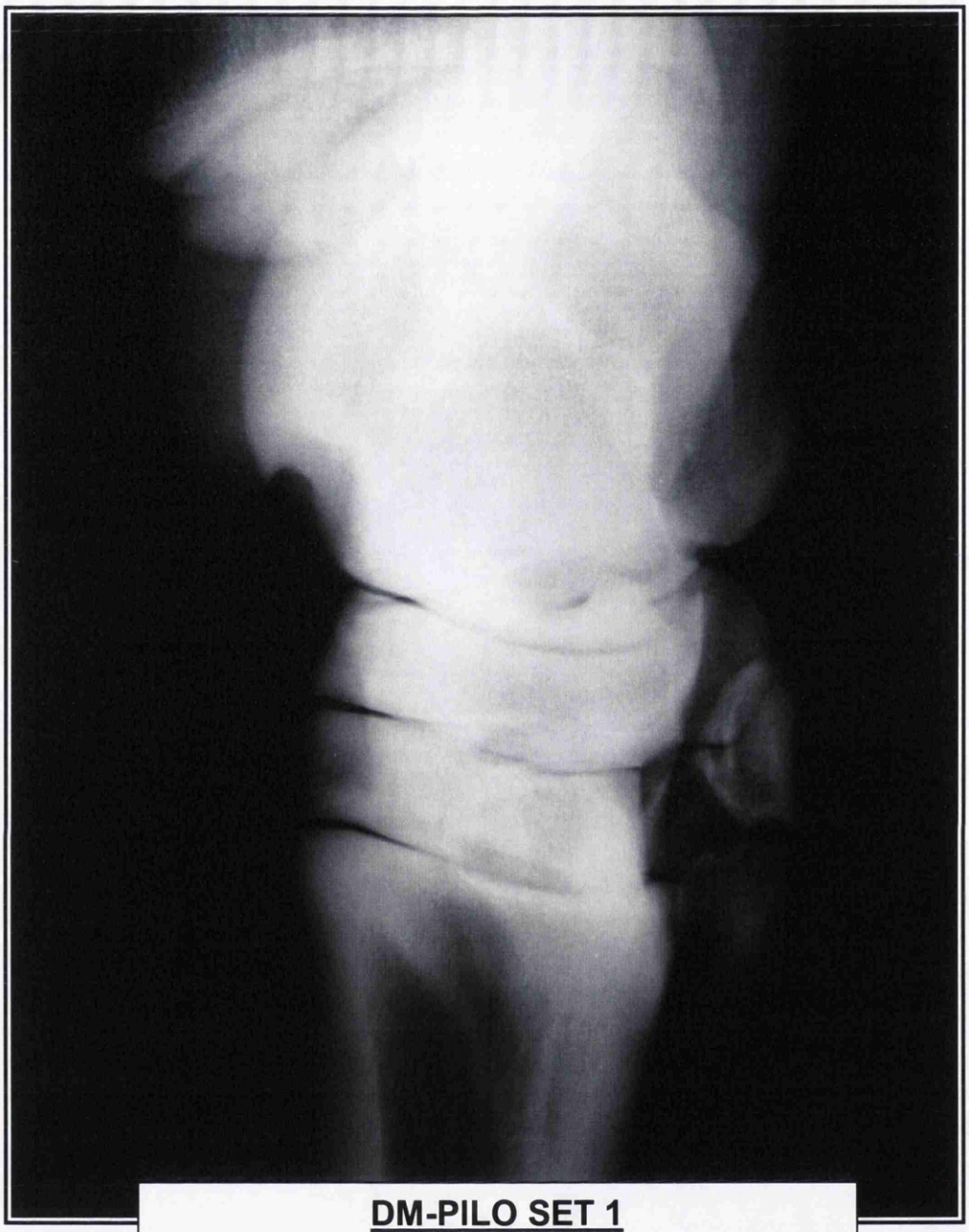




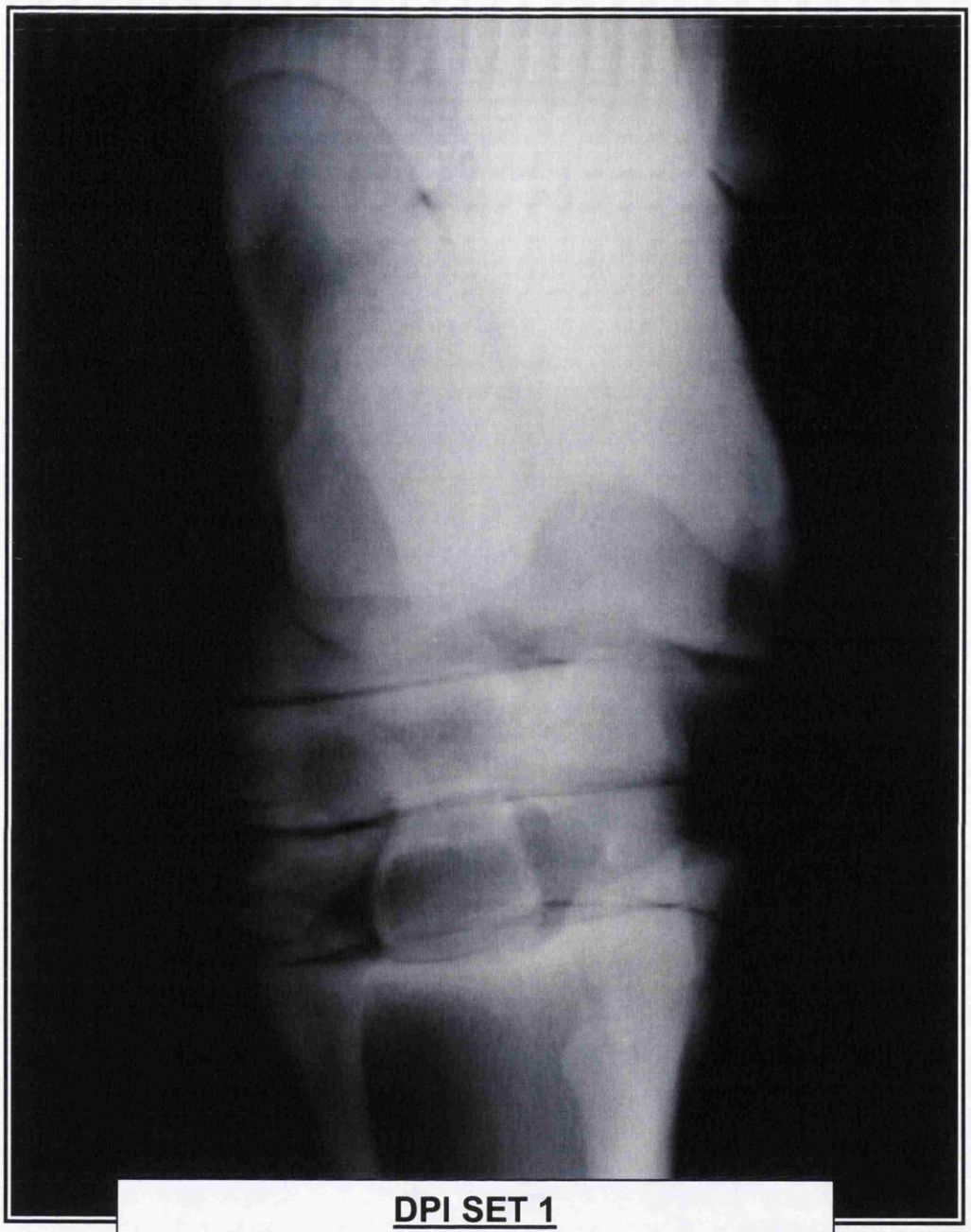
LM SET 1



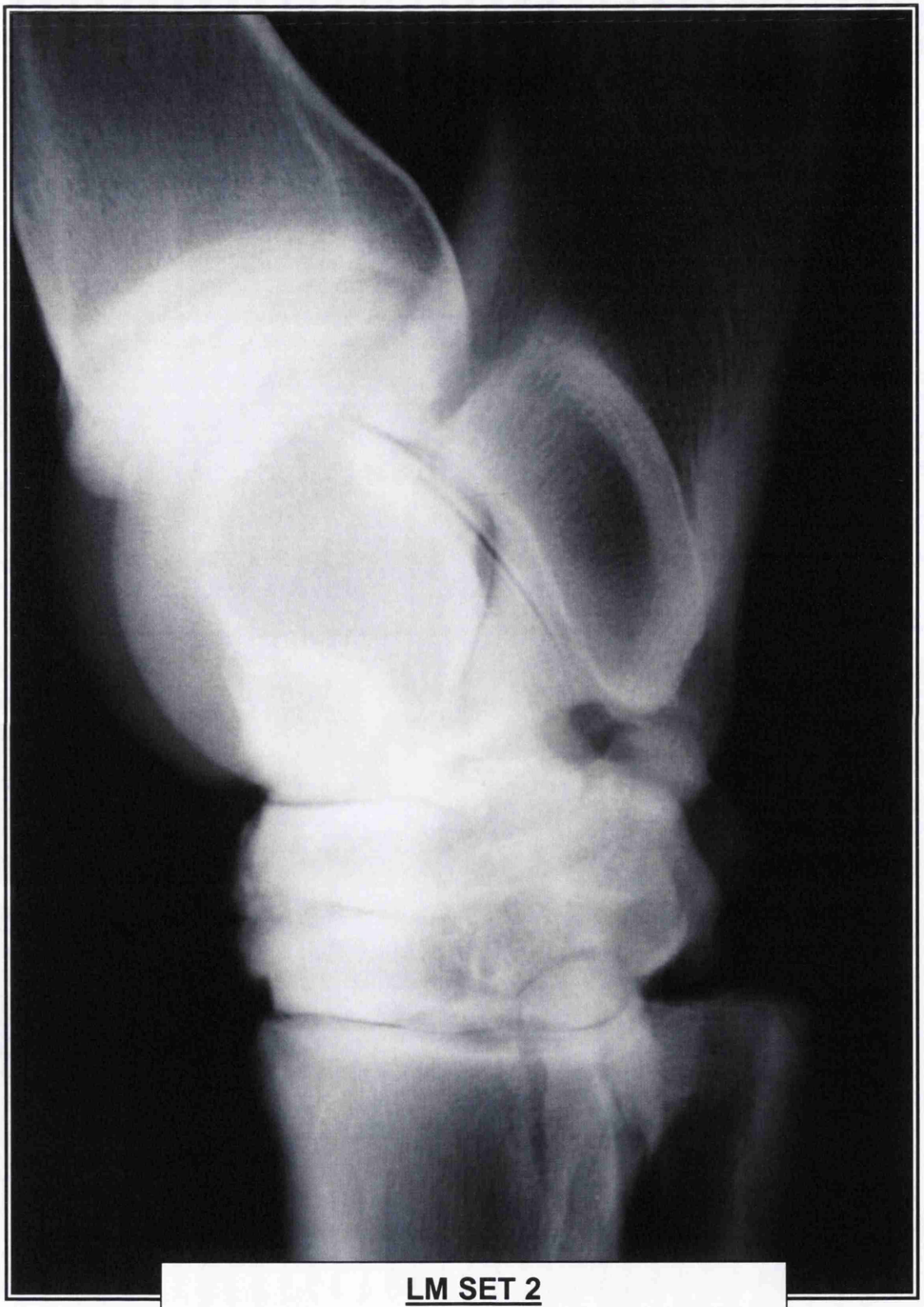
DL-PIMO SET 1



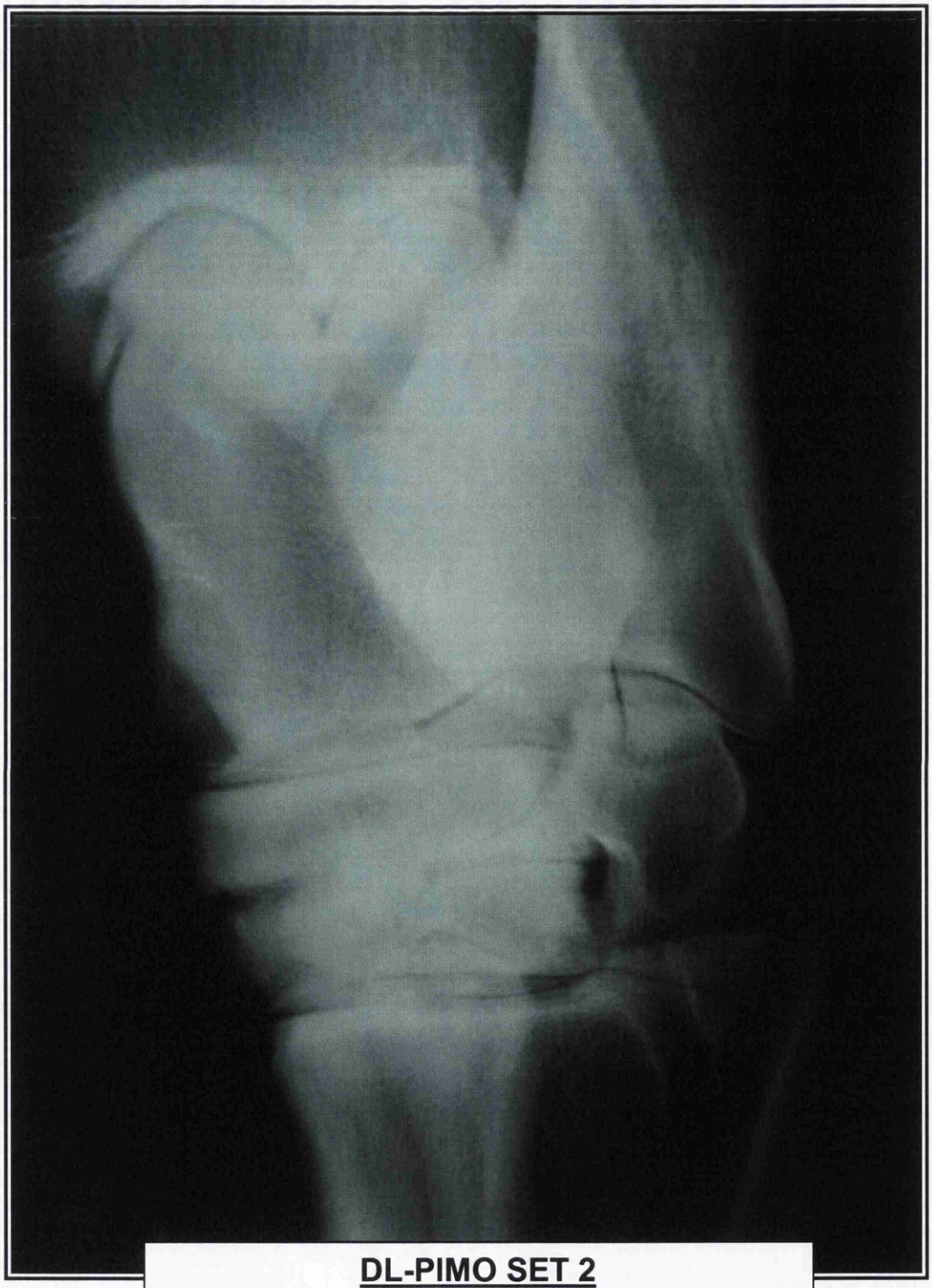
DM-PILO SET 1



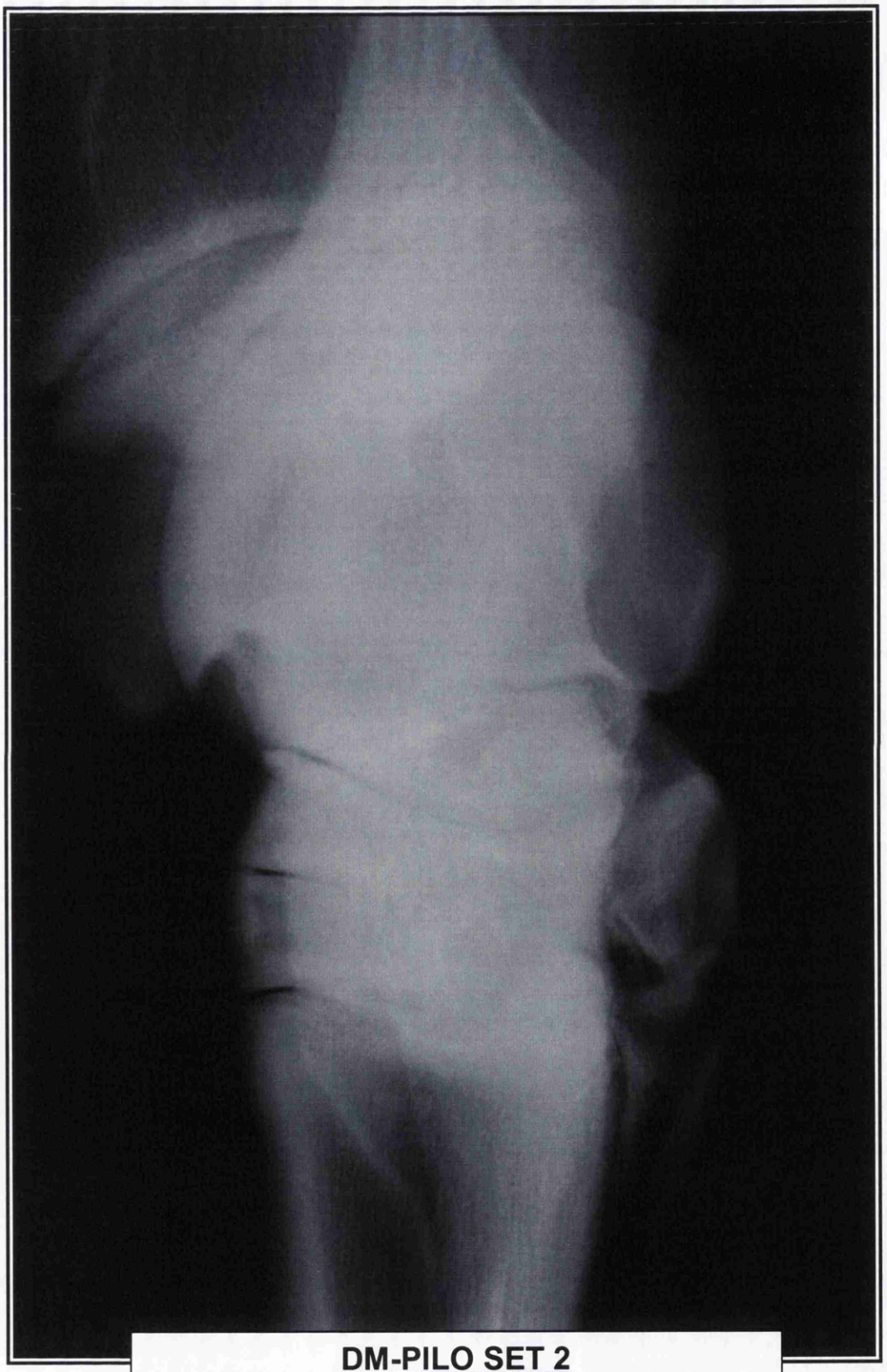
DPI SET 1



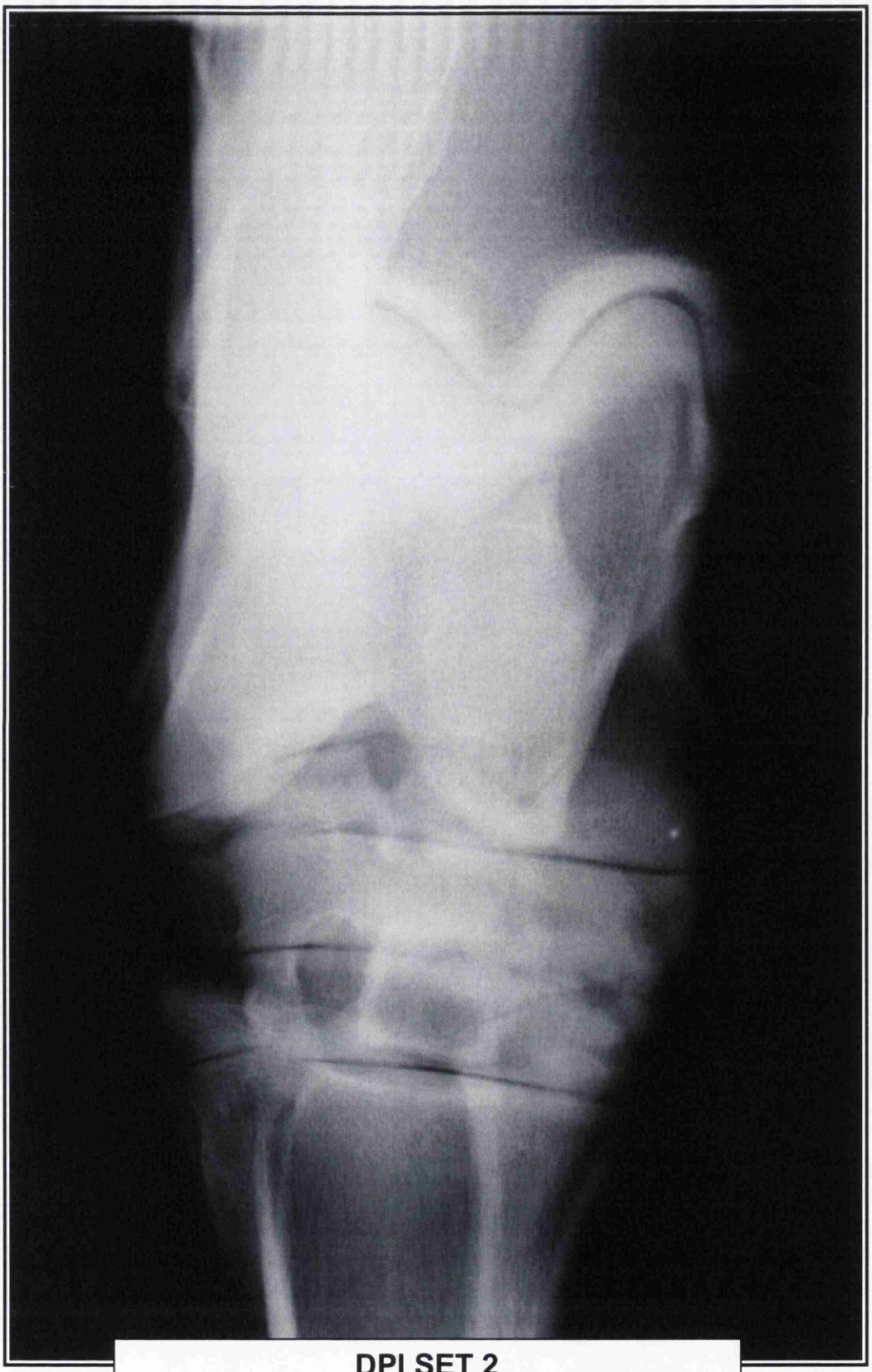
LM SET 2



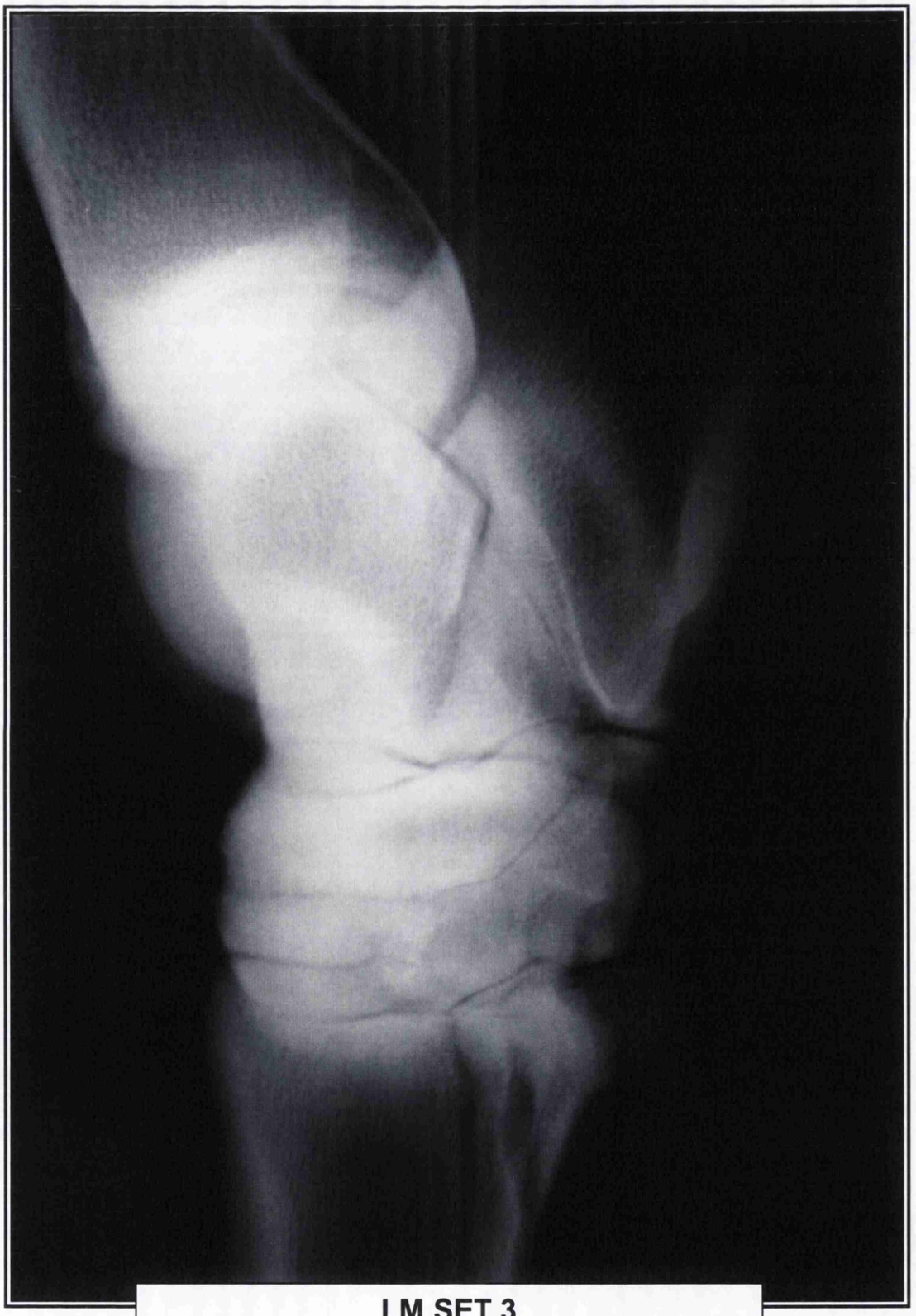
DL-PIMO SET 2



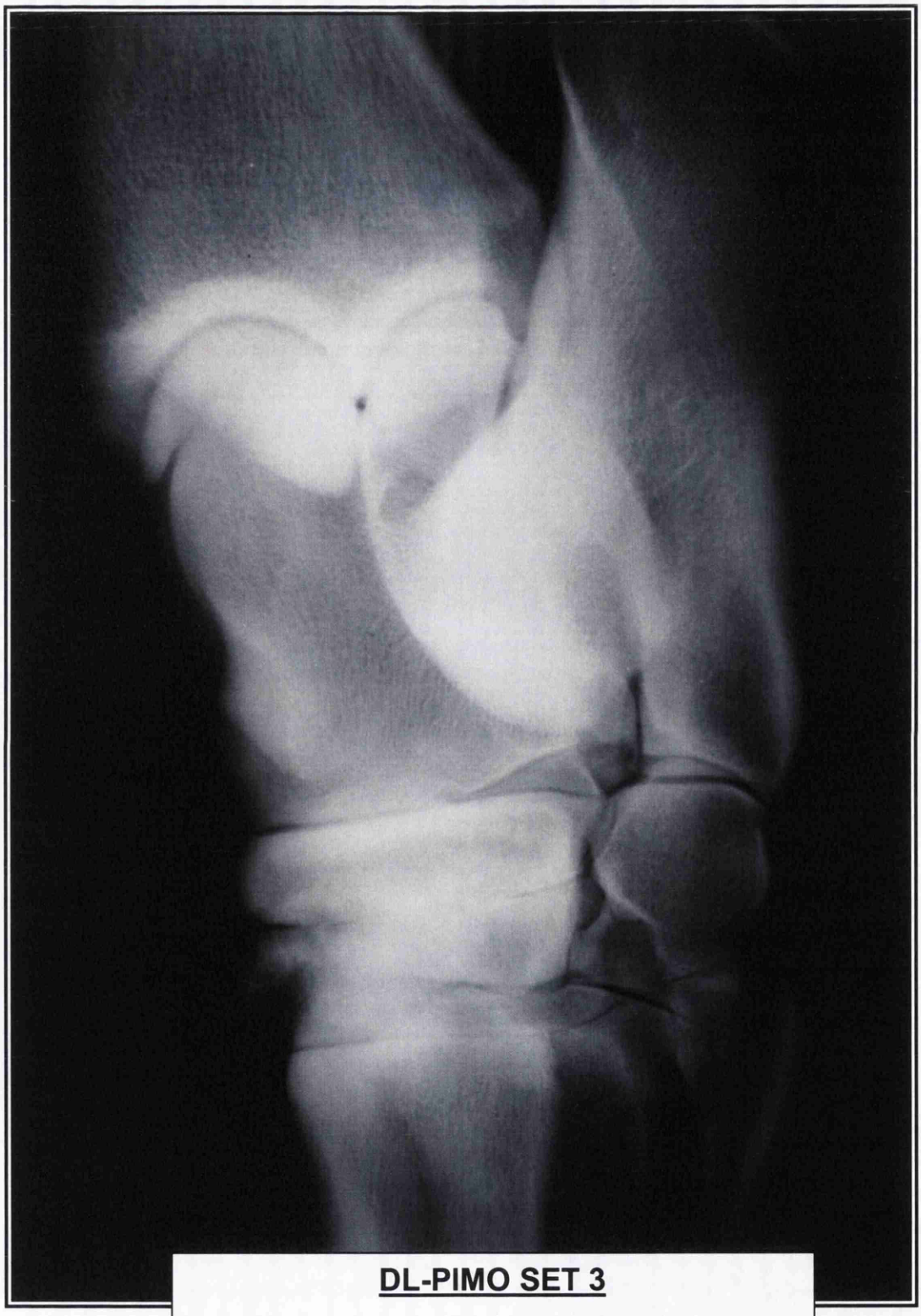
DM-PILO SET 2



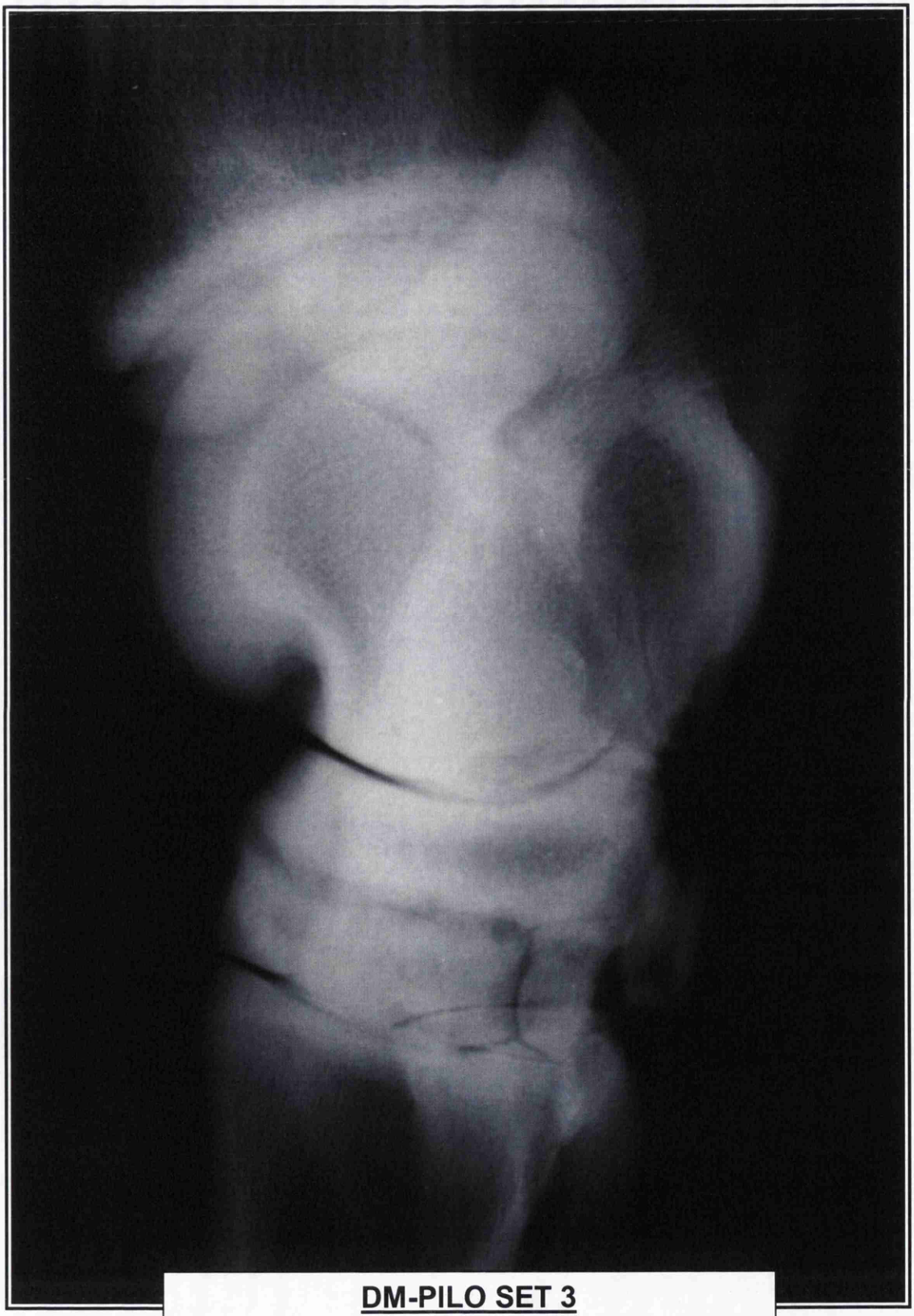
DPI SET 2



LM SET 3



DL-PIMO SET 3



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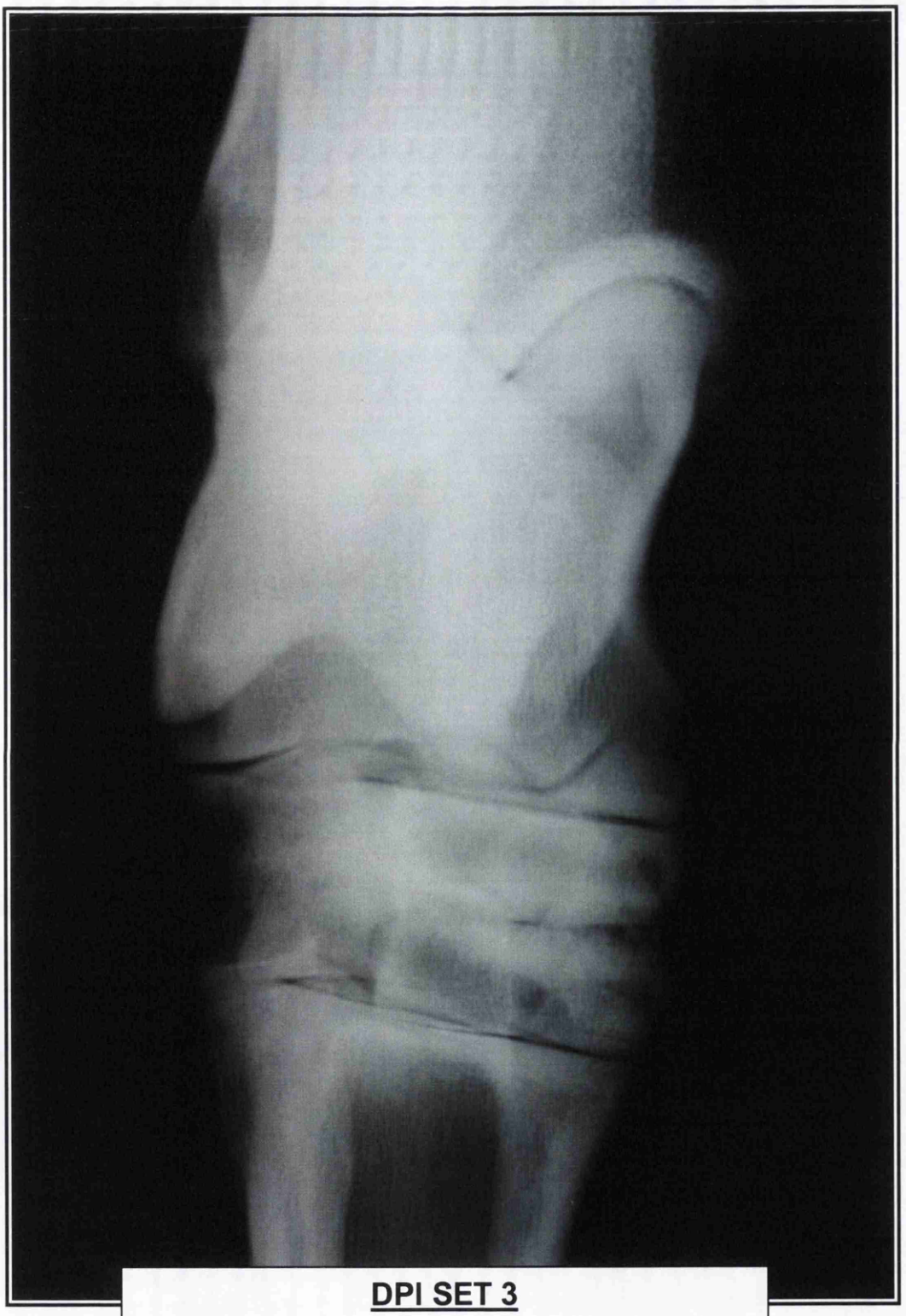


DPI SET 3

Mr/Mrs ... MRCVS
.....
.....
.....
.....

20th May 2005

UNIVERSITY
of
GLASGOW

Re: Retrospective study on the outcome of treatment of horses with osteoarthritis of the distal tarsal joints (bone spavin) conducted by the Weipers Centre for Equine Welfare, Faculty of Veterinary Medicine, Glasgow University

Dear Mr/Mrs .....,

As part of a retrospective study performed by the Weipers Centre for Equine Welfare, Glasgow Veterinary School, investigating treatment outcome in horses with osteoarthritis of the distal tarsal joints we would like to conduct a telephone survey of your clients, whose horses have been diagnosed and treated for osteoarthritis of the distal tarsal joints at the Weipers Centre for Equine Welfare.

This telephone survey will try to assess if the horses have been able to return to their previous use and level of exercise, and whether the horses have received further treatment for the condition.

We would greatly appreciate it if you would let us know if you would prefer us **not** to contact your clients. In that instance we would make sure that horses referred from your practice are excluded from the survey.

Please contact us directly at the Centre (0141 330 5999) or send us an electronic message (R.Labens@vet.gla.ac.uk).

Thank you very much for your cooperation

With best wishes,

Raphael Labens
Mag.Med.Vet; DEC, MRCVS
Resident in Equine Surgery

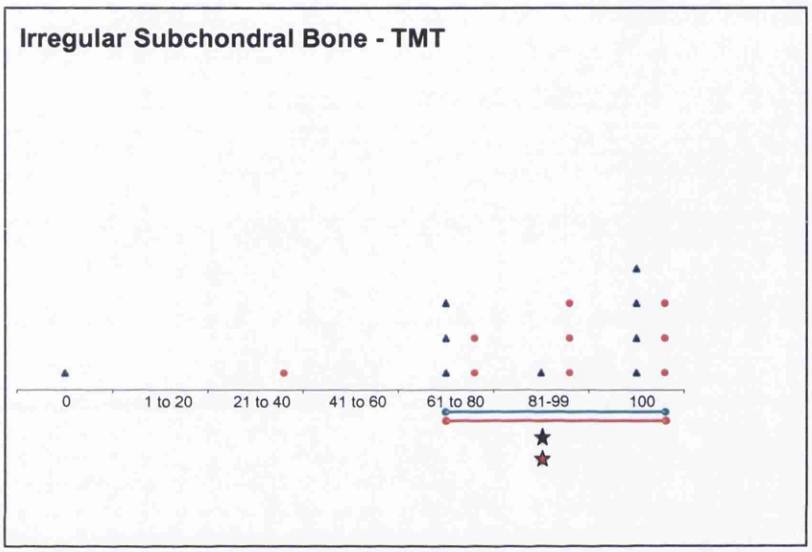
Lance Voute
BVSc, Cert ES(Orth), MRCVS
Lecturer in Equine Surgery

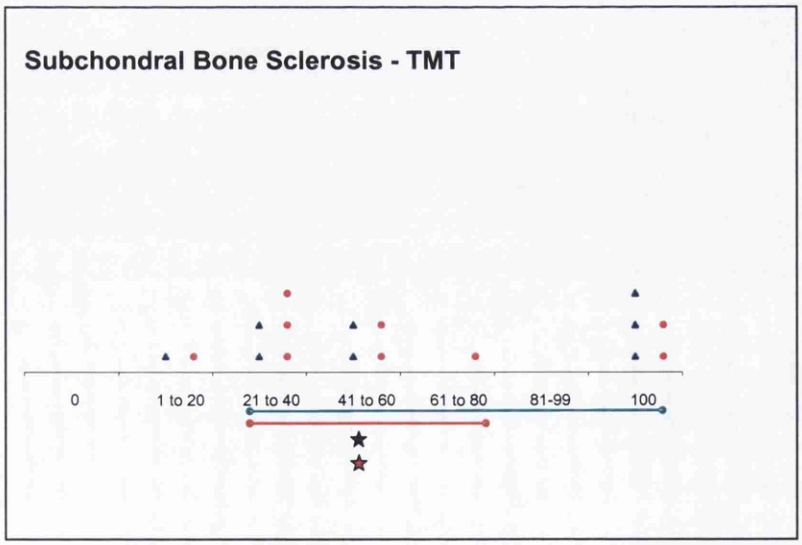
Prof. Sandy Love
BVMS, PhD, MRCVS
Head of Centre

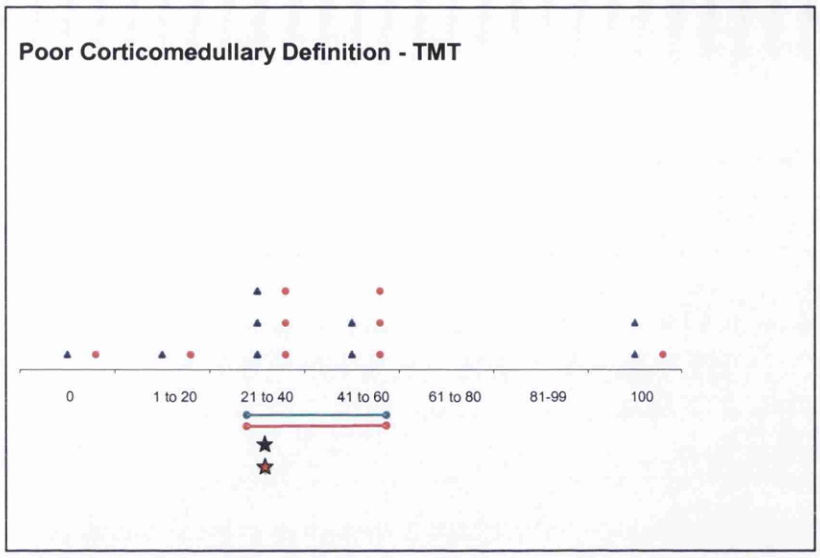
APPENDICES

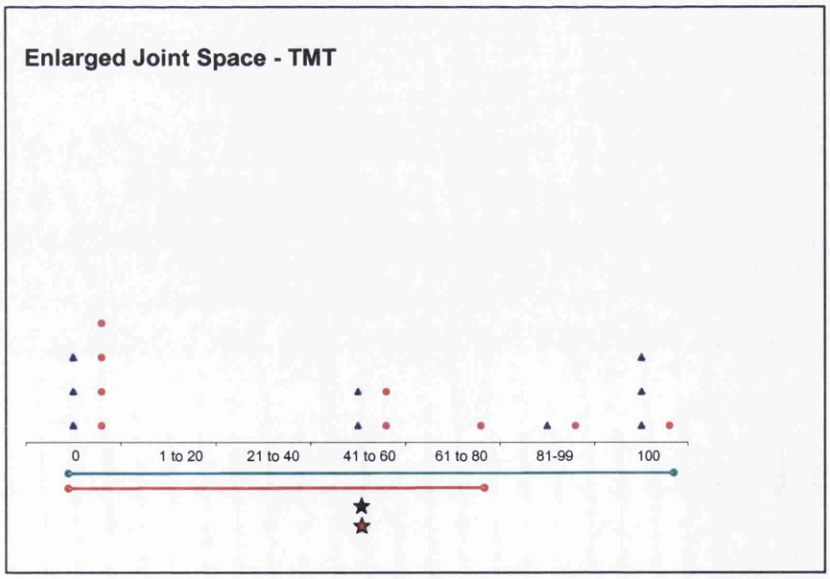
Figures 4.2.1
Graphical display of the results from the Delphi consultation process

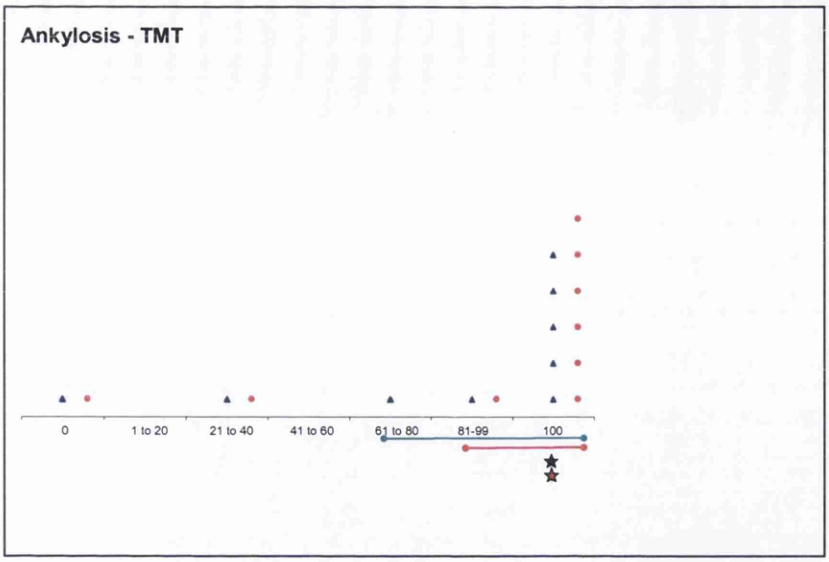
The bars indicate the interquartile range, the stars the position of the median;
results from the 1st round are in blue and from the 2nd in red;
TMT = tarsometatarsal joint; DIT = distal intertarsal joint;
PIT = proximal intertarsal joint; Mt3 = third metatarsal bone

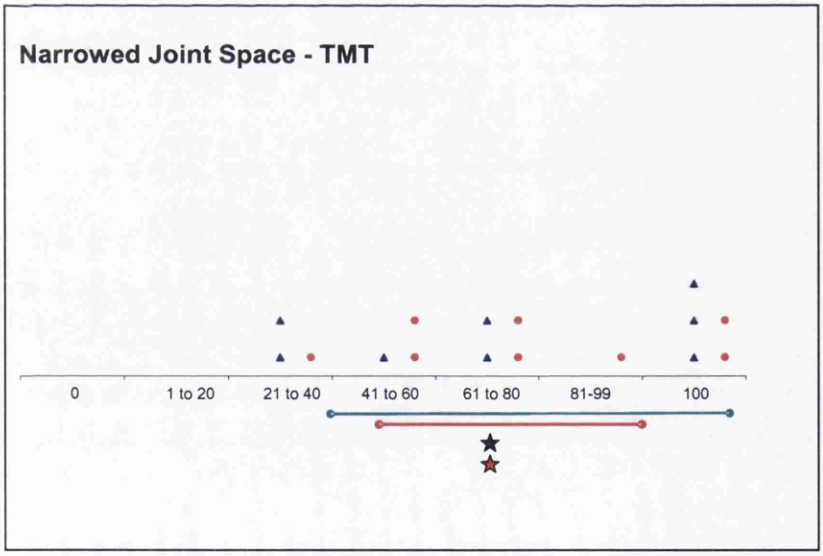


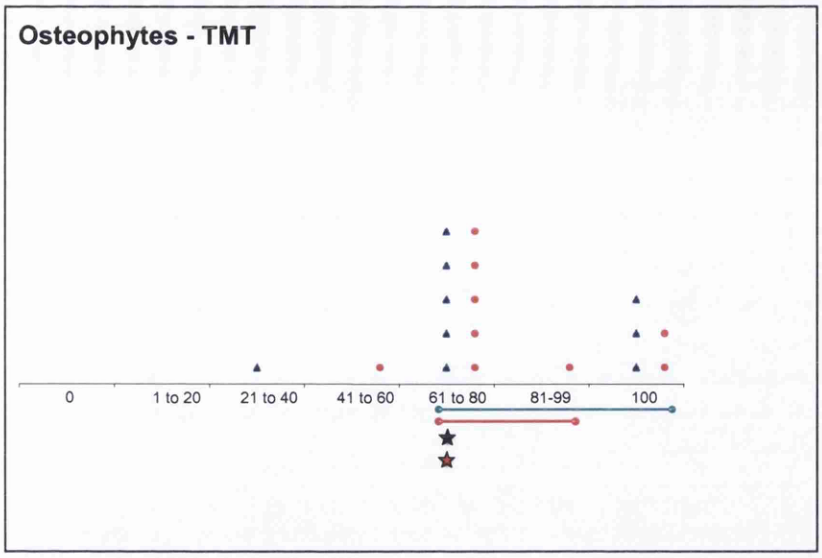


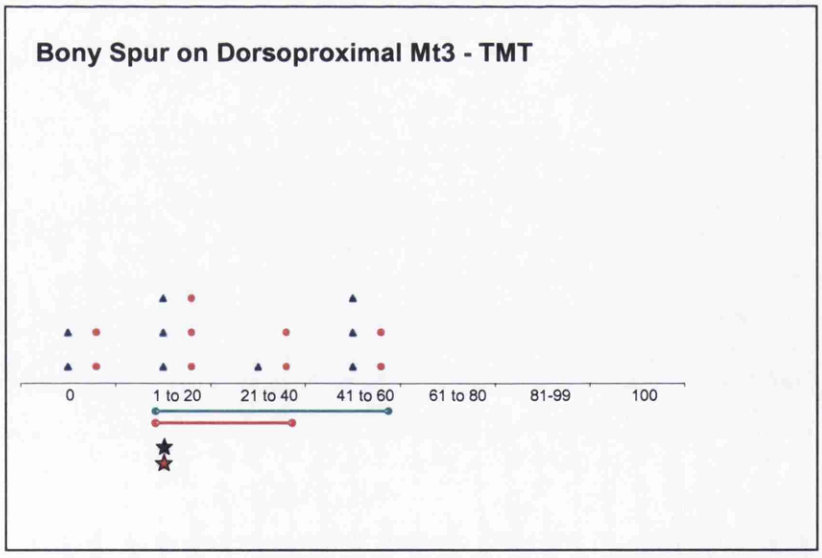

Poor Corticomedullary Definition - TMT
0
1 to 20
21 to 40
41 to 60
61 to 80
81-99
100

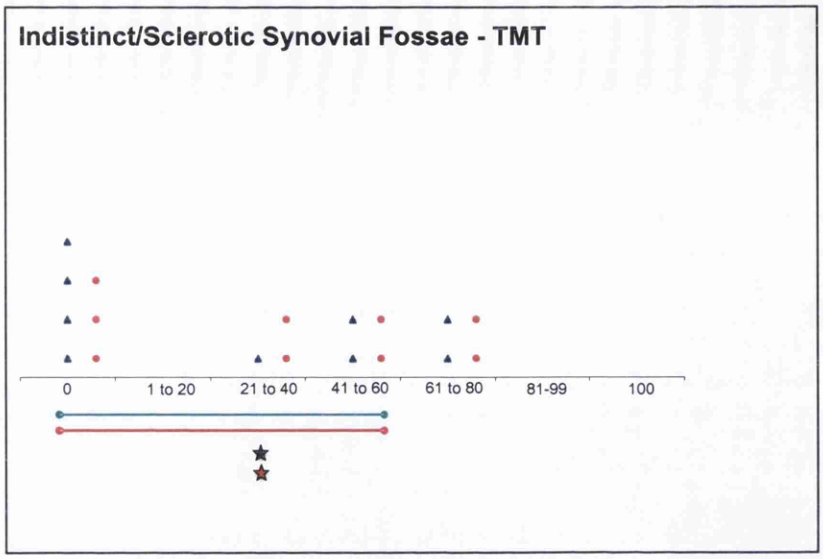

Enlarged Joint Space - TMT
0
1 to 20
21 to 40
41 to 60
61 to 80
81-99
100

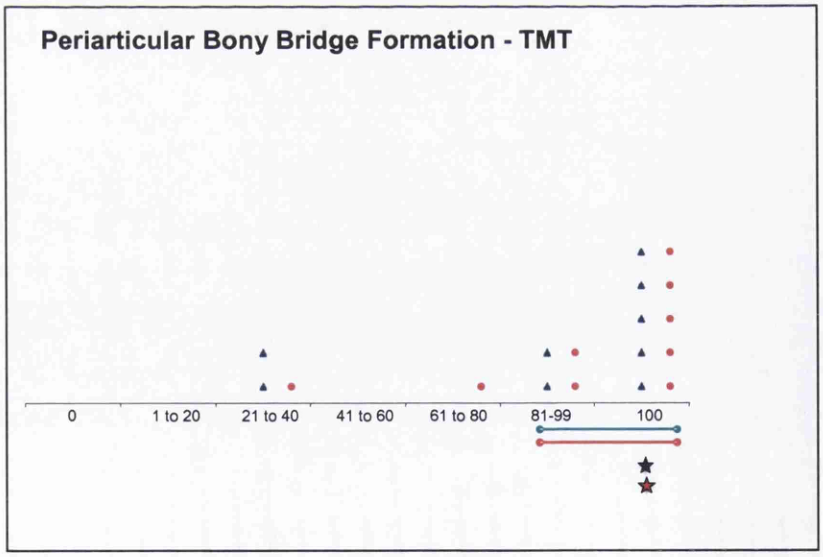

Ankylosis - TMT
0
1 to 20
21 to 40
41 to 60
61 to 80
81-99
100

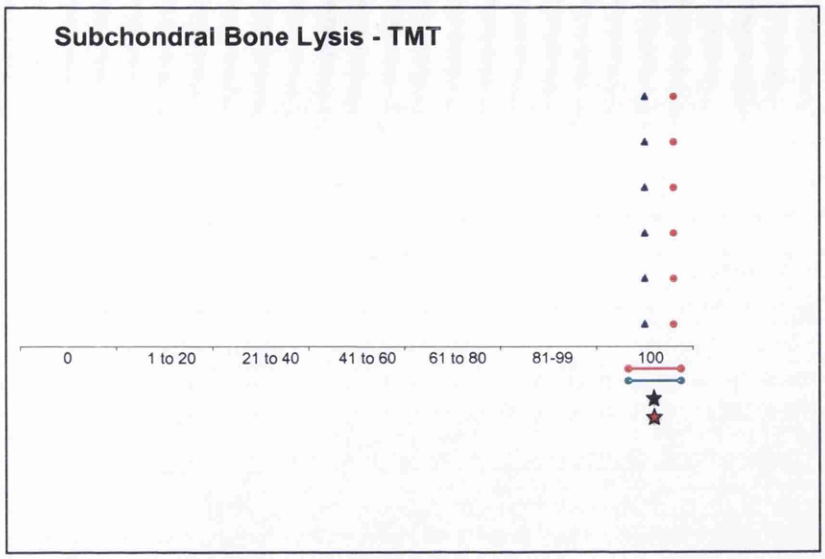

Narrowed Joint Space - TMT
0
1 to 20
21 to 40
41 to 60
61 to 80
81-99
100

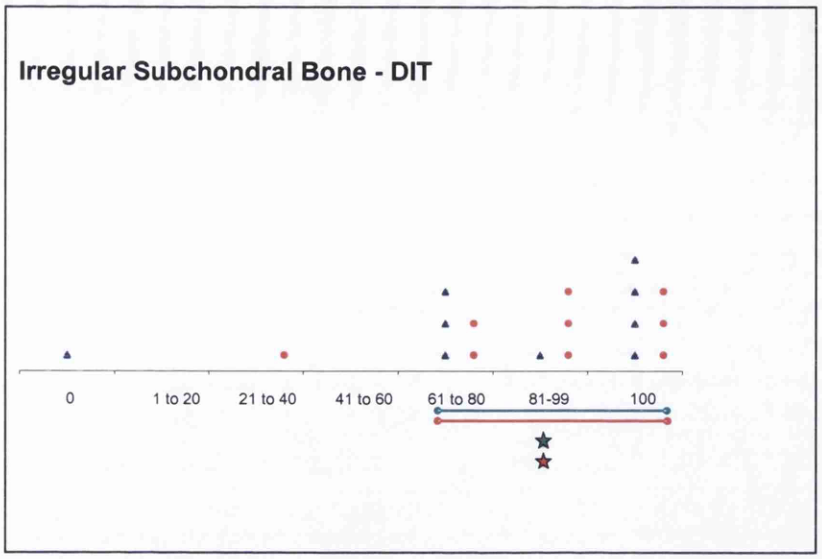

Osteophytes - TMT
0
1 to 20
21 to 40
41 to 60
61 to 80
81-99
100

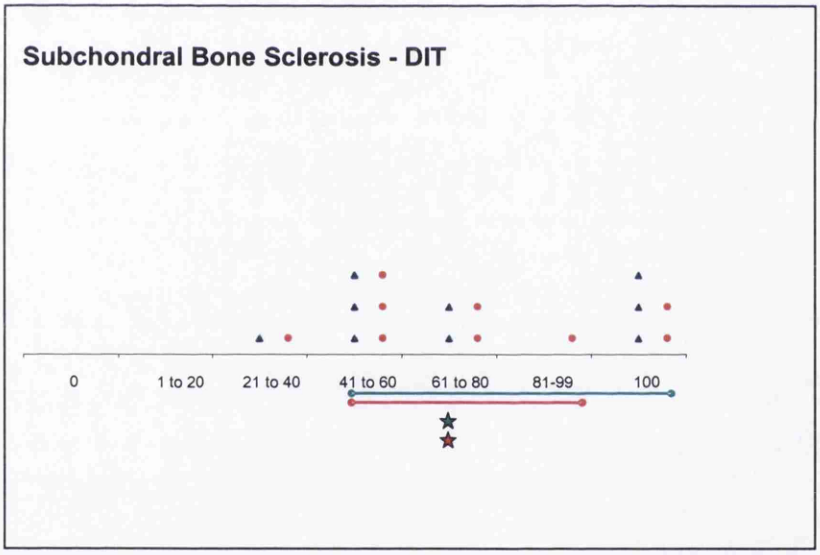

Bony Spur on Dorsoproximal Mt3 - TMT
0
1 to 20
21 to 40
41 to 60
61 to 80
81-99
100

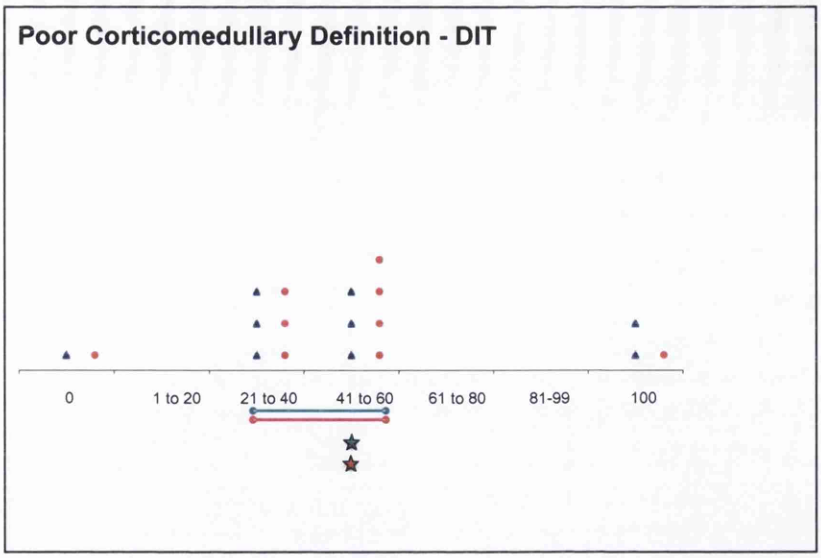

Indistinct/Sclerotic Synovial Fossae - TMT
0
1 to 20
21 to 40
41 to 60
61 to 80
81-99
100

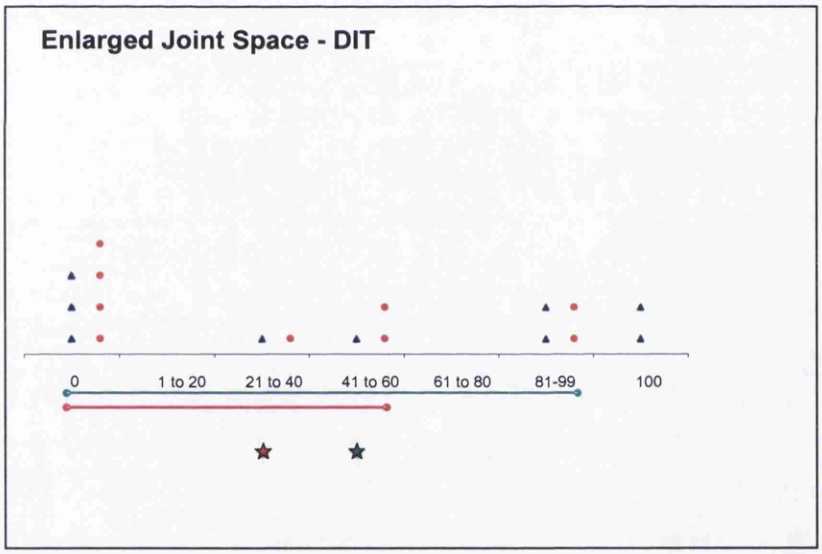

Periarticular Bony Bridge Formation - TMT
0
1 to 20
21 to 40
41 to 60
61 to 80
81-99
100

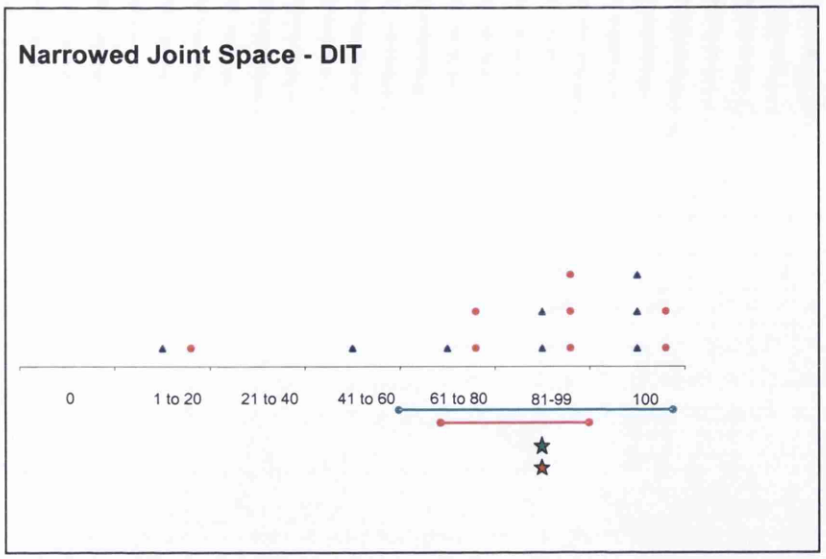

Subchondral Bone Lysis - TMT
0
1 to 20
21 to 40
41 to 60
61 to 80
81-99
100

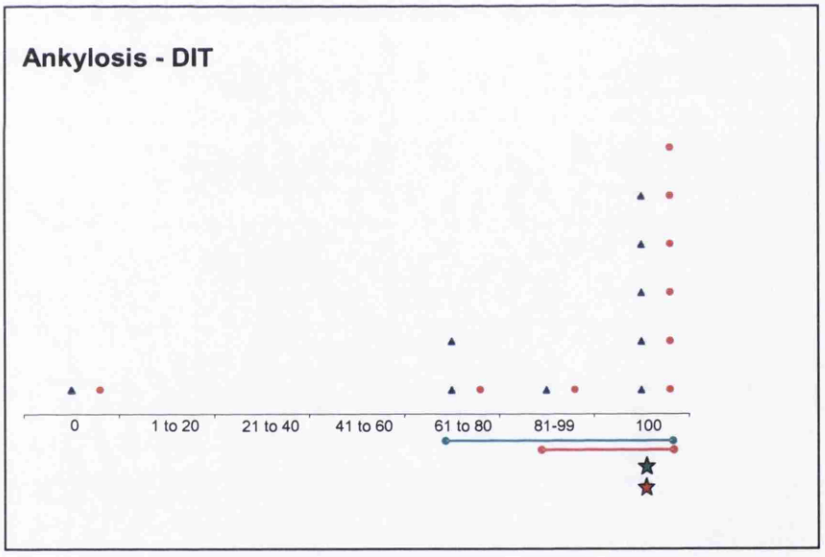

Irregular Subchondral Bone - DIT
0
1 to 20
21 to 40
41 to 60
61 to 80
81-99
100

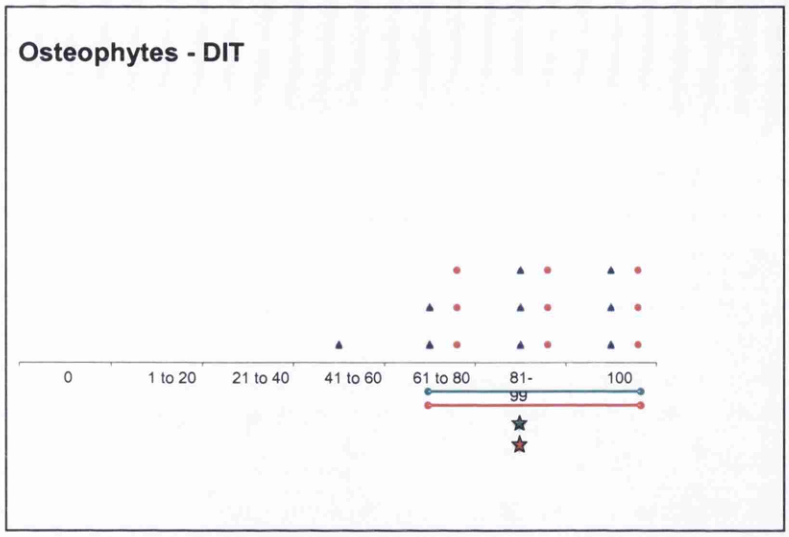

Subchondral Bone Sclerosis - DIT
0
1 to 20
21 to 40
41 to 60
61 to 80
81-99
100

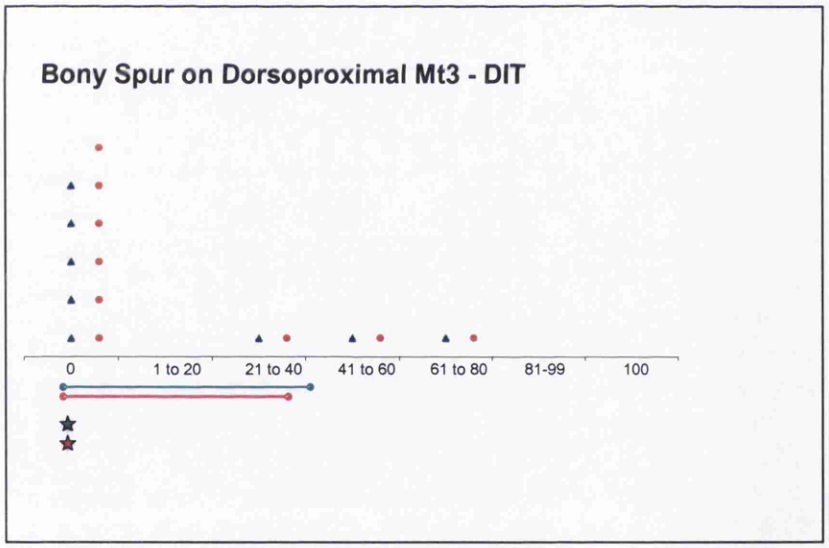

Poor Corticomedullary Definition - DIT
0
1 to 20
21 to 40
41 to 60
61 to 80
81-99
100

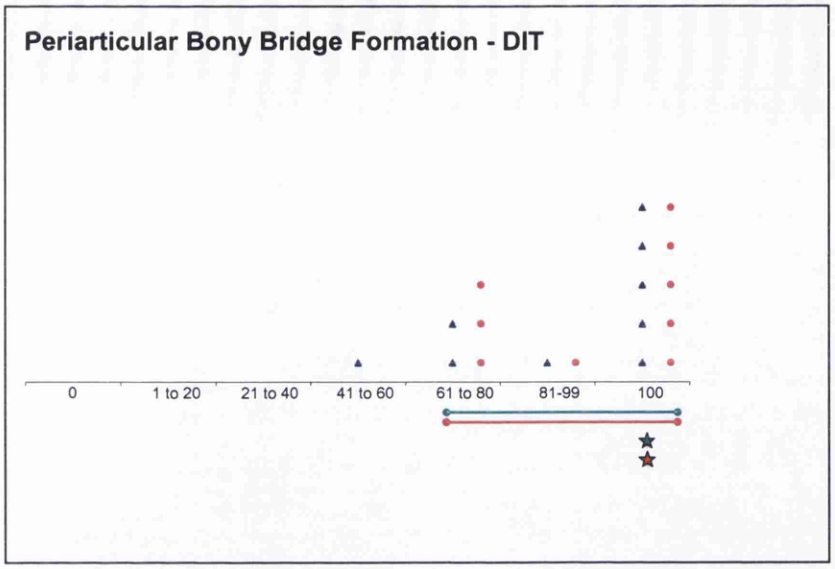

Enlarged Joint Space - DIT
0
1 to 20
21 to 40
41 to 60
61 to 80
81-99
100

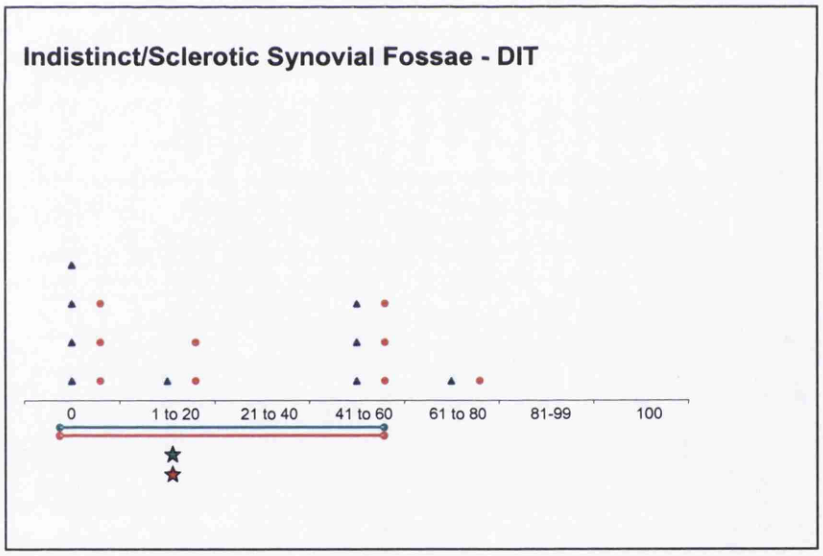

Narrowed Joint Space - DIT
0
1 to 20
21 to 40
41 to 60
61 to 80
81-99
100

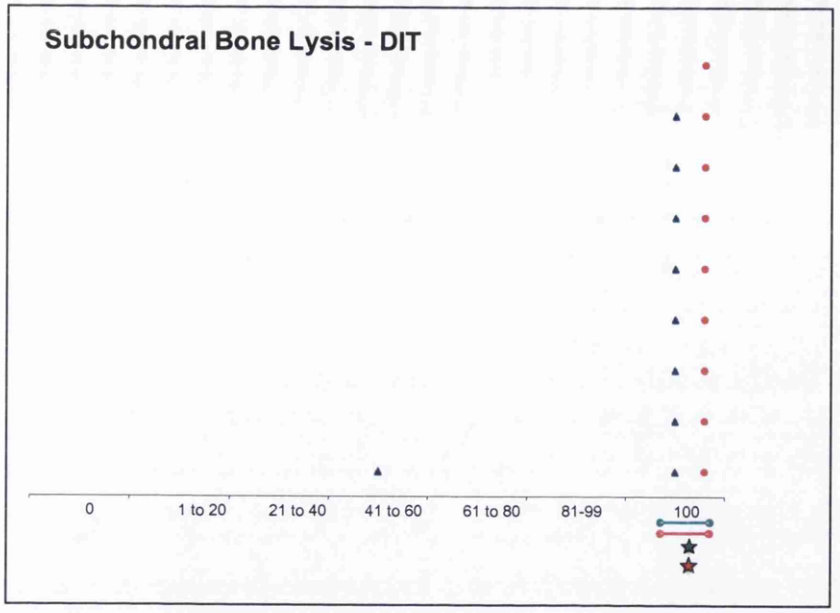

Ankylosis - DIT
0
1 to 20
21 to 40
41 to 60
61 to 80
81-99
100

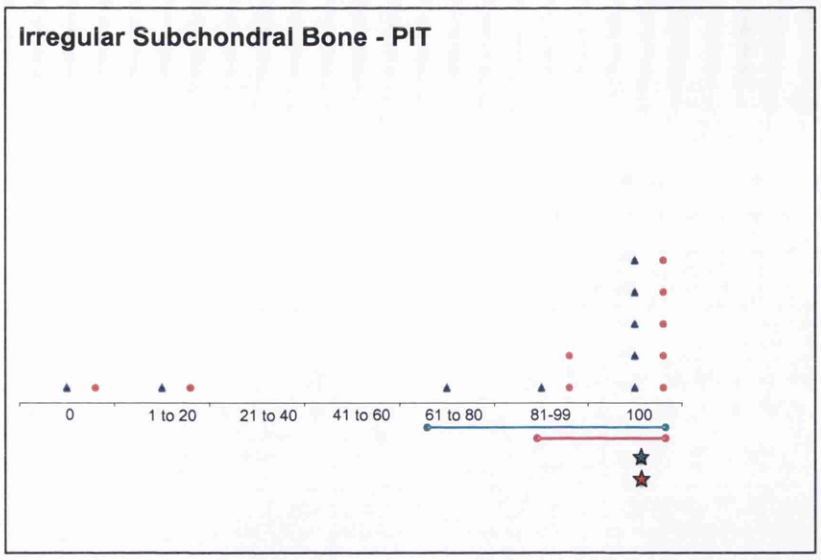

Osteophytes - DIT
0
1 to 20
21 to 40
41 to 60
61 to 80
81-99
100

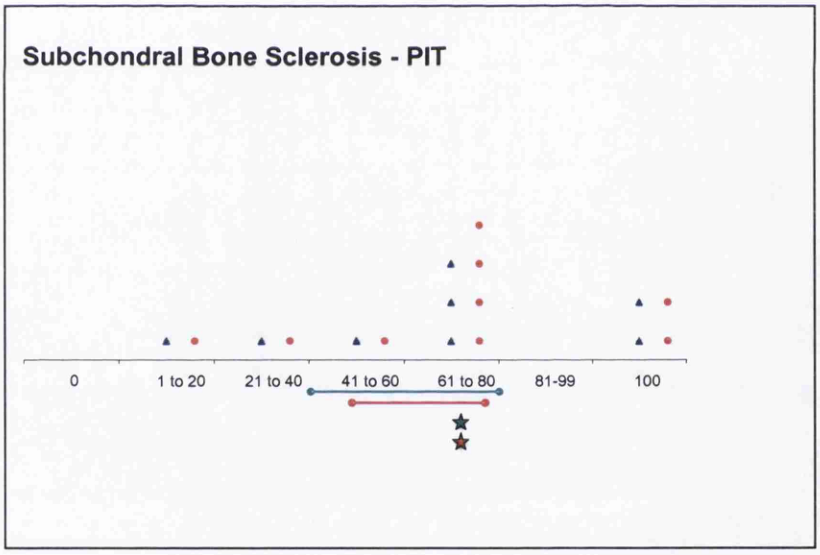

Bony Spur on Dorsoproximal Mt3 - DIT
0
1 to 20
21 to 40
41 to 60
61 to 80
81-99
100

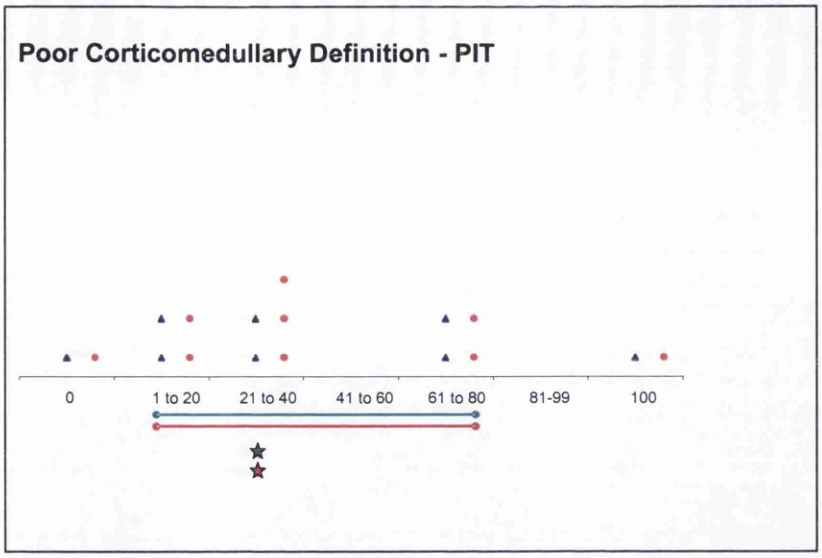

Periarticular Bony Bridge Formation - DIT
0
1 to 20
21 to 40
41 to 60
61 to 80
81-99
100

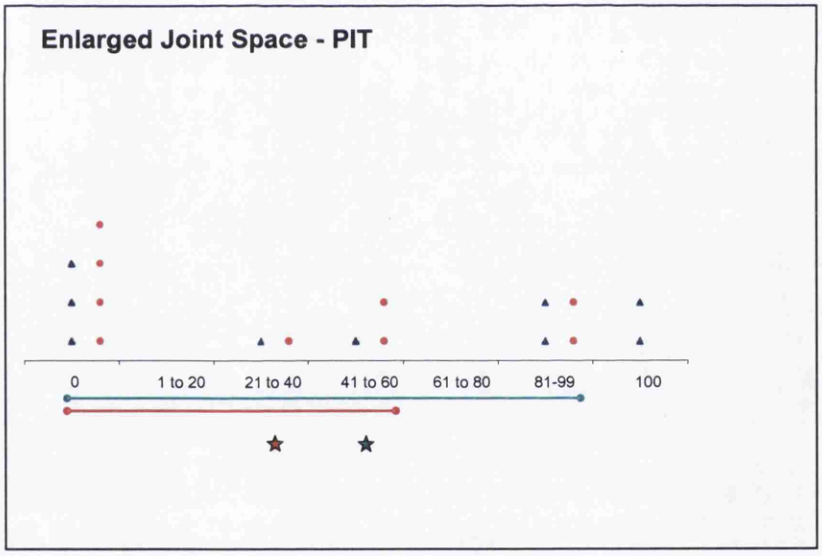

Indistinct/Sclerotic Synovial Fossae - DIT
0
1 to 20
21 to 40
41 to 60
61 to 80
81-99
100

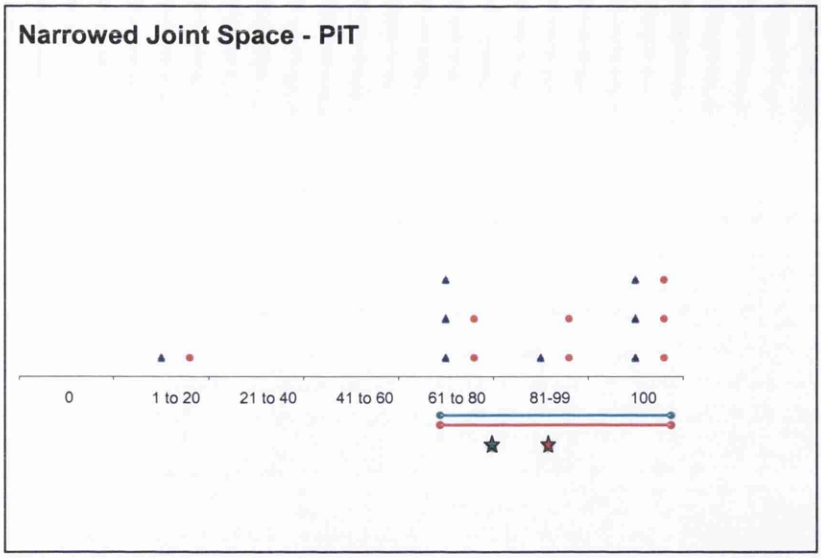

Subchondral Bone Lysis - DIT
0
1 to 20
21 to 40
41 to 60
61 to 80
81-99
100

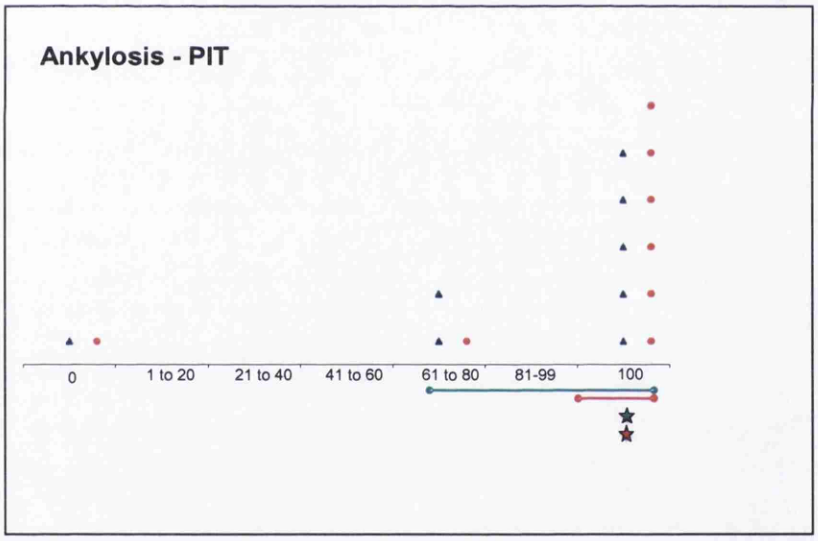

Irregular Subchondral Bone - PIT
0
1 to 20
21 to 40
41 to 60
61 to 80
81-99
100

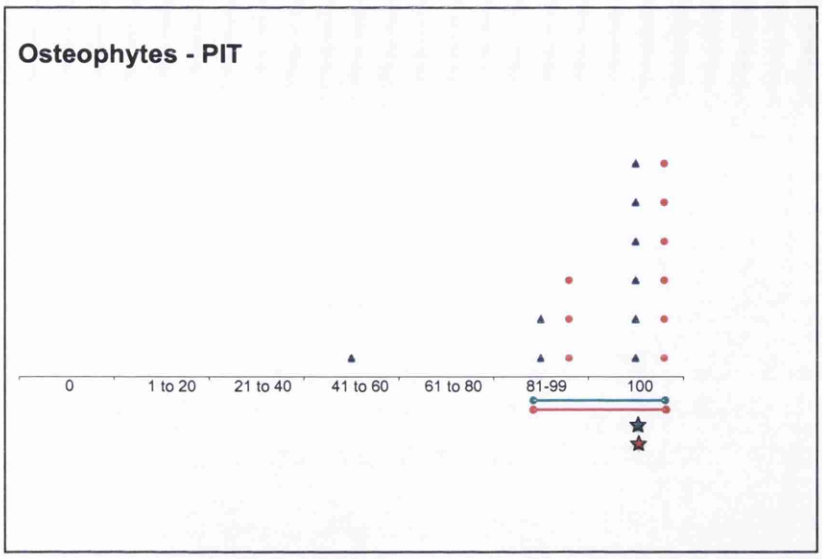

Subchondral Bone Sclerosis - PIT
0
1 to 20
21 to 40
41 to 60
61 to 80
81-99
100

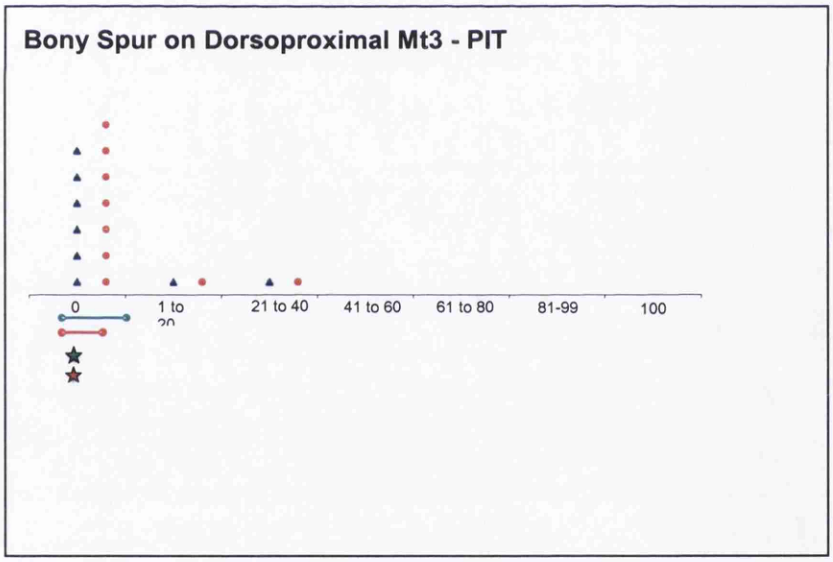

Poor Corticomedullary Definition - PIT
0
1 to 20
21 to 40
41 to 60
61 to 80
81-99
100

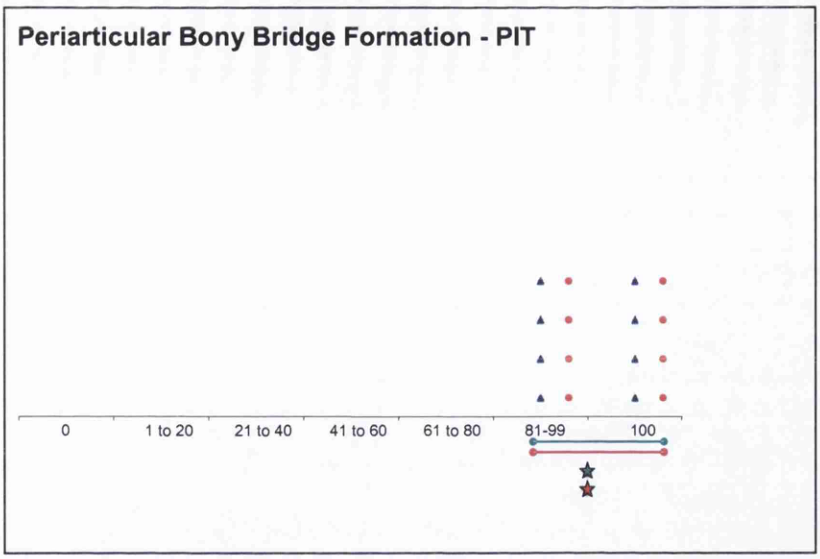

Enlarged Joint Space - PIT
0
1 to 20
21 to 40
41 to 60
61 to 80
81-99
100

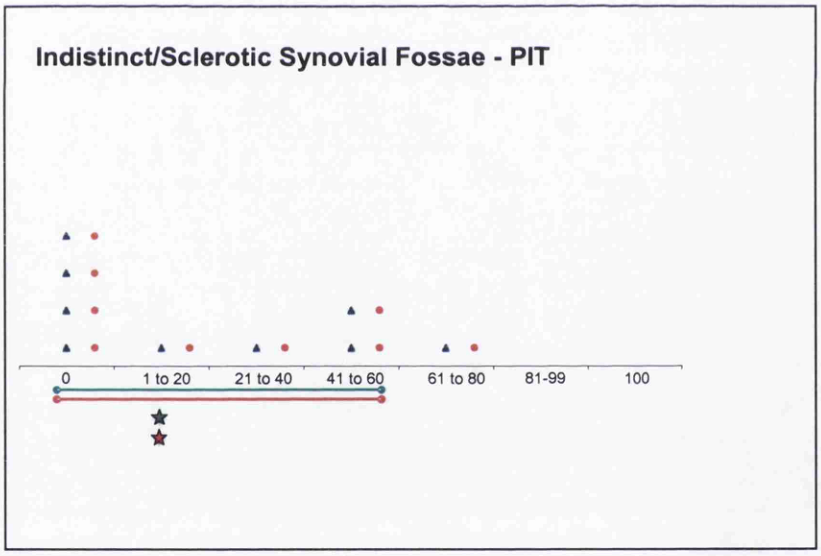

Narrowed Joint Space - PIT
0
1 to 20
21 to 40
41 to 60
61 to 80
81-99
100

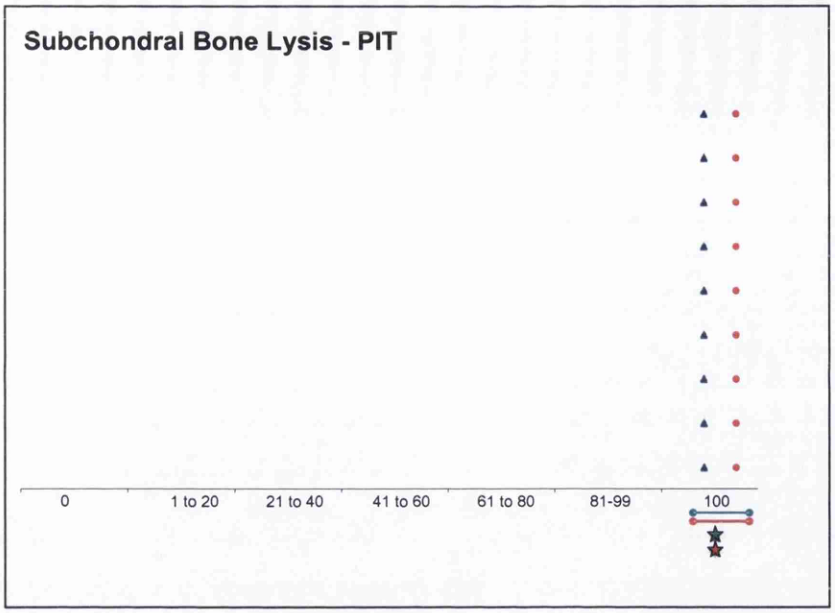

Ankylosis - PIT
0
1 to 20
21 to 40
41 to 60
61 to 80
81-99
100


Osteophytes - PIT
0
1 to 20
21 to 40
41 to 60
61 to 80
81-99
100


Bony Spur on Dorsoproximal Mt3 - PIT
0
1 to
21 to 40
41 to 60
61 to 80
81-99
100

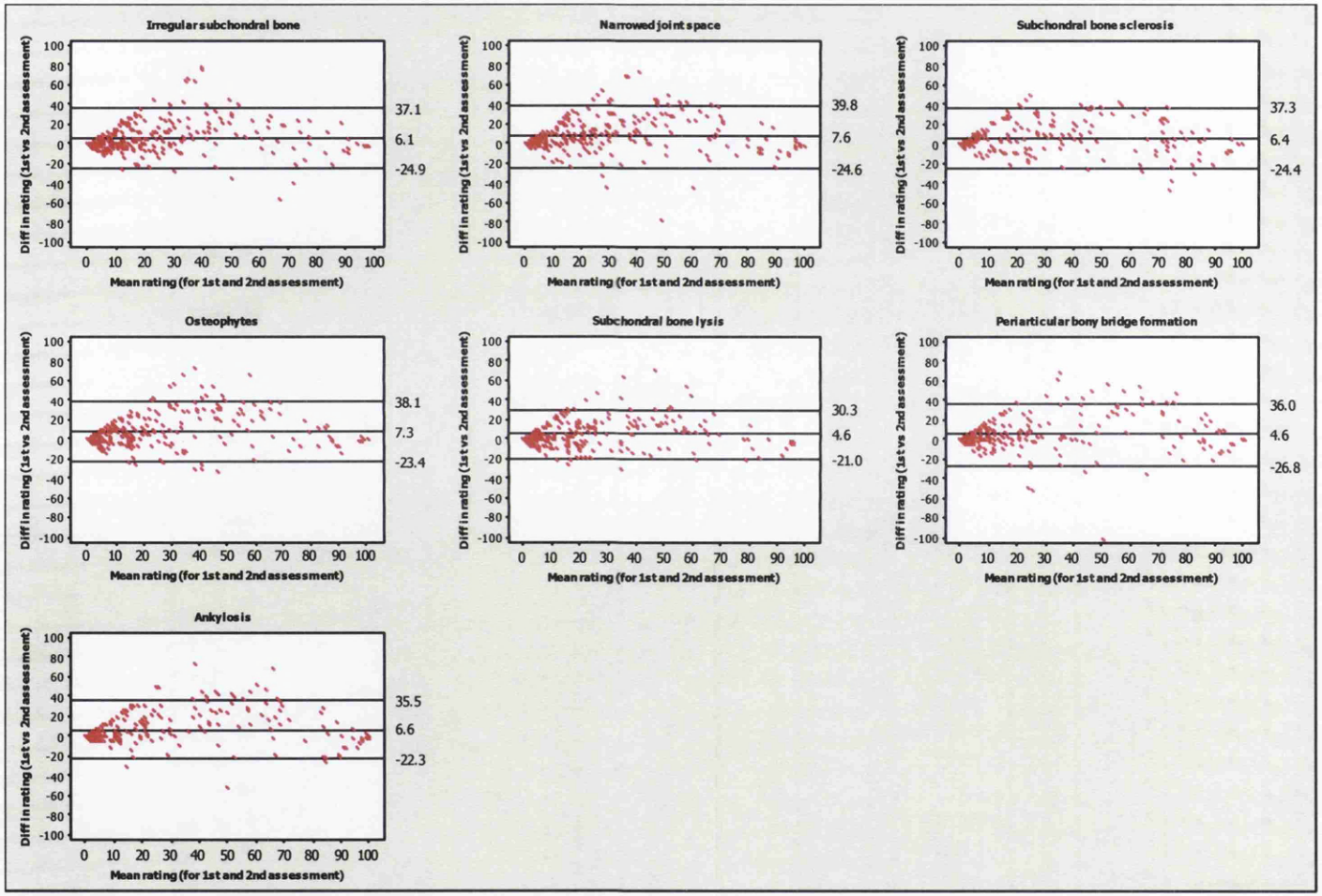

Periarticular Bony Bridge Formation - PIT
0
1 to 20
21 to 40
41 to 60
61 to 80
81-99
100


Indistinct/Sclerotic Synovial Fossae - PIT
0
1 to 20
21 to 40
41 to 60
61 to 80
81-99
100

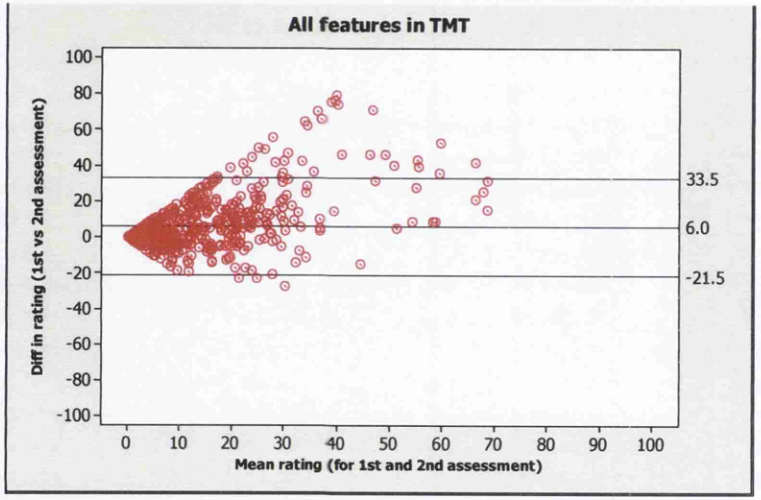

Subchondral Bone Lysis - PIT
0
1 to 20
21 to 40
41 to 60
61 to 80
81-99
100

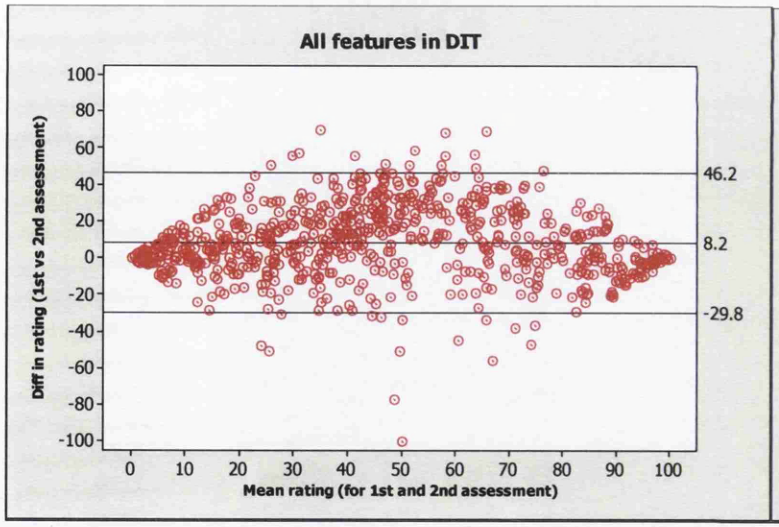
Figures 4.2.2: Graphical display of the results from the reliability experiment

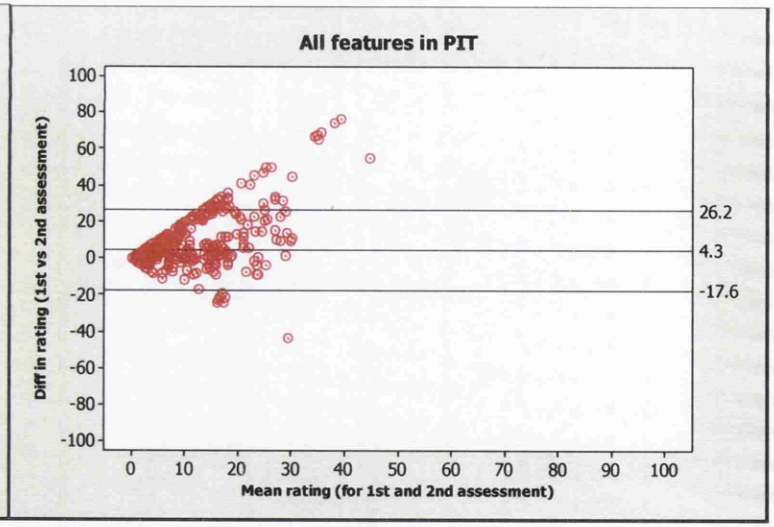
Bland-Altman plot showing the differences between 1st and 2nd rating for 7 radiographic features



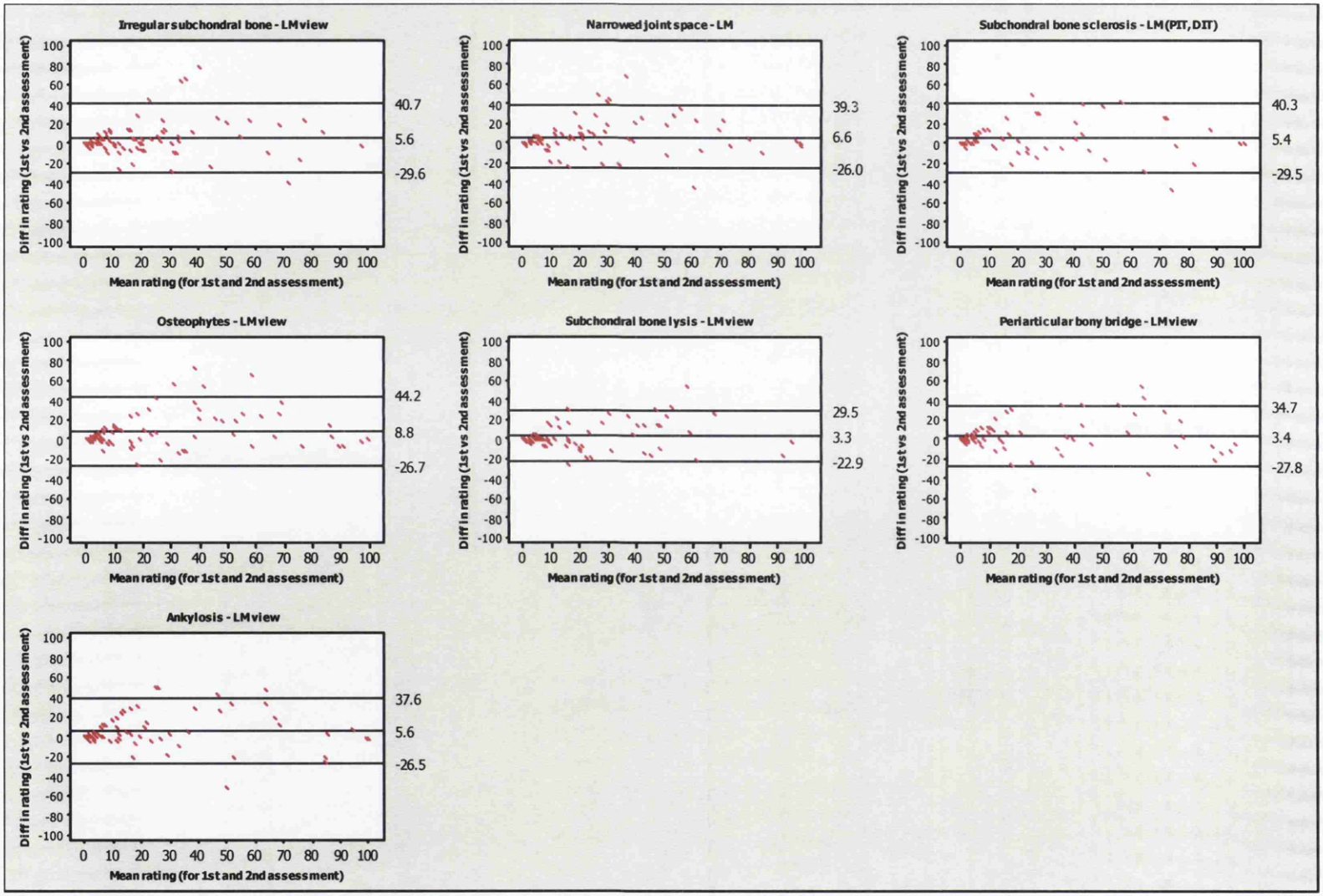
Bland-Altman plot showing the differences between 1st and 2nd rating for all features in the three joints (TMT = tarsometatarsal; DIT = distal intertarsal; PIT = proximal intertarsal joint)



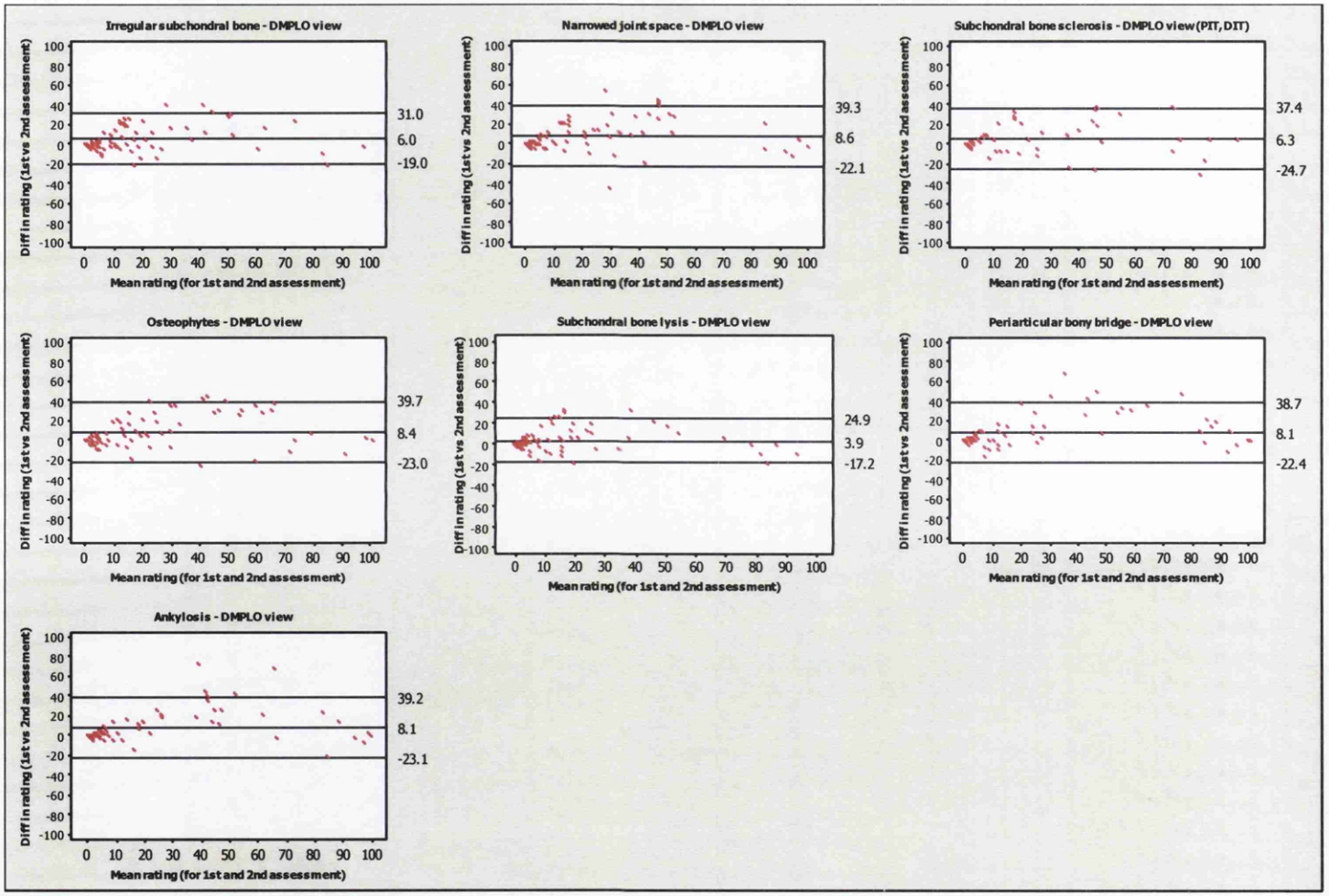




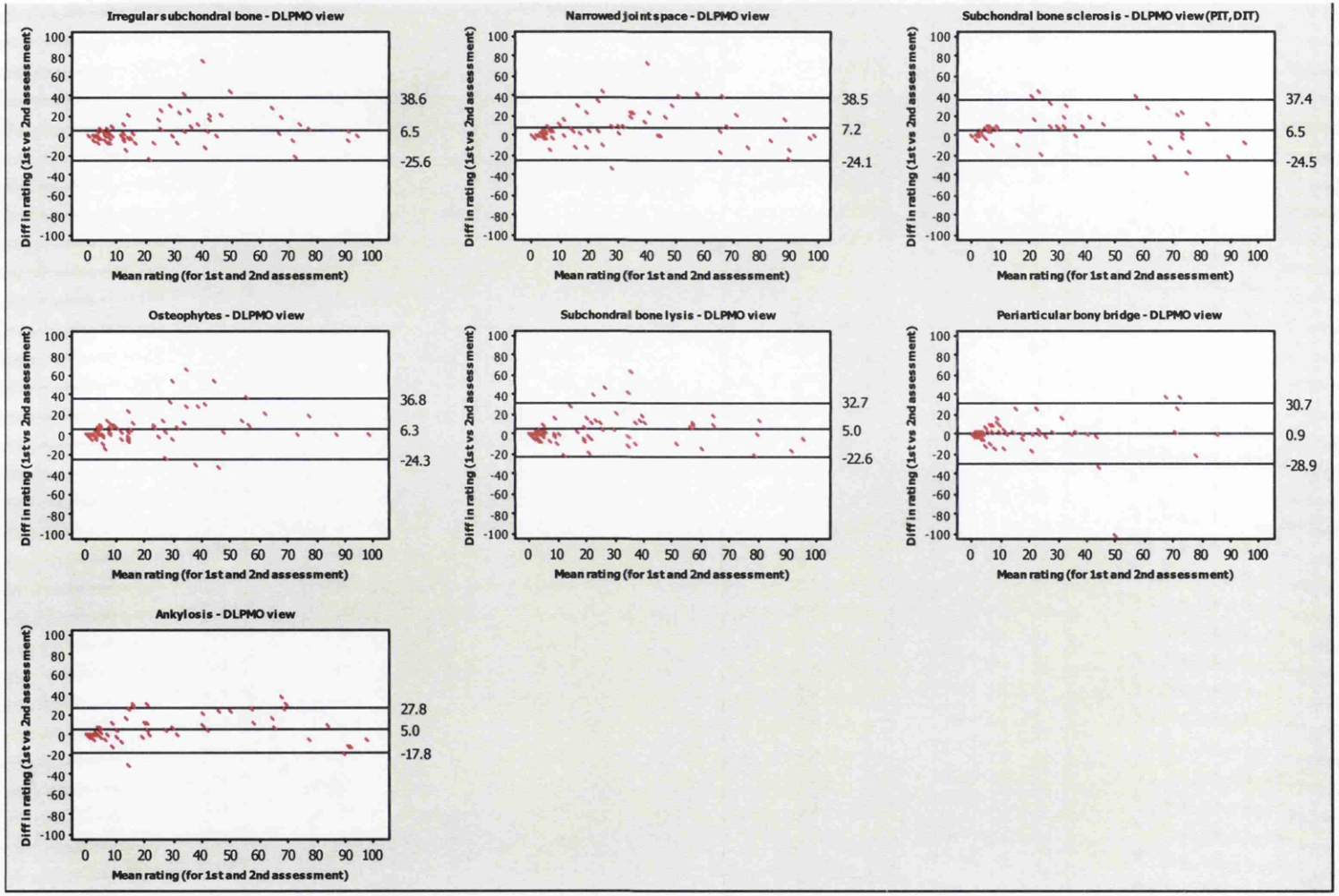
Bland-Altman plot showing the differences between 1st and 2nd rating for all radiographic features in the lateromedial (LM) view



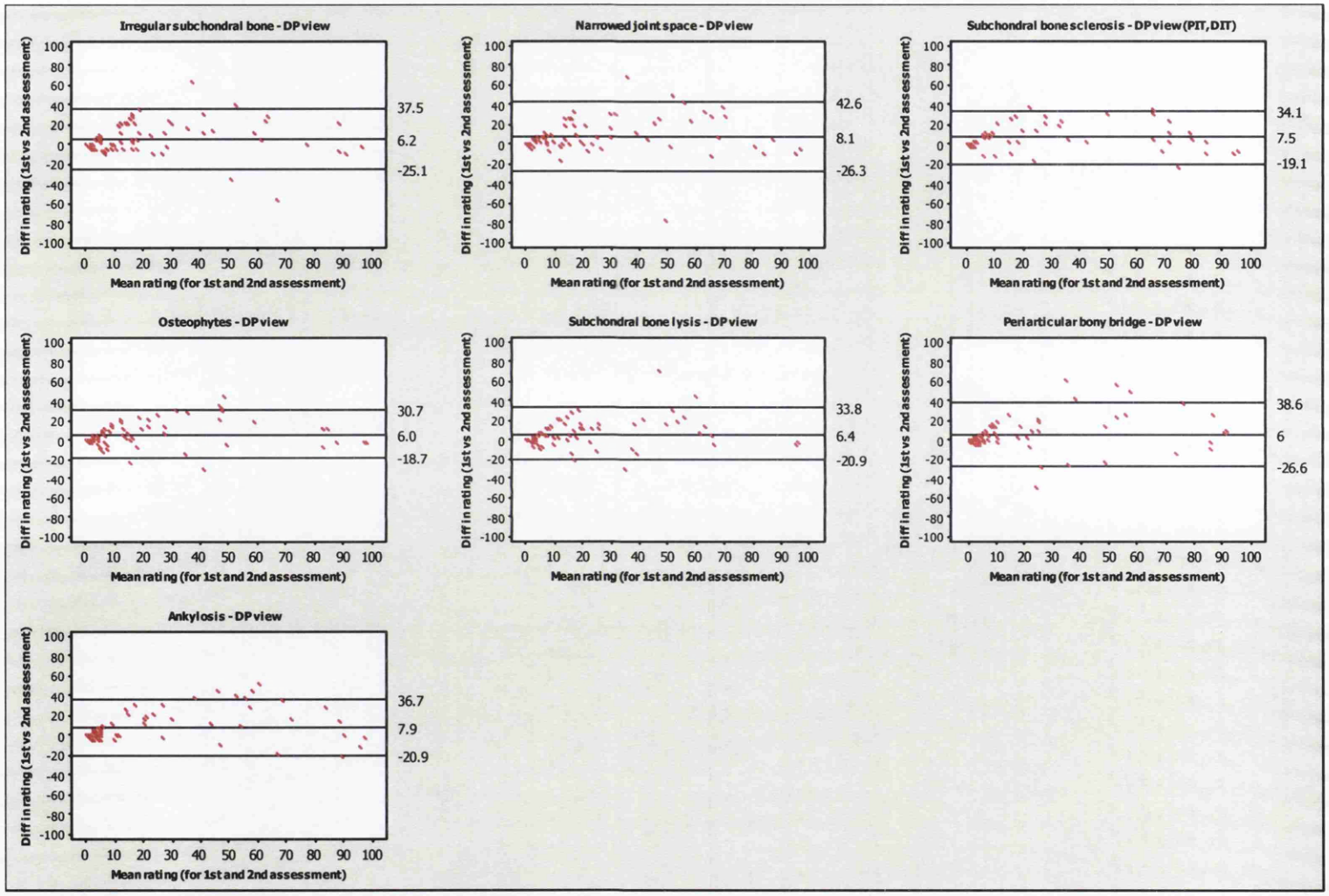
Bland-Altman plot showing the differences between 1st and 2nd rating for all radiographic features in the dorsomedial plantaromedial oblique (DM-PlLO) view



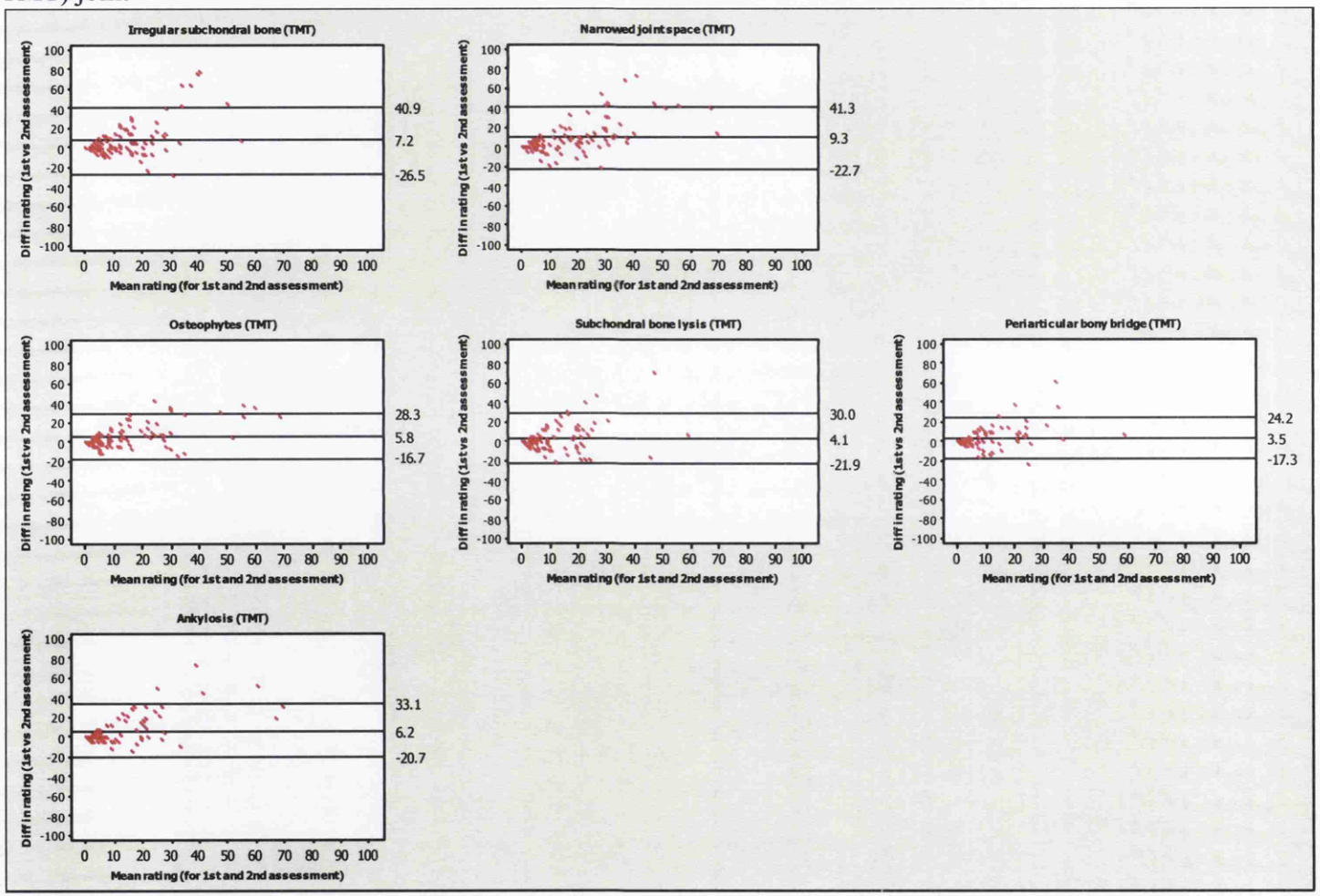
Bland-Altman plot showing the differences between 1st and 2nd rating for all radiographic features in the dorsolateral plantaromedial oblique (DL-PlMO) view



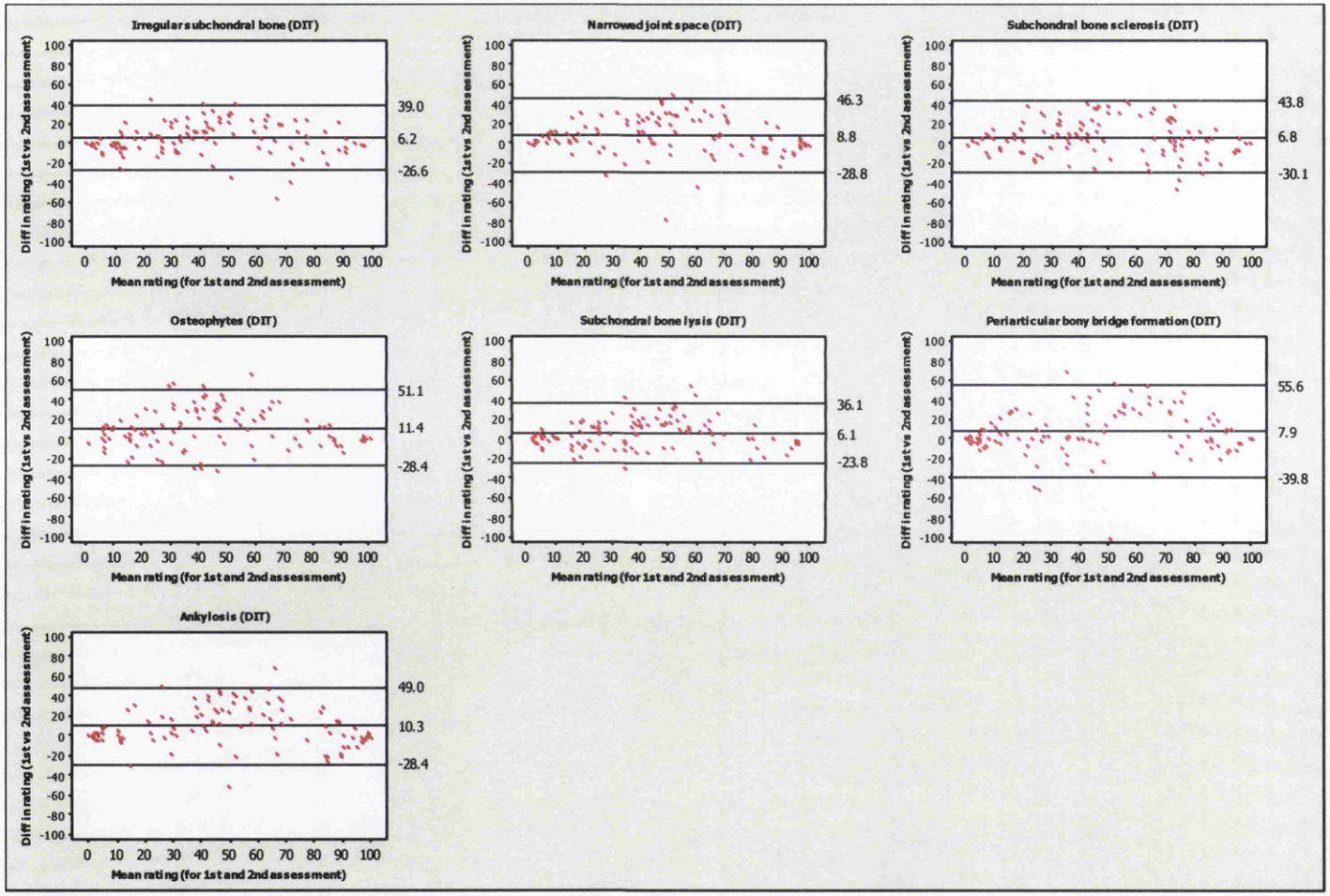
Bland-Altman plot showing the differences between 1st and 2nd rating for all radiographic features in the dorsoplantar (DPl) view



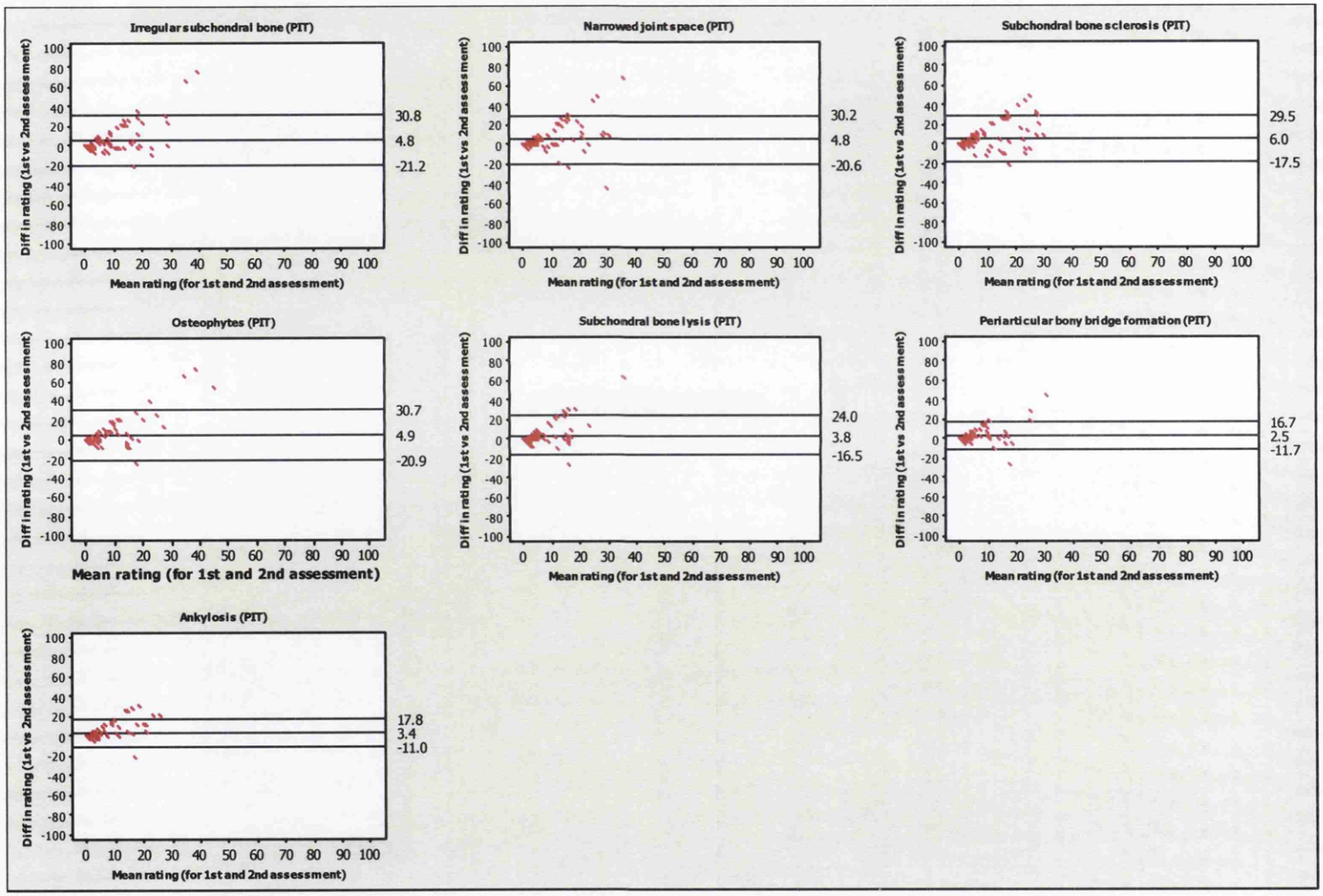
Bland-Altman plot showing the differences between 1st and 2nd rating for all radiographic features in the tarsometatarsal (TMT) joint



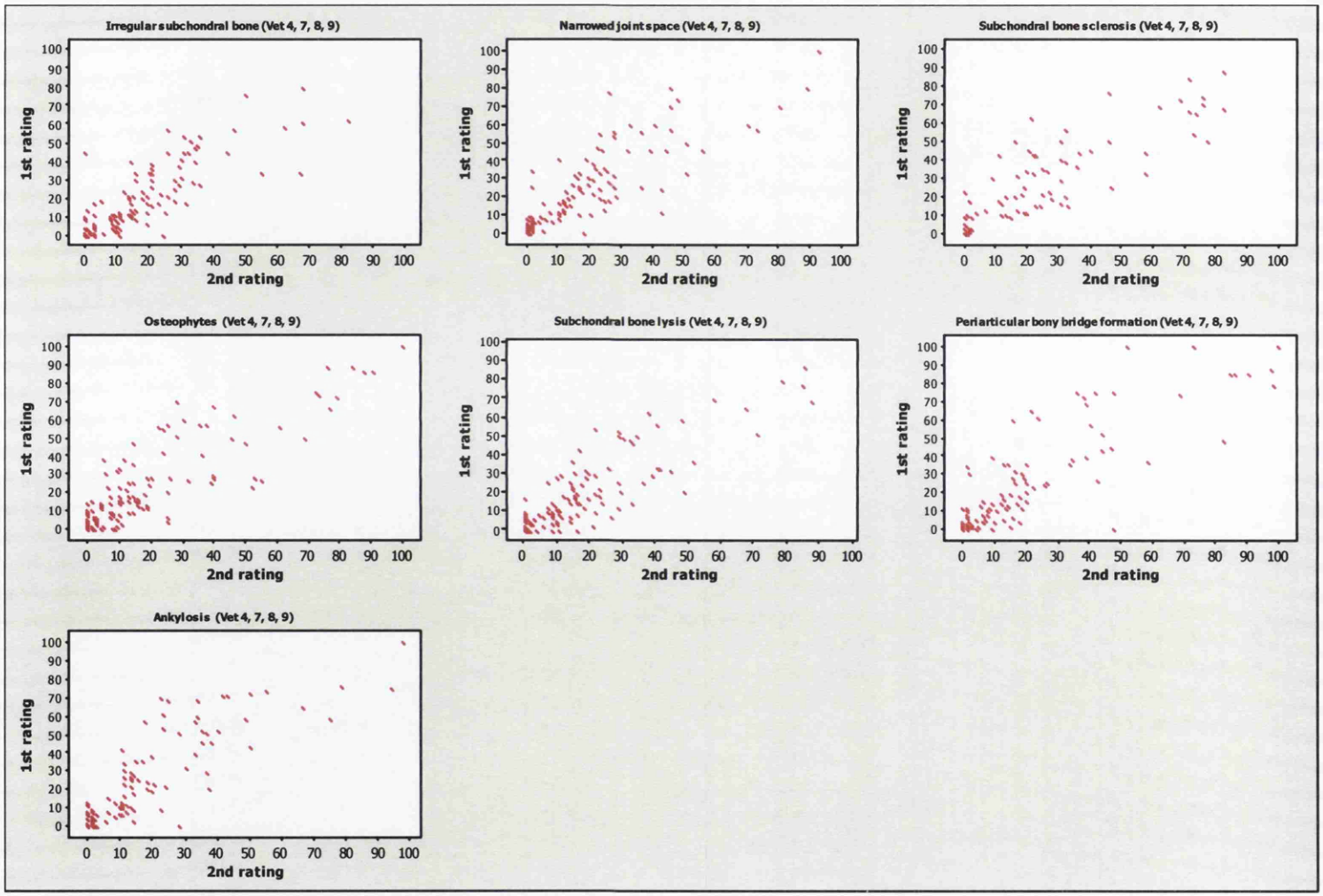
Bland-Altman plot showing the differences between 1st and 2nd rating for all radiographic features in the distal intertarsal (DIT) joint



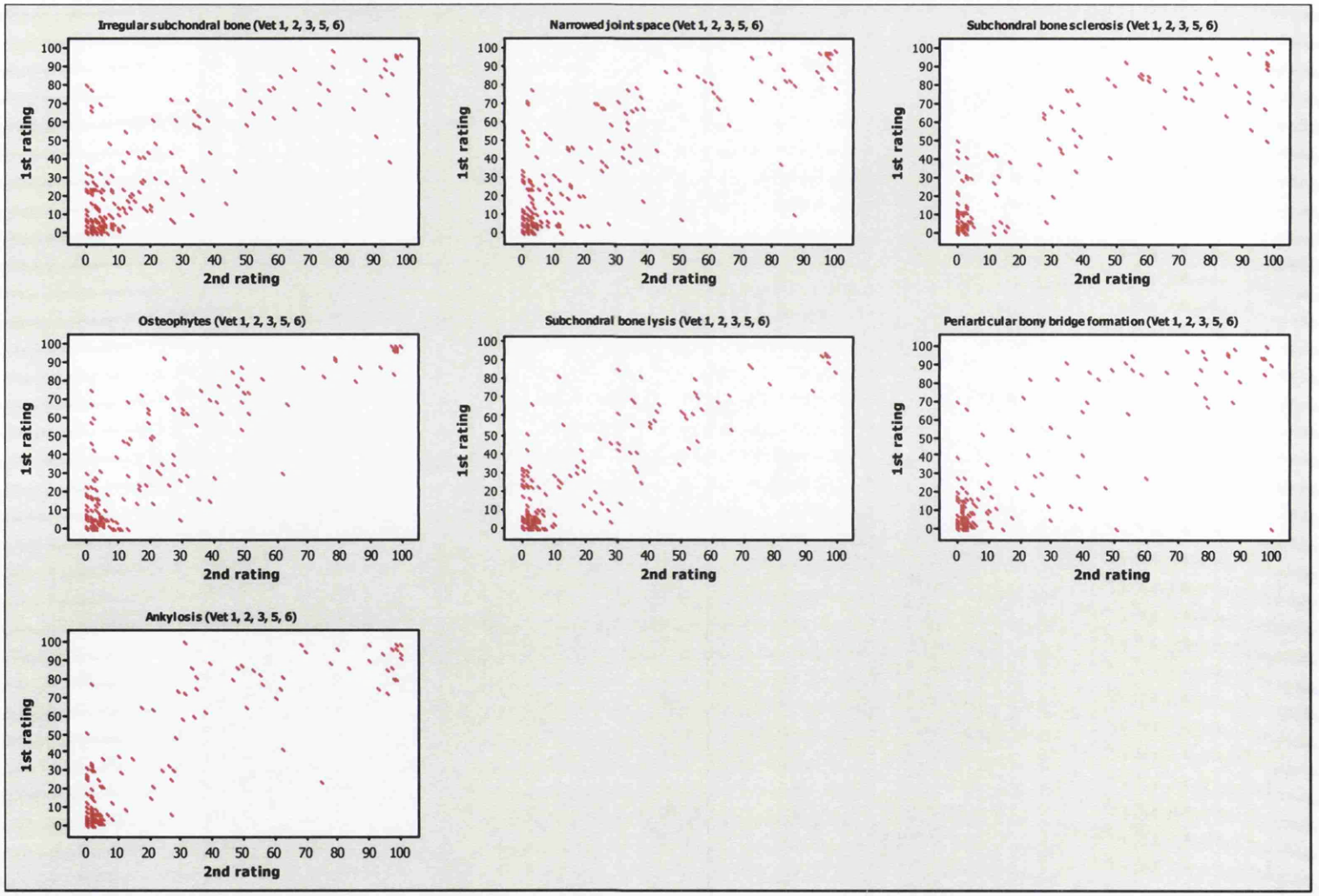
Bland-Altman plot showing the differences between 1st and 2nd rating for all radiographic features in the proximal intertarsal (PIT) joint



Rating results in Group II (assessors with higher repeatability)



Rating results in Group I (assessors with lower repeatability)



Rating results for Group I (Vet 1,2,3,5,6) and Group II (Vet 4,7,8,9)

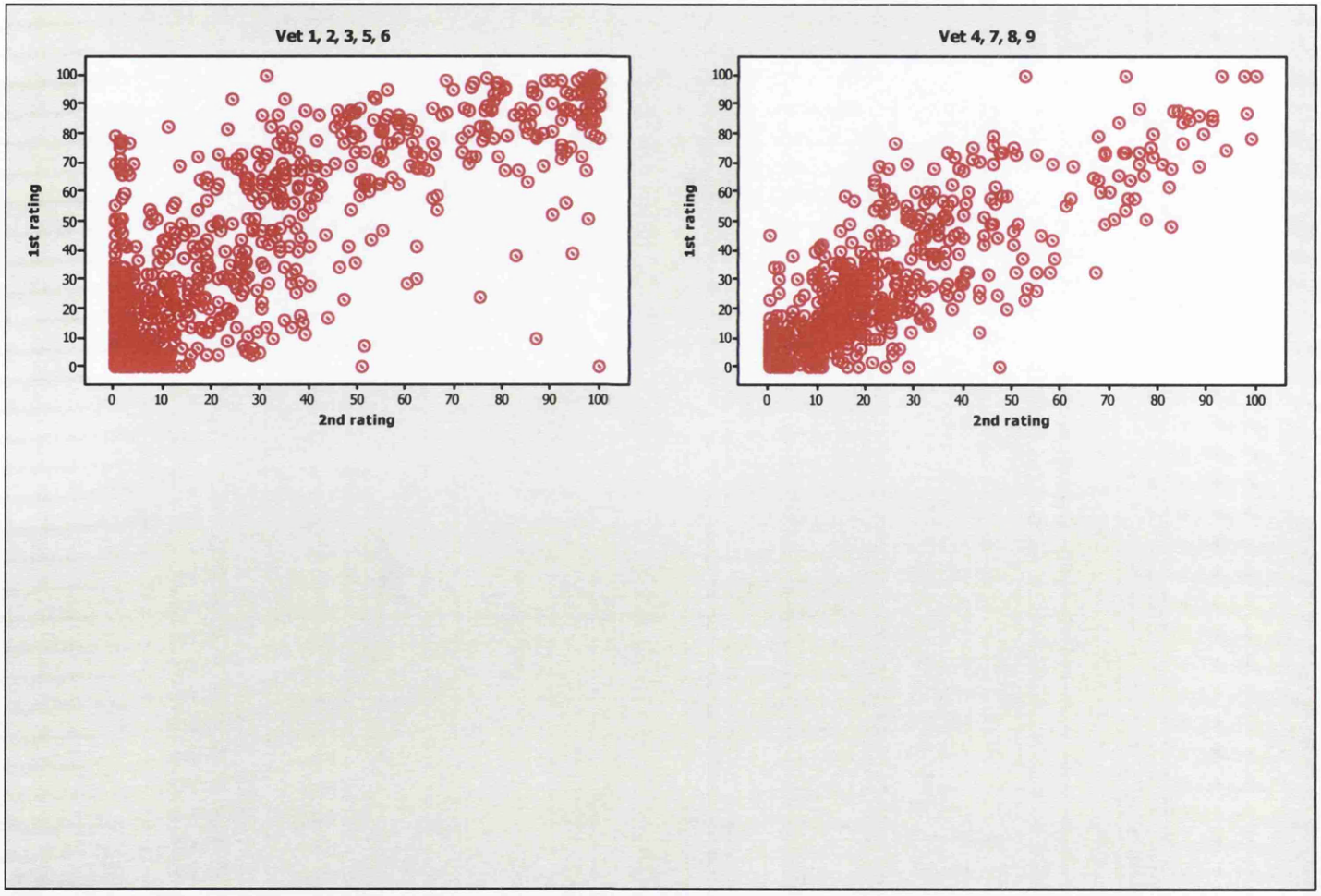


Table 4.1: Total result of the 1st round of the consultation process
(The letter stands for the examiners' response, indicating the group of importance; 0 (group a); 1-20 (group b); 21-40 (group c); 41-60 (group d); 61-80 (group e); 81-99 (group f); and 100 (group g))

TMT	EX 1	EX 2	EX 3	EX 4	EX 5	EX 6	EX 7	EX 8	EX 9
Irregular subchondral bone	g	a	f	g	e	g	e	e	g
Subchondral bone sclerosis	g	b		g	d	g	d	c	c
Poor corticomedullary definition	c	a	d	g	d	g	c	c	b
Enlarged joint space	a	a	g	g	f	d	d	a	g
Narrowed joint space		d	c	g	e	g	g	c	e
Ankylosis	a	g	c	e	g	g	g	f	g
Osteophytes	g	e	e	g	e	g	e	c	e
Bony spur on dorsoproximal Mt3	a	b	a	d	d	d	c	b	b
Periarticular bony bridge formation	f	g	c	g	f	g	g	c	g
Indistinct/sclerotic synovial fossae	e	a	c	a	d	e	d	a	a
Subchondral bone lysis	g	g	g	g	g		g	g	g
DIT	EX 1	EX 2	EX 3	EX 4	EX 5	EX 6	EX 7	EX 8	EX 9
Irregular subchondral bone	g	a	f	g	e	g	e	e	g
Subchondral bone sclerosis	g	c	e	g	d	g	d	d	e
Poor corticomedullary definition	d	a	c	g	d	g	c	d	c
Enlarged joint space	a	a	f	g	f	c	d	a	g
Narrowed joint space		f	b	g	e	g	g	d	f
Ankylosis	a	g	e	e	g	g	g	f	g
Osteophytes	g	f	f	g	e	g	e	d	f
Bony spur on dorsoproximal Mt3	a		a	a	e	d	c	a	a
Periarticular bony bridge formation	f	g	e	g	e	g	g	d	g
Indistinct/sclerotic synovial fossae	e	a	b	a	d	d	d	a	a
Subchondral bone lysis	g	g	g	g	g	g	g	d	g
PIT	EX 1	EX 2	EX 3	EX 4	EX 5	EX 6	EX 7	EX 8	EX 9
Irregular subchondral bone	g	a	b	g	f	g	e	g	g
Subchondral bone sclerosis	g	b	e		e	g	d	e	c
Poor corticomedullary definition	c	a	b		e	g	c	e	b
Enlarged joint space	a	a	f	g	f	c	d	a	g
Narrowed joint space		e	b	e	e	g	g	g	f
Ankylosis	a	g	e	e	g	g	g		g
Osteophytes	g	g	g	g	f	g	d	g	f
Bony spur on dorsoproximal Mt3	a		a	a	c	a	b	a	a
Periarticular bony bridge formation	f	g	f	g	f	g	g		f
Indistinct/sclerotic synovial fossae	e	a	b	a	d	c	d	a	a
Subchondral bone lysis	g	g	g	g	g	g	g	g	g

Table 4.2: Total result of the 2nd round of the consultation process
(The letter stands for the examiners' response, indicating the group of importance; 0 (group a); 1-20 (group b); 21-40 (group c); 41-60 (group d); 61-80 (group e); 81-99 (group f); and 100 (group g))

TMT	EX 1	EX 2	EX 3	EX 4	EX 5	EX 6	EX 7	EX 8	EX 9
Irregular subchondral bone	g	c	f	f	e	g	f	e	g
Subchondral bone sclerosis	g	b	c	e	d	g	d	c	c
Poor corticomedullary definition	c	a	d	d	d	g	c	c	b
Enlarged joint space	a	a	g	e	f	d	d	a	a
Narrowed joint space		d	c	f	e	g	g	d	e
Ankylosis	a	g	c	g	g	g	g	f	g
Osteophytes	g	e	e	f	e	g	e	d	e
Bony spur on dorsoproximal Mt3	a	b	a	c	d	d	c	b	b
Periarticular bony bridge formation	f	g	c	g	f	g	g	e	g
Indistinct/sclerotic synovial fossae	e	a	c	c	d	e	d	a	a
Subchondral bone lysis	g	g	g	g	g		g	g	g
DIT	EX 1	EX 2	EX 3	EX 4	EX 5	EX 6	EX 7	EX 8	EX 9
Irregular subchondral bone	g	c	f	f	e	g	f	e	g
Subchondral bone sclerosis	g	c	e	f	d	g	d	d	e
Poor corticomedullary definition	d	a	c	d	d	g	c	d	c
Enlarged joint space	a	a	f	d	f	c	d	a	a
Narrowed joint space		f	b	f	e	g	g	e	f
Ankylosis	a	g	e	g	g	g	g	f	g
Osteophytes	g	f	f	g	e	g	e	e	f
Bony spur on dorsoproximal Mt3	a	a	a	a	e	d	c	a	a
Periarticular bony bridge formation	f	g	e	g	e	g	g	e	g
Indistinct/sclerotic synovial fossae	e	a	b	b	d	d	d	a	a
Subchondral bone lysis	g	g	g	g	g	g	g	g	g
PIT	EX 1	EX 2	EX 3	EX 4	EX 5	EX 6	EX 7	EX 8	EX 9
Irregular subchondral bone	g	a	b	g	f	g	f	g	g
Subchondral bone sclerosis	g	b	e	e	e	g	d	e	c
Poor corticomedullary definition	c	a	b	c	e	g	c	e	b
Enlarged joint space	a	a	f	d	f	c	d	a	a
Narrowed joint space		e	b	f	e	g	g	g	f
Ankylosis	a	g	e	g	g	g	g		g
Osteophytes	g	g	g	g	f	g	f	g	f
Bony spur on dorsoproximal Mt3	a	a	a	a	c	a	b	a	a
Periarticular bony bridge formation	f	g	f	g	f	g	g		f
Indistinct/sclerotic synovial fossae	e	a	b	a	d	c	d	a	a
Subchondral bone lysis	g	g	g	g	g	g	g	g	g

Table 5.1: General information

No	Age	Sex	Breed	Work	Winging footflight	Mediat foot imbalance	FL lx	Bilat HL lx	Becoming biiat lx
206720	9	1	Connemara x	General purpose	1	1	1		
206347	11	m	Cleveland x	Jumping					
206085	9	0	Paint	General purpose					1
205171	11	1	Th x	General purpose	1				
203857	8	1	Arab x	General purpose				1	
203662	13	1	Highland pony	General purpose			1	1	
203618	9	0	Riding pony	General purpose	1	1	1	1	
203552	8	0	x	Jumping		1	1		
203551	11	0	Th	x	1	1	1	1	
203166	13	1	Hunter	General purpose			1	1	
203165	8	1	Hunter	General purpose					
202714	6	0	Th	Jumping			1	1	
202228	18	1	Welsh Cob	Dressage					
202000	14	1	Th x	General purpose	1	1		1	
201660	x	1	Th	General purpose				1	
201408	7	0	WB	Jumping				1	
201394	12	0	Th x	Jumping				1	
201383	9	1	Th x	Jumping					
201211	9	0	Th x	General purpose			1	1	
201210	16	1	Riding Pony	General purpose					1
201208	4	1	Irish Draught x	x				1	
201032	11	1	x	Jumping	1		1		1
200763	9	1	Th	General purpose			1	1	
200696	8	0	Riding Pony	General purpose				1	
200635	12	0	Th x	General purpose	1	1	1	1	
200412	5	0	WB x	x		1	1		1
200244	10	0	Hunter x	General purpose	1		1	1	
200190	7	1	Th x	Eventing	1				
200156	9	1	Th x	General purpose		1		1	
145801	14	1	Riding Pony	General purpose					
145706	13	1	Riding Horse	General purpose			1		
145561	6	1	Th	General purpose	1		1	1	
145534	8	1	WB	Dressage			1	1	
145307	6	1	WB	Jumping		1			1
145189	8	1	Irish Draught	General purpose					
145089	13	0	Riding Horse	General purpose	1		1	1	
144275	7	1	Arab	General purpose				1	
144240	8	0	Th	Jumping	1				1
143673	7	1	WB	Dressage	1	1			
142942	6	1	WB	Jumping		1			
142917	11	1	Th	General purpose			1		
142883	6	0	WB	Dressage					1
142463	8	1	Th	x					
140465	13	1	Arab	Hunting	1	1		1	
139791	8	1	Th	General purpose					
139099	7	1	Th	Eventing	1	1			1
136859	7	1	Th	Hunting	1			1	
135183	6	1	Th	General purpose	1		1		1
134775	6	1	Connemara	General purpose	1	1	1		
137465	10	1	Riding Horse	General purpose			1	1	
203543	11	1	Th x	General purpose			1	1	

Table 5.2: Lameness grades after 1st i.a. medication in 48 horses (59 DTJ)

No	Initial Lx	Lx following tx	TX	Joints treated
203857 LHc	1	1	TR+HA	TMT
203857 RHc	1	1	TR+HA	TMT
203618 RHs	1	1.5	TR+HA	TMT
203166 LHs	1.5	0	TR+HA	TMT+DIT
203165 LHs	1	2	TR+HA	TMT
202714 LHc	3	0	TR+HA	TMT
201208 RHs	1.5	0.5	TR+HA	TMT
200190 LHs	3	3	TR+HA	TMT
145706 LHs	1	1	TR+HA	TMT+DIT
145534 LHs	2	0	TR+HA	TMT
145534 RHc	1	1	TR+HA	TMT
145189 LHs	3.5	2	TR+HA	TMT
144240 RHs	2	2	TR+HA	TMT
142883 LHs	1	0	TR+HA	TMT
142883 RHc	2	0	TR+HA	TMT
140465 RHc	2	1	TR+HA	TMT
139099 RHs	2	0	TR+HA	TMT
202000 RHs	2.5	2	TR	TMT
201408 LHc	3.5	3	TR	TMT
201210 LHs	2	0	TR	TMT
200156 RHs	2	2	TR	TMT
206720 LHs	2	2	MPA	TMT+DIT
206347 RHs	2	2.5	MPA	TMT+DIT
206085 RHs	2	2.5	MPA	TMT
205171 LHs	2.5	2	MPA	TMT+DIT
203662 LHs	3	0	MPA	TMT
203552 RHs	3	3	MPA	TMT
203551 RHs	3	1	MPA	TMT
203551 LHc	2	1	MPA	TMT
202228 RHs	1	1	MPA	TMT+DIT
201660 LHs	2	2	MPA	TMT+DIT
201394 RHs	3	2	MPA	TMT+DIT
201383 LHs	1.5	1.5	MPA	TMT+DIT
201211 RHs	2	0	MPA	TMT
201211 LHc	2	0.5	MPA	TMT
201210 RHs	3.5	1.5	MPA	TMT+DIT
201032 LHs	1	0	MPA	TMT
201032 RHs	2	1	MPA	TMT
200763 LHs	2	2	MPA	TMT
200763 RHc	1.5	3	MPA	TMT
200696 RHc	2.5	2	MPA	TMT
200635 LHc	3.5	1.5	MPA	TMT
200635 RHs	2	0	MPA	TMT
200412 LHs	1	1	MPA	TMT
200412 RHc	2	2	MPA	TMT
200244 LHs	2	2	MPA	TMT
145801 LHs	3	2	MPA	TMT+DIT
145561 LHs	2	2	MPA	TMT+DIT
145307 RHs	1	0	MPA	TMT
145089 LHs	1.5	2	MPA	TMT
144275 LHs	1	0	MPA	TMT+DIT
144275 RHc	2	2.5	MPA	TMT+DIT
143673 LHs	1	1	MPA	TMT+DIT
142942 RHs	2	1	MPA	TMT
142917 LHs	2	1	MPA	TMT+DIT
142463 RHs	2	1	MPA	TMT+DIT
139791 LHs	2	0	MPA	TMT
136859 LHs	1	0.5	MPA	TMT+DIT
135183 LHs	2	0	MPA	TMT+DIT

Table 5.3: Lameness grades after 2nd i.a. medication in 12 horses (13 DTJ)

No	Lx at 2nd tx	Lx after 2nd tx	TX	Joints treated
203552 RH	3	2	MPA	TMT+DIT
203543 LHc	4	3.5	MPA	TMT+DIT
203165 LHs	2	1	MPA	TMT+DIT
202000 RHs	2	2	MPA	TMT+DIT
201208 RHs	2	1.5	TR+HA	TMT
200244 LHs	2	2	MPA	TMT
200190 LHs	3	3	MPA	TMT
144240 RHs	2	0	MPA	TMT+DIT
139099 RHs	2	1	MPA	TMT
137465 RHs	2	2	MPA	TMT
137465 LHc	2	1	MPA	TMT
134775 LHs	1	1	MPA	TMT
203662 LHs	1.5	3	MPA	TMT

Table 5.4: Times of re-examination

No	Clinician	Initial Exam	Rex1	Time since last seen	Rex2	Time since last seen	Rex3	Time since last seen	Recheck 4	Time since last seen	Recheck 5	Follow up
206720	Vet 3	14/09/2004	27/11/2004	73								73
200763	Vet 3	30/05/2003	04/08/2003	64								64
206085	Vet 6	24/06/2004	20/07/2004	26	19/09/2004	85						85
200156	Vet 6	14/08/2002	20/09/2002	36	17/10/2002	63	12/03/2004	568				568
206347	Vet 5	22/07/2004	08/10/2004	76								76
205171	Vet 5	01/03/2004	05/05/2004	64	19/08/2004	168						168
203857	Vet 3	30/09/2003	24/11/2003	54								54
203662	Vet 1	03/09/2003	13/10/2003	40	12/12/2003	99	08/02/2004	155	02/06/2004	269		269
203618	Vet 5	05/09/2003	04/11/2003	59	28/06/2004	293						293
203552	Vet 2	26/08/2003	07/10/2003	41	18/11/2003	82	04/05/2004	248				248
203551	Vet 2	20/08/2003	25/11/2003	95								95
203166	Vet 3	08/07/2003	23/08/2003	45								45
203165	Vet 4	07/07/2003	02/09/2003	55	22/10/2003	105						105
202714	Vet 1	19/05/2003	27/06/2003	38	26/08/2003	97						97
202228	Vet 9	30/04/2003	21/05/2003	21								21
202000	Vet 5	27/02/2003	24/05/2003	87	03/07/2003	126	09/09/2003	192				192
201660	Vet 6	21/01/2003	06/03/2003	45								45
201408	Vet 8	16/12/2002	08/03/2003	82								82
201394	Vet 1	19/12/2002	18/02/2003	59	19/06/2003	180	06/10/2003	287				287
201383	Vet 1	11/08/2003	30/09/2003	49								49
201211	Vet 1	27/11/2002	27/01/2003	60								60
201210	Vet 1	26/11/2002	08/01/2003	42	19/02/2003	83						83
201208	Vet 1	25/11/2002	10/01/2003	45	13/05/2003	168	25/06/2003	210				210
201032	Vet 3	11/12/2002	20/02/2003	69	22/04/2003	131						131
200696	Vet 3	08/10/2002	21/11/2002	43								43
200635	Vet 4	01/10/2002	10/12/2002	69	29/01/2003	68	31/03/2003	180				180
200412	Vet 2	06/09/2002	02/11/2002	56	09/12/2002	93	08/04/2003	212				212
200244	Vet 6	26/08/2002	01/10/2002	35	19/11/2002	83	07/01/2003	131				131
200190	Vet 4	19/08/2002	11/10/2002	52	03/12/2002	104	15/01/2003	146	20/05/2003	271	08/07/2003	319

No	Clinician	Initial Exam	Rex1	Time since last seen	Rex2	Time since last seen	Rex3	Time since last seen	Recheck 4	Time since last seen	Recheck 5	Follow up
145189	Vet 6	07/05/2002	28/06/2002	51								51
145089	Vet 6	16/01/2003	18/02/2003	32								32
144275	Vet 4	17/01/2002	15/04/2002	88								88
144240	Vet 4	10/06/2002	31/07/2002	51	11/11/2002	151						151
143673	Vet 2	20/05/2002	21/08/2002	91								91
142942	Vet 2	25/07/2001	25/10/2001	90								90
142917	Vet 2	23/07/2001	02/11/2001	99								99
142883	Vet 2	18/07/2001	13/08/2001	25	06/11/2001	108	21/02/2002	213				213
142463	Vet 10	23/05/2001	19/07/2001	56	21/08/2001	88						88
140465	Vet 4	10/07/2003	25/08/2003	45								45
139791	Vet 11	17/05/2000	05/06/2000	18								18
139099	Vet 2	06/02/2003	17/04/2003	71	27/05/2003	111	11/12/2003	305				305
136859	Vet 1	16/04/1999	15/06/1999	59	07/12/1999	231	08/03/2000	322				322
135183	Vet 3	09/03/2000	22/11/2002	973	16/01/2003	1027						1027
134775	Vet 12	03/06/1998	29/05/2002	1436	13/08/2002	1510						1510
137465	Vet 2	03/12/2002	13/03/2003	100	08/04/2003	125						125
203543	Vet 3	25/08/2003	07/10/2003	42	20/11/2003	85						85
145801	Vet 1	17/07/2002	23/08/2002	36								36
145706	Vet 4	28/08/2002	14/11/2002	76								76
145561	Vet 1	18/06/2002	19/09/2002	91								91
145534	Vet 7	17/06/2002	13/08/2002	56	05/11/2002	138	10/02/2003	233				233
145307	Vet 2	20/05/2002	19/09/2002	119								119

Table 5.9: Lameness on re-examination

No	Recheck 1	Recheck 2	Recheck 3	Recheck 4	Recheck 5
206720	1				
200763	1				
206085	1	1			
200156	1	1	1		
206347	1				
205171	1	1			
203857	1				
203662	1	1	1	1	
203618	1	1			
203552	1	1	1		
203551	1				
203166	1				
203165	1	1			
202714	0	1			
202228	1				
202000	1	1	1		
201660	1				
201408	1				
201394	1	1	1		
201383	1				
201211	1				
201210	1	1			
201208	1	1	1		
201032	1	1			
200696	1				
200635	1	0	0		
200412	1	1	1		
200244	1	1	1		
200190	1	1	1	1	1
145801	1				
145706	1				
145561	1				
145534	1	1	1		
145307	0				
145189	1				
145089	1				
144275	1				
144240	1	1			
143673	1				
142942	1				
142917	1				
142883	1	1	0		
142463	1	1			
140465	1				
139791	0				
139099	1	1	1		
136859	1	1	1		
135183	1	0			
134775	1	1			
137465	1	1			
203543	1	1			

Table 5.10: Grades of hindlimb lameness assessed at the trot in a straight line

No	Lame LH st	Reex1 LH st	Reex2 LH st	Reex3 LH st	Reex4 LH st	Reex 5 LHs	Bila t lx	La me RH st	Reex1 RH st	Reex2 RH st	Reex3 RH st	Reex4 RH st
	1st i.a. tx	2nd t i.a. tx	- No information									
206720	2	2						-	-			
200763	2	2					1	1	0			
206085	0	0	0				1	2	2.5	3		
200156	1	0	0	1			1	2	2	2	1	
206347	-	-						2	2.5			
205171	2.5	2	1.5					-	-	-		
203857	1	1					1	1	1			
203662	3	0	2.5	1.5	3		1	3	0.5	0	0	0
203618	0	0	0				1	1	1.5	0		
203552	-	-	-	-				3	3	2	2.5	
203551	0	0					1	3	1			
203166	1.5	0					1	0	3			
203165	1	2	1					-	-	-		
202714	0	0	0				1	1	0	0		
202228	-	-						1	1			
202000	0	0	0	0			1	2.5	2	2	2	
201660	2	2					1	0	0			
201408	0	1					1	0	0			
201394	2.5	0	0	0			1	3	2	2	1	
201383	1.5	1.5						-	-			
201211	0	0					1	2	0			
201210	2	0	1.5				1	0	3.5	1.5		
201208	1	0	0	0			1	1.5	0.5	2	1.5	
201032	1	0	0				1	0	2	1		
200696	0	2					1	0	1			
200635	0	1	0	0			1	2	0	0	0	
200412	1	1	1	1			1	0	0	0	0	
200244	2	2	2	2			1	1	0	0	0	
200190	3	3	1.5	2	3	3		-	-	-	-	-
145801	3	2						-	-			
145706	1	1						-	-			
145561	2	2					1	0	1			
145534	2	0	0	1			1	0	0	0	2	
145307	0	0					1	1	0			

145189	3.5	2						-	-				
145089	1.5	2					1	1	0				
144275	1	0					1	0	1				
144240	0	0	0				1	2	2	0			
143673	1	1						-	-				
142942	-	-						2	1				
142917	2	1						-	-				
142883	0	0	1	0			1	0.5	0.5	0	0		
142463	-	-	-					2	1	3.5			
140465	1	0					1	1	0				
139791	2	0						-	-				
139099	0	2	0	0			1	2	0	2	1		
136859	1	0.5	2	2			1	1	0	0	0		
135183	0	2	0				1	1	1.5	0			
134775	2	1	1					-	-	-			
137465	0	0	0				1	2	2	2			
203543	0	0	2.5				1	3	3	0			

Table 5.11: Grades of hindlimb lameness assessed at the trot on the lunge

No	Lame LH ci	Reex1 LH ci	Reex2 LH ci	Reex3 LH ci	Reex4 LH ci	Reex 5 LH ci	Bila t lx	La me RH ci	Reex1 RH ci	Reex2 RH ci	Reex3 RH ci	Reex4 RH ci
	1st i.a. tx	2nd t i.a. tx	- No information									
206720	3.5	3						-	-			
200763	3	4					1	1.5	3			
206085	0	0	1.5				1	-	-	-		
200156	2	1.5	2	2			1	3	3	3	3	
206347	-	-						-	-			
205171	3.5	-	-					-	-	-		
203857	1	1					1	1	1			
203662	-	-	-	-	-		1	-	-	-	-	-
203618	3	1.5	-				1	3	2	-		
203552	-	-	-	-				-	-	-	-	
203551	2	1					1	3	-			
203166	2	0					1	1	4			
203165	2	3	3					-	-	-		
202714	3	0	2				1	2	0	0		
202228	-	-						3	-			
202000	-	-	-	-			1	-	-	-	-	
201660	3.5	-					1	2	0			
201408	3.5	3					1	2	3			
201394	-	-	-	-			1	-	-	-	-	
201383	-	-						-	-			
201211	2	0.5					1	2.5	0.5			
201210	-	-	-				1	-	-	-		
201208	-	-	-	-			1	3	-	-	-	
201032	1.5	1	0				1	0	2.5			
200696	2	2.5					1	2.5	2			
200635	3.5	1.5	0	0			1	3.5	1.5	0	0	
200412	3	3	2	2			1	0	0	2	2	
200244	-	4	2	-			1	-	2	1	0	
200190	4	-	-	-	-	-		-	-	-	-	-
145801	-	-						-	-			
145706	3	3						-	-			
145561	2	3					1	3	-			
145534	2	1	2				1	1	1	2	-	
145307	-	-					1	-	-			

145189	-	-						-	-			
145089	2	2					1	2	0			
144275	3	2.5					1	2	2.5			
144240	0	0	1				1	2	3	2		
143673	-	-						-	-			
142942	-	-						-	-			
142917	-	-						-	-			
142883	0	0	2	0			1	0	0	2	0	
142463	-	-	-					-	-	-		
140465	2	0					1	2	1			
139791	-	-						-	-			
139099	-	-	-	-			1	-	-	-	-	
136859	-	-	-	-			1	-	-	-	-	
135183	0	2	0				1	-	-	-		
134775	-	3	3					-	-	-		
137465	2	2	1				1	2	2	1		
203543	3.5	4	3.5				1	2.5	3	1		

Table 5.12: Radiographic findings (0=absent, 1=present)

TMT									
No	irreg subch bone	sclerosis	narrow jt	osteophytes	bridge	lysis	ankylosis	OA PIT	Severity
206720 LH	0	0	0	1	0	0	0		Mild
206347 RH	1	0	0	0	0	0	0		Mild
206085 RH	0	0	0	1	1	0	0		Sev
205171 LH	0	1	1	1	1	1	1		Sev
203857 RH	0	0	0	1	0	0	0	Mild	Mild
203857 LH	0	0	0	1	0	0	0		Mild
203662 LH	0	1	1	1	0	1	0		Sev
203618 RH	0	0	0	1	0	0	0		Mild
203552 RH									
203551 RH	0	0	0	1	0	0	0		Mild
203551 LH	0	0	0	1	0	0	0		Mild
203543 LH	1	0	0	1	0	0	0		Mod
203166 LH	0	0	0	1	0	0	0		Mild
203165 LH	0	0	0	0	0	0	0		None
202714 LH	0	0	0	1	0	0	0		Mild
202228 RH	0	0	0	1	0	0	0	Mod	Mild
202000 RH	1	0	1	1	0	0	0		Mild
201660 LH	0	0	1	0	0	0	0		Mild
201408 LH	0	0	0	1	0	0	0		Mild
201394 RH	0	0	0	1	0	0	0		Mod
201383 LH	0	0	0	0	0	0	0		None
201211 RH	0	0	0	1	0	0	0		Mild
201211 LH	0	0	0	1	0	0	0		Mild
201210 RH	0	0	0	1	0	0	0		Mild
201210 LH	0	0	0	0	0	0	0		Mild
201208 RH	0	0	0	1	0	0	0		Mild
201032 RH	0	0	0	1	0	0	0		Mild
201032 LH	0	0	0	1	0	0	0		Mild
200763 RH	0	0	0	1	0	0	0		Mild
200763 LH	0	0	0	1	0	0	0	Mild	Mild
200696 RH	1	0	0	0	0	0	0		Mild
200635 RH	0	0	0	1	0	0	0		Mild
200635 LH	0	0	0	1	0	0	0		Mild
200412 RH	0	0	0	1	0	0	0		Mild
200412LH	0	0	0	1	0	0	0		Mild
200244 LH	0	0	0	1	0	0	0		Mild
200190 LH									
200156 RH	0	0	0	1	0	0	0		Mod
145801 LH	0	0	0	1	0	0	0		Mild
145706 LH	0	0	0	1	0	0	0		Mild
145561 LH	0	0	0	1	0	0	0	Mild	Mild
145534 RH	0	0	0	1	0	0	0		Mild
145534 LH	0	0	0	1	0	0	0		Mild
145307 RH	0	0	0	1	0	0	0		Mild
145189 LH	1	0	0	1	0	0	0	Mild	Mild
145089 LH	0	1	1	1	1	1	1	Sev	Sev
144275 RH	0	0	0	1	0	0	0		Mild
144275 LH	1	1	0	1	1	0	0		Sev
144240 RH	0	0	0	0	0	0	0		None
143673 LH	0	0	0	1	0	0	0		Mild
142942 RH	0	0	0	1	0	0	0	Mild	Mild
142917 LH	0	0	0	1	0	0	0	Mild	Mild
142883 RH	0	0	0	1	0	0	0		Mild
142883 LH	0	0	0	0	0	0	0		Mild
142463 RH	0	0	0	1	0	0	0		Mild
140465 RH	0	0	0	1	0	0	0		Mild
139791 LH	0	0	0	1	0	0	0		Mild
139099 RH	0	0	0	1	0	0	0		Mild
137465 RH									
137465 LH									
136859 LH	0	0	0	1	0	0	0		Mild
135183 LH	0	0	0	1	0	0	0		Mild
134775 LH	0	0	0	0	0	0	0		None

Table 5.13: Radiographic findings (0=absent, 1=present)

DIT								
No	irreg subch bone	sclerosis	narrow jt	osteophytes	bridge	lysis	ankylosis	Severity
206720 LH	1	0	1	1	1	1	1	Sev
206347 RH	0	0	0	1	0	0	0	Mild
206085 RH	1	0	1	1	1	1	1	Sev
205171 LH	0	1	1	1	1	1	1	Sev
203857 RH	0	0	0	1	0	0	0	Mild
203857 LH	1	0	0	1	0	0	0	Mild
203662 LH	0	1	1	0	1	1	1	Sev
203618 RH	0	0	1	1	0	0	0	Mild
203552 RH								
203551 RH	0	0	0	1	0	0	0	Mild
203551 LH	0	0	0	1	0	0	0	Mild
203543 LH	0	0	0	1	0	0	0	Mild
203166 LH	0	0	0	1	0	0	0	Mild
203165 LH	0	0	1	1	0	0	1	Sev
202714 LH	0	0	0	1	0	0	0	Mild
202228 RH	0	0	0	1	0	0	0	Mild
202000 RH	0	0	0	1	0	0	0	Mild
201660 LH	1	0	1	1	0	1	0	Mod
201408 LH	0	0	0	0	0	0	0	None
201394 RH	0	0	1	1	1	0	1	Sev
201383 LH	0	0	0	0	0	0	0	None
201211 RH	0	0	0	1	0	0	0	Mild
201211 LH	0	0	0	0	0	0	0	None
201210 RH	0	0	0	0	0	0	0	None
201210 LH	0	0	1	1	0	0	0	Mild
201208 RH	0	0	1	0	0	0	0	Mild
201032 RH	0	0	0	1	0	0	0	Mild
201032 LH	0	0	0	1	0	0	0	Mild
200763 RH	1	0	0	1	0	1	0	Mild
200763 LH	0	0	1	1	0	0	0	Mild
200696 RH	0	0	0	0	0	0	0	None
200635 RH	0	0	1	1	0	0	0	Mild
200635 LH	0	0	0	1	0	0	0	Mild
200412 RH	0	0	0	1	0	0	0	Mild
200412 LH	0	0	0	1	0	0	0	Mild
200244 LH	0	1	1	0	1	0	1	Mild
200190 LH								
200156 RH	0	0	0	1	0	0	0	Mild
145801 LH	1	0	1	1	0	0	0	Mod
145706 LH	0	0	0	1	0	0	0	Mild
145561 LH	0	0	0	1	0	0	0	Mild
145534 RH	1	0	0	1	0	0	0	Mild
145534 LH	1	0	1	1	0	0	0	Mild
145307 RH	0	0	0	1	0	0	0	Mild
145189 LH	0	0	0	1	0	0	0	Mild
145089 LH	1	1	1	1	0	0	1	Sev
144275 RH	0	0	1	1	0	0	0	Mild
144275 LH	1	0	1	1	0	1	0	Mod
144240 RH	0	0	1	1	0	0	0	Mild
143673 LH	1	0	0	1	0	1	0	Mod
142942 RH	0	0	0	0	0	0	0	None
142917 LH	1	0	1	1	0	1	1	Mod
142883 RH	1	0	0	0	0	1	0	Mild
142883 LH	1	0	0	1	0	0	0	Mild
142463 RH	0	0	1	1	0	1	1	Sev
140465 RH	0	0	0	0	0	0	0	None
139791 LH	1	0	0	1	0	1	0	Mod
139099 RH	1	0	0	1	0	0	0	Mild
137465 RH								
137465 LH								
136859 LH	1	1	1	1	0	1	1	Mod
134775 LH	0	0	0	1	0	0	0	Mild
135183 LH	1	0	1	1	0	0	0	Mod

Table 5.14: Results of scintigraphic analysis

	201211	200635	200763	200412	205171	202000	201394	203552	145534	203551	203618	201210
RH												
LM view												
ROI1	13.51	19.3	12.65	15.88	11.68	12.08	11.11	18.91	11.37	9.36	12.78	17
ROI2	11.4	8.59	7.02	8.72	12.46	9.8	9.24	11.76	14.38	11.98	8.93	12.32
ROI3	0.58	0.48	0.41	0.37	0.4	0.38	0.45	0.42	0.42	0	0.51	0.36
Focal uptake in % of DTJ surface area							9.55%	13.99%				
LH												
LM view												
ROI1	12.48	17.15	13.51	16.1	20.9	14.57	13.6	9.24	13.13	8.61	15.19	14.96
ROI2	10.38	8.35	8.22	9.57	9.55	10.77	9.61	10.95	15.12	11.27	9.73	10.15
ROI3	0.45	0.51	0.39	0.29	0.31	0.44	0.73	0.5	0.31	0.32	0.5	0.27
Focal uptake in % of DTJ surface area					21%		19.68%		10.28%			
RH												
PD view												
ROI1(PD)	16.39	14.74	15.68	16.82	14.89	0	15.74	16.47	15.29	15.01	24.99	22.38
Focal uptake in % of DTJ surface area		21.28%		10.54%								
PD view												
LH												
ROI1(PD)	16.29	13.56	15.87	18.07	26.96	0	19.27	32.46	19.45	13.77	24.18	17.29
Focal uptake in % of DTJ surface area				6.92%	23.62%		12.34%		16%			
RH												
IRU	diffuse	focal	diffuse	focal	diffuse	diffuse	focal	focal	diffuse	diffuse	diffuse	diffuse
ROI1-ROI3	12.93	18.82	12.24	15.51	11.28	11.7	10.66	18.49	10.95	9.36	12.27	16.64
ROI2-ROI3	10.82	8.11	6.61	8.35	12.06	9.42	8.79	11.34	13.96	11.98	8.42	11.96
ROI1adj/ROI2adj	1.195009	**2.320592**	**1.85174**	**1.857485**	0.935323	1.242038	1.212742	1.630511	0.784384	0.781302	1.457245	1.391304
Lameness	bilat	bilat	bilat	bilat	LH	bilat	bilat	RH	bilat	bilat	bilat	bilat

LH	201211	200635	200763	200412	205171	202000	201394	203552	145534	203551	203618	201210
IRU	diffuse	diffuse	diffuse	focal	focal	diffuse	focal	diffuse	focal	diffuse	diffuse	diffuse
ROI1-ROI3	12.03	16.64	13.12	15.81	20.59	14.13	12.87	8.74	12.82	8.29	14.69	14.69
ROI2-ROI3	9.93	7.84	7.83	9.28	9.24	10.33	8.88	10.45	14.81	10.95	9.23	9.88
ROI1adj/ROI2adj	1.21148	2.122449	1.675607	1.703664	2.228355	1.367861	1.449324	0.836364	0.865631	0.757078	1.591549	1.486842

Statistical Analysis of Lameness Grades with Minitab Version 14

Wilcoxon Signed Rank Test: Diff 1st TX

```
Test of median = 0.000000 versus median not = 0.000000

                    N
                  for   Wilcoxon          Estimated
             N  Test  Statistic      P     Median
Diff 1st TX  59    41      789.5  0.000     0.7500
```

Mann-Whitney Test and CI: Diff MPA, Diff TR+/-HA

```
               N  Median
Diff MPA      38  0.7500
Diff TR+/-HA  21  0.5000


Point estimate for ETA1-ETA2 is 0.0000
95.1 Percent CI for ETA1-ETA2 is (-0.5005,0.4999)
W = 1124.0
Test of ETA1 = ETA2 vs ETA1 not = ETA2 is significant at 0.8062
The test is significant at 0.8016 (adjusted for ties)
```

Mann-Whitney Test and CI: Diff MPA, Diff TR+HA

```
              N  Median
Diff MPA     38   0.750
Diff TR+HA   17   1.000


Point estimate for ETA1-ETA2 is -0.000
95.2 Percent CI for ETA1-ETA2 is (-1.000,0.500)
W = 1051.0
Test of ETA1 = ETA2 vs ETA1 not = ETA2 is significant at 0.8199
The test is significant at 0.8154 (adjusted for ties)
```

Wilcoxon Signed Rank Test: Diff 2nd TX

```
Test of median = 0.000000 versus median not = 0.000000

                    N
                  for   Wilcoxon          Estimated
             N  Test  Statistic      P     Median
Diff 2nd TX  13     8       29.0  0.141     0.5000
```

Wilcoxon Signed Rank Test: Diff focal IRU

```
Test of median = 0.000000 versus median not = 0.000000

                 N
                for   Wilcoxon         Estimated
           N  Test  Statistic      P     Median
Diff focal 7     4       10.0  0.100     0.8750
```

Wilcoxon Signed Rank Test: Diff diff

```
Test of median = 0.000000 versus median not = 0.000000

                 N
                for   Wilcoxon         Estimated
           N  Test  Statistic      P     Median
Diff diff  12    10       49.0  0.032      1.000
```

Mann-Whitney Test and CI: Group1 vs Group2 (MPA in DIT+TMT)

```
                        N  Median
MPA,DIT+TMT, Group2     6   0.000
MPA,DIT+TMT, Group1    11   1.000


Point estimate for ETA1-ETA2 is -1.000
96.1 Percent CI for ETA1-ETA2 is (-1.500,0.000)
W = 36.0
Test of ETA1 = ETA2 vs ETA1 not = ETA2 is significant at 0.0786
The test is significant at 0.0680 (adjusted for ties)
```

Mann-Whitney Test and CI: In Group 2: MPA vs TR in TMT

```
                  N  Median
MPA,TMT,Group2   17   1.000
TR,TMT,Group2    14   1.000


Point estimate for ETA1-ETA2 is -0.000
95.1 Percent CI for ETA1-ETA2 is (-1.000,1.000)
W = 269.5
Test of ETA1 = ETA2 vs ETA1 not = ETA2 is significant at 0.9367
The test is significant at 0.9347 (adjusted for ties)
```

Mann-Whitney Test and CI: In Group 2: MPA in TMT vs TMT and DIT

```
                      N  Median
MPA,TMT+DIT,Group2    6   0.000
MPA,TMT,Group2       17   1.000


Point estimate for ETA1-ETA2 is -1.000
95.4 Percent CI for ETA1-ETA2 is (-1.499,0.000)
W = 48.5
Test of ETA1 = ETA2 vs ETA1 not = ETA2 is significant at 0.1073
The test is significant at 0.0964 (adjusted for ties)
```

Table 5.15: Results of 6 examiners viewing scintigraphic images in 13 horses

(Results of > 50 % agreement are in bold)

No	Left LM			Right LM			Left PD			Right PD		
	Focal	Diffuse	None	Focal	Diffuse	None	Focal	Diffuse	None	Focal	Diffuse	None
145534	**6**				5	1	**6**				5	1
200412		5	1	3	3		**4**	2		**4**	2	
200635		6		1	5		2	4		**4**	2	
200763		6		1	3	2	1	4	1		3	3
201210		4	2	2	3	1		4	2	2	4	
201211	1	5		1	5		2	4			6	
201394	**6**			**5**	1		**6**				6	
202000	2	4			6							
203447	3	3			6		2	4			6	
203551		5	1		6			5	1		6	
203552		5	1	**6**				4	2	**6**		
203618		5	1		4	2		5	1	1	5	
205171	**6**				4	2	**6**				4	2

Table 5.16: Results of owner telephone interview

No	Different problem	Positive long term outcome	Negative long term outcome	Current Workload?	Altered intended use?	Additional problems?	Vet Attention?	Oral NSAID?	Lame?
206720			NA	very light daily exercise	1	0	SX	1	1
206347				NA					
206085		NA		in full work	0	0	SX	0	1
205171		1		full work (4x/week jumping cross country)	0	0	0	0	0
203857			1	† (euthanasia) 2004	1				1
203662			1	pasture pet	1	0	0	0	1
203618		1		in daily work (hacking, jumping)	0	0	0	plant extract	0
203552			1	light hacking ok, painful when schooling	1	0	0	1	1
203551				NA					
203166	1						† Cardiac disease		
203165			1	light work (3x/week) schooling and hacking	1	0	0	Cortaflex	1
202714			1	sold in 2003 due to lameness	1		/	1	1
202228		1		dressage (special olympics)	0	0	0	Cortaflex	0
202000			1	retired to the ILPH (Aberdeen)	1	0	0	0	1
201660	1			schooling and light hacking 4x/week	0	soft tissue injury same leg	0	Cortaflex	1
201408				NA					
201394	1			hacking 1-2x/week	0	front feet pain	0	1	1
201383				NA					
201211		1		riding school activity 5x/week	0	0	0	Cortaflex	0
201210			1	very light hack 2-3x/week	0	0	0	1	1
201208				NA					
201032			1	†	1				1
200763			NA	in pasture no exercise	1	0	SX	0	0
200696			1	†	1				1

No	Different problem	Positive long term outcome	Negative long term outcome	Current Workload?	Altered intended use?	Additional problems?	Vet Attention?	Oral NSAID?	Lame?
200635			1	†	1	0	0	0	1
200412		1		dressage jumping	0	0	0	Cortaflex	0
200244			1	sold 2003	1	0	0	1	1
200190				NA					
200156			NA	pasture turn out not worked for 13 mths	/		SX	0	
145801			1	light work - hacking 4-6x/ week	0	laminitis	0	0	1
145706			1	†	1				1
145561				NA					
145534		1		5x week dressage	0	0	0	Cortaflex	0
145307				NA					
145189	1					developed navicular disease	0		1
145089			1	retired - blood bank due to lameness	1				1
144275			1	blood bank soon after diagnosis	1	0	0	0	1
144240			1	broodmare - field turn out	1	0	0	0	1
143673		1		daily exercise - riding school	0	0	0	0	0
142942		1		daily exercise/show jumping	0	0	ia medications	Cortaflex	0
142917		1		hacking 5x/week	0	0	0	0	0
142883			1	sold in 2002	1				1
142463		1		sold in 2003	0	0	0	/	0
140465			1	3-4x/ week dressage	1	0	ia medications	1	1
139791			1	sold	1	/	/	/	/
139099			1	hacking, schooling 5x/week	1	0	0	Cortaflex	0
136859			1	†	1	/	ia medications	1	1
135183		1		riding lessons 5x/week	0	0	0	Cortaflex	0
134775				NA					
137465		1		hacking 5x/week	0	0	0	0	0
203543		1		light hacking 2x/week	0	0	0	0	0

REFERENCES

AAEP. (1999). Guide to veterinary services for horse shows. In AAEP (Ed.), *Proceedings of the 45th Annual Convention of the American Association of Equine Practitioners*. Lexington, Kentucky, AAEP.

Adkins, A. R., Yovich, J. V. and Steel, C. M. (2001) Surgical arthrodesis of distal tarsal joints in 17 horses clinically affected with osteoarthritis. *Australian Veterinary Journal* 79, 26-29.

Arnason, T. and Bjornsdottir, S. (2003) Heritability of age-at-onset of bone spavin in Icelandic horses estimated by survival analysis. *Livestock Production Science* 79, 285-293.

Autefage, A., Alvinerie, M. and Toutain, P. L. (1986) Synovial fluid and plasma kinetics of methylprednisolone and methylprednisolone acetate in horses following intra-articular administration of methylprednisolone acetate. *Equine Veterinary Journal* 18, 193-8.

Axelsson, M., Eksell, P., Roneus, B., Brostrom, H., Haggstrom, J. and Carlsten, J. (1998) Relationship between hind limb lameness and radiographic signs of bone spavin in Icelandic horses in Sweden. *Acta Veterinaria Scandinavica* 39, 349-357.

Axelsson, M., Bjornsdottir, S., Eksell, P., Haggstrom, J., Sigurdsson, H. and Carlsten, J. (2001) Risk factors associated with hindlimb lameness and degenerative joint disease in the distal tarsus of Icelandic horses. *Equine Veterinary Journal* 33, 84-90.

Barneveld, A. (1983a) Einzelne klinische Aspekte des Spates. *Praktische Tierarzt* 2, 123-124.

Barneveld, A. (1983b) Spavin in the horse. PhD, Rijksuniversiteit Utrecht.

Barneveld, A. (2004). Bone Spavin, a Dutch View. In V. A. Icelandic (Ed.), *Proceedings of the International Symposium on Diseases of the Icelandic Horse*: International Veterinary Information Service (www.ivis.org).

Barneveld, A. and van Weeren, P. R. (1999) Early changes in the distal intertarsal joint of Dutch Warmblood foals and the influence of exercise on bone density in the third tarsal bone. *Equine Veterinary Journal Supplement* 31, 67-73.

Bassage, L. H. and Ross, M. W. (2003) Diagnostic Analgesia. In: *Lameness in the Horse*, Eds: M. W. Ross and S. Dyson, Saunders, St. Louis. pp 93-124.

Baxter, G. M., Dechant, J. E. and Southwood, L. L. (2003a) Treatment of horses with distal tarsal osteoarthritis. *Compendium on Continuing Education for the Practicing Veterinarian*, 25 2, 148-155.

Baxter, G. M., Southwood, L. L. and Dechant, J. E. (2003b) Diagnosis of distal tarsal osteoarthritis in horses. *Compendium on Continuing Education for the Practicing Veterinarian*, 25 2, 138-147.

Bell, B. T. L., Baker, G. J., Foreman, J. H. and Abbott, L. C. (1993) In-vivo investigation of communication between the distal intertarsal and tarsometatarsal joints in horses and ponies. *Veterinary Surgery* 22, 289-292.

Bjornsdottir, S., Arnason, T., Axelsson, M., Eksell, P., Sigurosson, H. and Carlsten, J. (2000a) The heritability of degenerative joint disease in the distal tarsal joints in Icelandic horses. *Livestock Production Science* 63, 77-83.

Bjornsdottir, S., Axelsson, M., Eksell, P., Sigurdsson, H. and Carlsten, J. (2000b) Radiographic and clinical survey of degenerative joint disease in the distal tarsal joints in Icelandic horses. *Equine Veterinary Journal* 32, 268-272.

Bjornsdottir, S., Anason, T. and Lord, P. (2003) Culling rate of Icelandic horses due to bone spavin. *Acta Veterinaria Scandinavica* 44, 161-169.

Bjornsdottir, S., Ekman, S., Eksell, P. and Lord, P. (2004a) High detail radiography and histology of the centrodistal tarsal joint of Icelandic horses age 6 months to 6 years. *Equine Veterinary Journal* 36, 5-11.

Bjornsdottir, S., Jorundsson, E. and Arnadottir, L. (2004b). Bone disease of the saga horse - A 1000 year old story. In V. A. Icelandic (Ed.), *International Symposium on Diseases of the Icelandic Horse*: International Veterinary Information Service, Ithaca, New York, USA.

Bland, J. M. (2000) Multifactorial methods. In: *An introduction to medical statistics*, 3rd edn., Ed: J. M. Bland, Oxford University Press, Oxford. pp 308-333.

Bland, J. M. (2000) Regression and correlation. In: *An introduction to medical statistics*, 3rd edn., Ed: J. M. Bland, Oxford University Press, Oxford. pp 185-209.

Bland, J. M. (2000) Summarizing data. In: *An introduction to medical statistics*, 3rd edn., Ed: J. M. Bland, Oxford University Press, Oxford. pp 47-67.

Bland, J. M. and Altman, G. A. (1995) Comparing methods of measurement: why plotting difference against standard method is misleading. *The Lancet* 346, 1085-1087.

Bogner, B., Bock, P. and Stanek, C. (1998) Correlation of radiological and histological changes of the medial tendon attachment and the related subtendinous bursa of the cranial tibialis muscle in horses affected with spavin. *Pferdeheilkunde* 14, 197-204.

Bohanon, T. C. (1998) Tarsal arthrodesis. In: *Current Techniques of Equine Surgery and Lameness*, Eds: N. A. White and J. N. Moore, WB Saunders, Philadelphia. pp 433-440.

Bohanon, T. C., Schneider, R. K. and Weisbrode, S. E. (1991) Fusion of the distal intertarsal and tarsometatarsal joints in the horse using intraarticular sodium monoiodoacetate. *Equine Veterinary Journal* 23, 289-295.

Boswell, J. C., McGuigan, H. P. and Schramme, M. (2000). The position of the point of zero moment relative to the foot in normal horses and horses suffering from osteoarthritis of the small tarsal joints (bone spavin), *Proceedings of 4th International Workshop on Animal Locomotion* (pp. 67). Vienna.

Bowles, N. (1999) The Delphi technique. *Nursing Standard* 13, 32-6.

Branch, M. V., Murray, R. C., Dyson, S. J. and Goodship, A. E. (2003). Can we visualise pathology of the distal tarsal joints using magnetic resonance imaging? In BEVA (Ed.), *Proceedings 42nd BEVA Congress* (pp. 297). Birmingham: Equine Veterinary Journal Ltd., Newmarket.

Burtscher, W. O. (1994) Zur Spaterkrankung beim Pferd: Korrelation klinischer und radiologischer Befunde mit dem Behandlungsergebnis sowie histologische Untersuchungen an der Bursa subtendinea musculi tibialis cranialis. Dissertation, Veterinaermedizinische Universitaet Wien.

Butler, J. A., Colles, C. M., Dyson, S. J., Kold, S. E. and Poulos, P. W. (2000) The Tarsus. In: *Clinical Radiology of the Horse*, 2 edn., Blackwell Science, Oxford. pp 247-284.

Clayton, H. M., Almeida, P. E., Prades, M., Brown, J., Tessier, C. and Lanovaz, J. L. (2002). Double blind study of the effects of an oral supplement intended to support joint health in horses with tarsal degenerative joint disease. In AAEP (Ed.),

Proceedings of the 48th Annual Convention of the American Association of Equine Pracitioners (pp. 314-317). Orlando.

Clegg, P. and Booth, T. (2000) Drugs used to treat osteoarthritis in the horse. *In Practice* 22, 594-603.

Dabarainer, R. M., Carter, G. K. and Dyson, S. J. (2003) The Tarsus. In: *Lameness in the Horse*, Eds: M. W. Ross and S. J. Dyson, Saunders. pp 440-449.

Dabareiner, R. M., Cohen, N. D., Carter, G. K., Nunn, S. and Moyer, W. (2005) Lameness and poor performance in horses used for team roping: 118 cases (2000-2003). In: *Journal of the American Veterinary Medical Association*, American Veterinary Medical Association, Schaumburg. pp 226 10, 1694-1699.

Dechant, J. E., Baxter, G. M., Southwood, L. L., Crawford, W. H., Jackman, B. R., Stashak, T. S., Trotter, G. W. and Hendrickson, D. A. (2003) Use of a three-drill-tract technique for arthrodesis of the distal tarsal joints in horses with distal tarsal osteoarthritis: 54 cases (1990-1999). *Journal of the American Veterinary Medical Association*, 223 12, 1800-1805.

Dik, K. J. (1983) X-ray-diagnostics of spavin. *Praktische Tierarzt* 64, 119-120.

Dowling, B. A., Dart, A. J. and Matthews, S. M. (2004) Chemical arthrodesis of the distal tarsal joints using sodium monoiodoacetate in 104 horses. *Australian Veterinary Journal*, 82 1/2, 38-42.

Driesang, I. and Boehm, D. (1993) Spat beim Pferd - klinische, roentgenologische und szintigraphische Befunde. *Tieraerztliche Praxis* 21, 141-148.

Dyson, S. J. and Romero, J. M. (1993) An investigation of the injection techniques for local analgesia of the equine distal tarsusand proximal metatarsus. *Equine Veterinary Journal* 25, 30-35.

Dyson, S. J. (2004). Are there any advances in the treatment of distal hock joint pain? In V. A. Icelandic (Ed.), *Proceedings of the International Symposium on Diseases of the Icelandic Horse*: International Veterinary Information Service (www.ivis.org), Ithaca, New York, USA.

Eastman, T. G., Bohanon, T. C., Beeman, G. M. and Swanson, T. D. (1997). Owner survey on cunean tenectomy as a treatment for bone spavin in performance horses. In AAEP (Ed.), *Proceedings of the 43rd Annual Convention of the American Association of Equine Practitioners* (pp. 121-122).

Ebbesen, E. and Konecni, V. (1975) Decision making and information integration in the courts: The setting of bail. *Journal of Personality and Social Psychology* 32, 805-821.

Eksell, P., Axelsson, M., Brostrom, H., Roneus, B., Haggstrom, J. and Carlsten, J. (1998) Prevalence and risk factors of bone spavin in Icelandic horses in Sweden: A radiographic field study. *Acta Veterinaria Scandinavica* 39, 339-348.

Eksell, P., Uhlhorn, H. and Carlsten, J. (1999) Evaluation of different projections for radiographic detection of tarsal degenerative joint disease in Icelandic horses. *Veterinary Radiology & Ultrasound* 40, 228-232.

Ferrie, J. and Lentelink, P. (2002) Shoeing for hindlimb conditions. In: *Corrective Farriery, A Textbook of Remedial Horseshoeing*, Vol 1, Ed: C. Simon, R & W Publications (Newmarket) Ltd, Newmarket. pp 158-162.

Friker, J., Maierl, J. and Liebich, H. (2000) Investigation of the communication between the distal intertarsal and the tarsometatarsal joint in horses. *Pferdeheilkunde* 16, 352-358.

Gabel, A. A. (1979a) Diagnosis, relative incidence, and probable cause of cunean tendon bursitis-tarsitis of Standardbred horses. *Journal of the American Veterinary Medical Association* 175, 1079-1085.

Gabel, A. A. (1979b) Treatment and prognosis for cunean tendon bursitis-tarsitis of Standardbred horses. *Journal of the American Veterinary Medical Association* 175, 1086-1088.

Gabel, A. A. (1983). Prevention, diagnosis and treatment of inflammation of the distal hock. In AAEP (Ed.), *Proceedings of the 28th Annual Convention of the American Association of Equine Practitioners* (pp. 287-298).

Garcia-Lopez, J. M. (2003) Computed Tomography. In: *Lameness in the Horse*, Eds: M. W. Ross and S. J. Dyson, Saunders. pp 213-215.

Gaustad, G., Dolvik, N. I. and Larsen, S. (1999) Comparison of intra-articular injection of 2ml of 0.9% NaCl solution with rest alone for treatment of horses with traumatic arthritis. *American Journal of Veterinary Research* 60, 1117-21.

Gordon, Helmer and Dalkey. (1964). The Delphi consultation process.

Gough, M. and Munroe, G. (1998) Decision making in the diagnosis and management of bone spavin in horses. *In Practice* 20, 252-259.

Gough, M., Munroe, G. and Mayhew, I. G. (2002) Diffusion of mepivacaine between adjacent synovial structures in the horse. Part 2: tarsus and stifle. *Equine Veterinary Journal* 34, 85-90.

Gunther, K. P. and Sun, Y. (1999) Reliability of radiographic assessment in hip and knee osteoarthritis. *Osteoarthritis and Cartilage* 7, 239-246.

Hartung, K., Munzer, B. and Keller, H. (1983) Radiologic evaluation of spavin in young trotters. *Veterinary Radiology* 24, 153-155.

Hasson, F., Keeney, S. and McKenna, H. (2000) Research guidelines for the Delphi survey technique. *Journal of Advanced Nursing* 32, 1008-15.

Hewetson, M., Christley, R. C., Hunt, I. D. and Voute, L. C. (2006) Reliability of observational gait analysis for assessment of lameness severity in the horse. *The Veterinary Record* "in press".

Hoffman, P., Slovic, P. and Rorer, L. (1968) An analysis of variance model for the assessment of configural cue utilization in clinical judgement. *Psychological Bulletin* 69.

Hotchkiss, J. W. (2004) Quantitative epidemiological studies on recurrent airway obstruction in the horse population of Great Britain using a risk-screening questionnaire. PhD, University of Glasgow.

Imschoot, J., Verschooten, F. and Demoor, A. (1990) Partial tibial neurectomy and neurectomy of the deep peroneal nerve as a treatment of bone spavin in the horse. *Vlaams Diergeneeskundig Tijdschrift* 59, 222-224.

Imschoot, J., Seenhaut, M., Demoor, A. and Verschooten, F. (1995) Partial tibial neurectomy and neurectomy of the deep peroneal nerve as a treatment of bone spavin in 24 horses. *Equine Practice* 17, 8-13.

Innes, J. F., Costello, M., Barr, F. J., Rudorf, H. and Barr, A. R. S. (2004) Radiographic progression of osteoarthritis of the canine stifle: A prospective study. *Veterinary Radiology & Ultrasound* 45, 143-148.

Jansson, N., Sonnichsen, H. V. and Hansen, E. (1995) Bone spavin in the horse - fenestration technique - a retrospective study. *Pferdeheilkunde* 11, 97-100.

Jones, J. and Hunter, D. (1995) Qualitative Research: Consensus methods for medical and health services research. *British Medical Journal* 311, 376-380.

Kallman, D. A., Wigley, F. M., Scott, W. W., Jr., Hochberg, M. C. and Tobin, J. D. (1989) New radiographic grading scales for osteoarthritis of the hand. Reliability for determining prevalence and progression.[see comment]. *Arthritis & Rheumatism* 32, 1584-91.

Kellgren, J. and Lawrence, J. (1957) Radiological assessment of osteoarthrosis. *Annals of the Rheumatic Diseases* 16, 494-501.

Kessler, S., Dieppe, P., Fuchs, J., Sturmer, T. and Gunther, K. P. (2000) Assessing the prevalence of hand osteoarthritis in epidemiological studies. The reliability of a radiological hand scale. *Annals of the Rheumatic Diseases* 59, 289-92.

Kramer, J., Keegan, K. G., Wilson, D. A., Smith, B. K. and Wilson, D. J. (2000) Kinematics of the hind limb in trotting horses after induced lameness of the distal intertarsal and tarsometatarsal joints and intra-articular administration of anesthetic. *American Journal of Veterinary Research* 61, 1031-1036.

Kraushansen, A. E., Jann, H. W., Kerr, D. V. and Fackelman, G. E. (1992) Arthrographic analysis of communication between the tarsometatarsal and distal intertarsal joints of the horse. *Veterinary Surgery* 21, 139-144.

Labens, R. (2005). Casebook submitted for the RCVS Certificate in Equine Surgery (Orth) unpublished data.

Laverty, S., Stover, S. M., Belanger, D., O'Brien, T. R., Pool, R. R., Pascoe, J. R., Tayler, K. and Harrington, T. (1991) Radiographic, high detail radiographic, microangiographic and histological findings of the distal portion of the tarsus in weanling, young and adult horses. *Equine Veterinary Journal* 23, 413-421.

McCarroll, G. D. and McClure, S. R. (2002) Initial experiences with extracorporeal shock wave therapy for treatment of bone spavin in horses - part II. *Veterinary and Comparative Orthopaedics and Traumatology* 15, 184-186.

McKibbin, L. S. and Paraschak, D. M. (1985) An investigation on the use of cryosurgery for treatment of bone spavin, splint, and fractured splint bone injuries in Standardbred horses. *Cryobiology* 22, 468-476.

McLaughlin, R. M. and Gaughan, E. M. (1998) Force Plate Gait Analysis. In: *Current Techniques in Equine Surgery and Lameness*, 2nd edn., Eds: N. A. White and J. N. Moore, W.B. Saunders Company, Philadelphia. pp 45-49.

Murray, R. C., Dyson, S. J., Weekes, J. S., Branch, M. V. and Hladick, S. (2004) Nuclear scintigraphic evaluation of the distal tarsal region in normal horses. *Veterinary Radiology & Ultrasound*, 45 4, 345-351.

Murray, R. C., Dyson, S. J., Weekes, J. S., Short, C. and Branch, M. V. (2005) Scintigraphic evaluation of the distal tarsal region in horses with distal tarsal pain. *Veterinary Radiology & Ultrasound*, 46 2, 171-178.

Newman, S., Rogers, K. M., McGuigan, M. P., Boswell, J. C., Schramme, M. C. and Wilson, A. M. (2000). The effect of corrective shoeing on the position of the point of zero moment relative to the foot in horses suffering from osteoarthritis of the small tarsal joints (bone spavin), *39th BEVA Congress* (pp. 198). Birmingham.

Phelps, R. H. and Shanteau, J. (1978) Livestock Judges: How much information can an expert use? *Organizational Behaviour and Human Performance* 21, 209-219.

Platt, D. (1997) Review of current methods available for the treatment of bone spavin. *Equine Veterinary Education* 9, 258-264.

Platt, D. (2001) The role of oral disease-modifying agents glucosamine and chondroitin sulphate in the management of equine degenerative joint disease. *Equine Veterinary Education* 13, 206-215.

Polito, A., Del Borrello, M., Isola, M., Zemella, N. and Bandello, F. (2005) Repeatability and reproducibility of fast molecular thickness mapping with stratus optical coherence tomography. *Archives of Ophthalmology* 123, 1330-1337.

Powell, C. (2003) The Delphi technique: myths and realities. *Journal of Advanced Nursing* 41, 376-82.

Roethlisberger, R. and Ueltschi, G. (1989) Ein Beitrag zur radiologischen Untersuchung am krankhaft veraenderten Sprunggelenk des Pferdes. *Pferdeheilkunde* 5, 181-189.

Ross, M. W. (2003) Manipulation. In: *Lameness in the Horse*, Eds: M. W. Ross and S. J. Dyson, Saunders. pp 440-449.

Sammut, E. B. and Kannegieter, N. J. (1995) Use of sodium monoiodoacetate to fuse the distal hock joints in horses. *Australian Veterinary Journal* 72, 25-28.

Schramme, M. (2000). Degenerative disease of the hock: Treatment options, *Proceedings of 39th BEVA Congress* (pp. 71-72). Birmingham.

Scruton, C., Baxter, G. M., Cross, M. W. and Frisbie, D. D. (2005) Comparison of intra-articular drilling and diode laser treatment for arthrodesis of the distal tarsal joints in normal horses. *Equine Veterinary Journal* 37, 81-6.

Serena, A., Schumacher, J., Schramme, M. C., Degraves, F., Bell, E. and Ravis, W. (2005) Concentration of methylprednisolone in the centrodistal joint after administration of methylprednisolone acetate in the tarsometatarsal joint. *Equine Veterinary Journal* 37, 172-4.

Silbersiepe, Berge and Mueller. (1986) Lehrbuch der speziellen Chirurgie fuer Tieraerzte and Studierende. Enke Verlag, Stuttgart.

Slovic, P. (1969) Analyzing the expert judge: A descriptive study of a stockbroker's decision processes. *Journal of Applied Psychology* 53, 255-263.

Smith, R. K., Dyson, S. J., Schramme, M. C., Head, M. J., Payne, R. J., Platt, D. and Walmsley, J. P. (2005) Osteoarthritis of the talocalcaneal joint in 18 horses. *Equine Veterinary Journal* 37, 166-171.

Stanger, P., Lauk, H. D., von Plocki, K. A., Jaenich, H. U. and Keller, H. (1994) Zur Behandlung der Spaterkrankung durch die Arthrodese der distalen Tarsalgelenke - Langzeitergebnisse. *Pferdeheilkunde* 10, 75-79.

Strusberg, I., Mendelberg, R. C., Serra, H. A. and Strusberg, A. M. (2002) Influence of weather conditions on rheumatic pain. *Journal of Rheumatology* 29, 335-8.

Sullins, K. E. (2002) Distal Tarsal Synovitis and Osteoarthritis (Bone Spavin). In: *Adams' Lameness in Horses*, 5th edn., Ed: T. S. Stashak, Lippincott Williams & Wilkins, Baltimore. pp 931-942.

Thomas, F. (1912) Geschichte der Therapie des Spates der Pferde. University of Leipzig.

Tooth, L. R. and Ottenbacher, K. J. (2004) The κ Statistic in Rehabilitation Research: An Examination. *Archives of Physical Medicine and Rehabiliation* 85, 1371-1376.

Vaden, M. F., Purohit, R. C., McCoy, M. D. and Vaughan, J. T. (1980) Thermography: A technique for subclinical diagnosis of osteoarthritis. *American Journal of Veterinary Research* 41, 1175-1179.

Verschooten, F. and Schramme, M. (1994) Radiological examination of the tarsus. *Equine Veterinary Education* 6, 323-332.

Wamberg, K. (1953). A new treatment for spavin in horses, *15th Intl Vet Congr* (pp. 371).

Watrous, B. J., Hultgren, B. D. and Wagner, P. C. (1991) Osteochondrosis and juvenile spavin in equids. *American Journal of Veterinary Research* 52, 607-12.

White, S. A. and van den Broek, N. R. (2004) Methods for assessing reliability and validity for a measurement tool: a case study and critique using the WHO haemoglobin colour scale. *Statistics in Medicine* 23, 1603-1619.

Willms, F., Roehe, R. and Kalm, E. (1996) Zuechterische Bedeutung von Gliedmassenerkrankungen beim Pferd. *Pferdeheilkunde* 12, 345-346.

Wilson, A. M., McGuigan, M. P. and Pardoe, C. (2001). The biomechanical effect of wedged, eggbar and extension shoes in sound and lame horses. In AAEP (Ed.), *Proceedings of the 47th Annual Convention of the American Association of Equine Practitioners* (pp. 339-343).

Wissdorf, H., Hertsch, B. and Stadtbaumer, G. (1998) Tarsalbereich, Regio tarsi. In: *Praxisorientierte Anatomie des Pferdes*, Eds: H. Wissdorf, H. Gerhards and B. Huskamp, M. & H. Schaper Alfeld, Hannover. pp 412-429.

Wyn-Jones, G. and May, S. A. (1986) Surgical arthrodesis for the treatment of osteoarthrosis of the proximal intertarsal, distal intertarsal and tarsometatarsal joints in 30 horses: A comparison of four different techniques. *Equine Veterinary Journal* 18, 59-64.

Zubrod, C. J., Schneider, R. K., Hague, B. A., Ragle, C. A., Gavin, P. R. and Kawcak, C. E. (2005) Comparison of three methods for arthrodesis of the distal intertarsal and tarsometatarsal joints in horses. *Veterinary Surgery*, 34 4, 372-382.

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