PREVALENCE OF RADIOGRAPHIC CHANGES IN SOUTH AFRICAN THOROUGHBRED RACEHORSES AT THE YEARLING SALES, 2008-2010

By

YOLANDI SMIT

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Summary

Prevalence of radiographic changes in South African Thoroughbred racehorses at the yearling sales, 2008-2010.

By

Yolandi Smit

Supervisor: **Dr. H.J. Marais**

Co-supervisors: **Prof. L.M. Rubio-Martinez, Prof. A.J. Guthrie**

Department: **Companion Animal Clinical Studies**

Degree: **MSc**

Radiographic examination of Thoroughbred racehorses at the time of the yearling sales is common practice in South Africa. Although it is generally accepted that yearlings will have some radiographic changes, there is only one study that estimated the prevalence of these changes in Thoroughbred racehorse yearlings in South Africa. Furniss *et al* reported on the occurrence of radiographic abnormalities over a one-year period (Furniss 2011). Furniss *et al.* study differs from other studies in that there was a higher prevalence of palmar metacarpophalangeal and plantar metatarsophalangeal osteochondral fragments and a lower prevalence of pedal osteitis, dorsal osteochondral fragmentation of the metatarsophalangeal joint, distal metacarpal saggital ridge changes, ulnar carpal bone lucencies, carpal osteophytes, distal intertarsal and tarsometatarsal joint changes, tarsal osteochondrosis lesions and stifle osteochondrosis lesions was found.

This study will further assist practitioners to identify joints where the most prevalent changes are likely to occur.

Our objective was to describe the prevalence and distribution of radiographic changes in the metacarpophalangeal joint, metatarsophalangeal joint, carpi, tarsi,

stifle and fore digits of racing Thoroughbred yearlings in South Africa when examined as part of a pre-purchase examination during the Annual National Yearling Sales extending from 2008 through 2010.

Thoroughbred racehorse yearlings were subjected to radiographic evaluation including the digit (n= 566), metacarpophalangeal joint (n=566), metatarsophalangeal joint (n= 566), carpi (n= 566), tarsi (n= 566) and stifle (n=566). The radiographic changes were categorised by location and type of change present for each series.

The digit

Where informal comparisons with previously published data can be made, similar changes of pedal osteitis were recorded in this study, with a total percentage of 6.7%. There was an 8.7% prevalence of inversion of the third pedal bone. Other studies describing radiographic changes in Thoroughbred racehorse yearlings did not investigate inversion of the third pedal bone, therefore results cannot be compared.

The metacarpophalangeal and metatarsophalangeal joints with proximal sesamoid bones

The prevalence of dorsoproximal phalanx one fragmentation (1.2%) of metacarpophalangeal joints were similar compared to other studies. Osteochondral fragmentation of proximal plantar phalanx one (6%) was 8.5 times more prevalent when compared to proximal palmar phalanx one (0.7%). The latter prevalence is in agreement with similar studies. There were low incidences of subchondral cyst-like lesions seen in distal third metacarpus (0.4%), distal third metatarsus (0.2%) and proximal first phalanx, similar to other studies. The most common change recorded on the dorsal aspect of distal third metacarpus and metatarsus was a well-defined semi-circular notch (dorsal aspect of distal third metacarpus 20.3%; dorsal aspect of distal third metatarsus 27%) similar to other studies. Our study showed a higher

prevalence of lucencies present at dorsal aspect of distal third metacarpus (8.5%) and metatarsus (4.2%) compared to other studies.

There was a marked lower prevalence in the current study of flat distal palmar third metacarpal condyles (6%). Prevalence of palmar and plantar third metacarpal and metatarsal supracondylar lysis were markedly higher in the present study. Slight palmar and plantar third metacarpus and metatarsus supracondylar lysis was seen in 19.3% of the horses. Moderate to extreme palmar and plantar third metacarpus and metatarsus supracondylar lysis were present in 10.2% of the horses.

The carpi

There was a higher prevalence of dorsomedial carpal disease in our study population (11.3%) and prevalence of carpal osseous cyst-like lesions such as a circular lucency in ulnar carpal bone was lower (14%). A markedly higher prevalence of 4.2% in carpal osteochondral fragmentation was found.

The tarsi

Osteochondrosis of the tarsocrural joint showed a similar prevalence (13.4%). Degenerative joint disease of tarsometatarsal joint had a higher prevalence (36%) than the centrodistal (distal intertarsal) joint (20.3%). There was also a higher incidence of degenerative joint disease in tarsometatarsal joint (36%).

The stifle

In the current study, osteochondrosis of the stifle had a similar prevalence (3.6%) when compared to other studies.

Conclusion

In South Africa Thoroughbred racehorse yearlings, radiographic changes most commonly involved the metacarpo- and metatarsophalangeal joints, carpi and tarsi. This study revealed markedly higher prevalence of palmar and plantar third metacarpal and metatarsal supracondylar lysis (slight 19.3% and moderate to extreme 10.2%), carpal osteochondral fragmentation (4.2%) and degenerative joint disease in tarsometatarsal joint (36%).

Establishment of normal prevalence and distribution of radiographic changes in South Africa Thoroughbred yearlings will allow for comparison with populations of young horses worldwide. Knowledge of the normal prevalence will assist veterinarians to identify joints in which radiographic changes are most likely to occur.

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List of abbreviations

D65°MPlLO	Dorsal 65° medial plantar lateral oblique
D10°LPlMO	Dorsal 10° lateral plantar medial oblique
D15°PrPaDO	Dorsal 15° proximal plantar distal oblique
D15°Pr30°MPlLO	Dorsal 15° proximal 30° medial plantar lateral oblique
D15°Pr30LPlMO	Dorsal 15° proximal 30° lateral planter medial oblique
D 15°PrPaDO	Dorsal, 15° proximal palmar distal oblique
D30°MPaLO	Dorsal 30° medial palmar lateral oblique
D30°LPaMO	Dorsal 30° lateral palmar medial oblique
D (30° - 40°) LPaMO	Dorsal 30°-40° lateral palmar medial oblique
D (20° - 30°) MPaLO	Dorsal 20°-30° medial palmar lateral oblique
DICOM	Digital imaging and communications in medicine
CdCr	Caudocranial
LM	Lateromedial
LM flexed	Lateromedial flexed
P1	Phalanx one
MC3	Third metacarpal bone
MT3	Third metatarsal bone

Contents

Chapter 1: Introduction

1.1 Background

Radiographic changes recorded from pre-purchase radiographs of racing Thoroughbred yearlings have been investigated in Thoroughbred populations around the world, not only in terms of the prevalence of specific radiographic changes but also the impact these changes may have on the future racing career of the Thoroughbred horse (Jackson *et al*. 2009; Kane *et al*. 2003a, b; Oliver *et al*. 2008). The results of such studies will assist veterinarians, involved in the pre-purchase examinations of racing Thoroughbreds, on how to advise their clients with respect to the future racing performance of the horse. This knowledge has financial implications for the client and for the racing industry as a whole.

1.2 Problem statement

The only study performed on the prevalence and distribution of radiographic changes on racing Thoroughbred yearlings in South Africa was performed by Furniss *et al*. (2011) and consisted of a one-year (2009) investigation looking at repository radiographs. Our study investigated radiographic changes over three years (2008-2010) and allows the comparison of our findings to similar studies of Thoroughbred yearling radiographs in other parts of the world as well as the trend of radiographic changes over three South African yearling crops.

1.3 Research question

What is the prevalence and distribution of radiographic changes in the metacarpophalangeal joint, fore proximal sesamoid bones, metatarsophalangeal joint, hind proximal sesamoid bones, carpi, tarsi, stifles

and fore digits of Thoroughbred racehorse yearlings in South Africa presented for pre-purchase radiographic examination during National yearling sales during 2008 to 2010?

1.4 Hypothesis

Radiographic changes will be present in Thoroughbred racehorse yearlings presented for pre-purchase radiographic examination during the National yearling sales of 2008 till 2010 in South Africa and will be similar to those reported in other countries.

1.5 Objective

To describe the prevalence and distribution of radiographic changes in the metacarpophalangeal joints, fore proximal sesamoid bones, metatarsophalangeal joints, hind proximal sesamoid bones, carpi, tarsi, stifles and fore digits of Thoroughbred racehorse yearlings in South Africa when examined as part of pre-purchase examination during National yearlings sales extending from 2008 to 2010.

1.6 Benefits

The results of this research will provide the prevalence and distributive data of radiographic changes of South African racing Thoroughbred yearlings during 2008 to 2010. This will provide sufficient knowledge to equine practitioners participating in pre-purchase radiographic examinations on the prevalence and distribution of radiological changes pertaining to Thoroughbred racehorse yearlings in South Africa. This will enable practitioners and researchers to focus on the most commonly affected sites and the relevance of these findings.

Chapter 2: Literature review

2.1 Introduction

2.1.1 Comparative studies

Radiographic examination of Thoroughbred racehorses at the time of the yearling sales is common practice in most parts of the world. The first reports were performed in Kentucky, USA in 1993 with the repository system in place in 1996 (Kane *et al*. 2003a). New Zealand soon followed by initiating their repository system in January 2003 at Karaka, Auckland (Oliver *et al*. 2008). In South Africa the National Thoroughbred racehorse Yearling repository system was only established in 2007 in Germiston.

Howard *et al*. (1993) reported on the occurrence of radiographic abnormalities in 582 yearlings offered for sale during a six-year period. In 2003 Kane *et al.* published a paper on radiographic changes in racing Thoroughbred yearlings in Central Kentucky. Preston *et al*. performed a study on 397 Thoroughbred racehorse yearlings during 2006 Keeneland September yearling sale describing the prevalence of various presale radiographic findings as well as the association of those findings with sales price.

To the authors knowledge only one study has been performed pertaining to radiographic changes of Thoroughbred racehorse yearlings in South Africa. The study was performed by Furniss *et al.* (2011) on prevalence and distribution of radiographic changes of Thoroughbred racehorse yearlings during National Thoroughbred yearling sales of 2009 at Germiston. It provided an overview of prevalence and distribution of radiographic changes over a one year period of 269 Thoroughbred racehorse yearlings. The current study is performed over a period of three years and will provide a better

understanding of distribution and variation of prevalence and distribution of radiographic changes in Thoroughbred racehorse yearlings of South Africa.

Similar studies have also been carried out in Standardbred trotters (Grondahl & Engeland 1995). The changes found on survey radiographs are recorded and their prevalence noted as well as their effect on future racing performance. The number of starts, total earnings, and earnings per start and/or racing longevity are some factors used to reflect racing performance. Those changes not affecting the horse's future racing career are regarded as incidental. Jorgensen *et al.* (1997) found no significant association between the presence or type of radiological abnormalities and the subsequent performance and longevity; however horses with multiple radiographic changes had a tendency to lower earnings and a shorter racing career than horses with single radiographic changes (Jorgensen *et al.* 1997).

Findings in previous studies have been classified depending on the prognosis for future racing career of the Thoroughbred racehorse (Kane *et al.* 2003a; Mcllwraith 2005). These findings have been correlated to their performance in terms of sales price and various factors reflecting the success of the racing career (Kane *et al.* 2003b).

Sale price, earnings, number of starts, record times, racing longevity, percentage of starts placed, are all factors which can be used to determine the success of a racehorse's career (Grondahl & Engeland 1995; Jorgensen *et al.* 1997; Colón *et al.* 2000; Kane *et al.* 2003b). Statistics show that Thoroughbred racehorse yearlings that were radiographed were more likely to be sold and the median sale price was higher than for non-radiographed yearlings (Kane *et al.* 2003b). Racing performance and sales data is obtained from the specific

racing authorities. Of all the Thoroughbred racehorse yearlings radiographed in a study, 81 % started at least 1 race during 2 and 3 years of age (Kane *et al.* 2003b). In more than one study it has been shown that approximately 50% of Thoroughbred racehorses raced as 2-year-olds (Bailey *et al.* 1999). In a study of 753 Standardbred trotters radiographed as yearlings, horses with osteochondrosis of the tarsocrural joint (48%) and palmar/plantar fragments of the metacarpo-/metatarsophalangeal joint (49%) raced less often but achieved almost similar race earnings as radiographically normal yearlings (Grondahl *et al.* 1994). It has been found that the presence of radiographic changes other than palmar/plantar bony fragments in the metacarpo-/metatarsophalangeal joints increased the risk of lameness by three years of age (Gaustad *et al.* 1996). Changes in the metacarpo-/metatarsophalangeal joints are more significant as it is a joint more susceptible to injury due to its relatively small surface area, greatest range of motion compared to other appendicular joints as well as the fact that the horses weight is transmitted through one joint during one phase of the stride in a galloping horse (Pool & Meagher 1990).

2.2 Pre-purchase radiographic examinations

2.2.1 Radiographic views

The South African authorities involved in the yearling sale (Thoroughbred Breeders Association of South Africa) standardize the views taken to evaluate each joint. Recommendations worldwide vary from 36 to 46 views in order to make up a complete and comprehensive radiographic examination (Dyson & Ross 2003; Kane *et al*. 2003a). Each radiographic examination in this study comprises a minimum of 36 radiographs evaluating the fore digits, metacarpophalangeal joints, metatarsophalangeal joints, carpi, tarsi and stifles (Table 1).

Table 1: Radiographic views required for pre-purchase examination of Thoroughbred racehorse yearlings.

	Radiographic views
Digit	LM (lateromedial)
Metacarpo-phalangeal joint	LM flexed (lateromedial flexed) D15°PrPaDiO(dorsal 15° proximal palmar distal oblique) D30°MPaLO(dorsal 30° medial palmar lateral oblique) D30°LPaMO(dorsal 30° lateral palmar medial oblique)
Metatarso-phalangeal joint	LM(lateromedial) D15°PrPlDiO(dorsal 15° proximal plantar distal oblique) D15°Pr30°MPlLO(dorsal 15° proximal 30° medial plantar lateral oblique; D15°Pr30°LPlMO(dorsal 15° proximal 30° lateral plantar medial oblique)
Carpus	LM flexed(lateromedial flexed) D(30°-40°)LPaMO(dorsal 30°-40° lateral palmar medial oblique) D(20°-30°)MPaLO(dorsal 20°-30° medial palmar lateral oblique)
Tarsus	LM(lateromedial) D65°MPlLO(dorsal 65° medial plantar lateral oblique) D10°LPlMO(dorsal 10° lateral plantar medial oblique)
Stifle	LM(lateromedial) CdCr(caudal to cranial)

2.3 Radiographic changes

2.3.1 The digit

2.3.1.1 Pedal osteitis

Pedal osteitis is defined as inflammation of distal phalanx and is associated with frontlimb lameness (Butler *et al.* 2000). Due to broad spectrum of radiographic changes present in distal phalanx and aetiologies it is preferred by some authors to use the term"pedal osteitis complex". Radiographically pedal osteitis is characterised in this study as osseous proliferation or resorption on the dorsal surface and/or solar margin of the distal phalanx. Changes are best viewed on lateromedial view (See Figure 1).

A study performed by Kane *et al.* (2003a) has shown that 33 of 300 yearlings had radiographic changes indicative of pedal osteitis with 16 of 33 yearlings having bilateral changes. A similar study recorded a prevalence of new bone formation on distal phalanx in 20.6% of racing Thoroughbreds radiographed (Jackson *et al.* 2003).

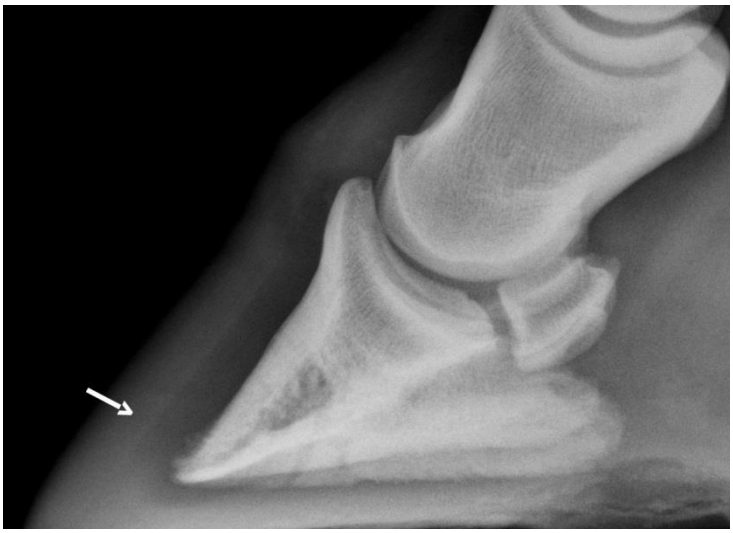

Figure 1: Lateromedial radiographic view of the distal phalanx. Pedal osteitis is shown on radiograph as an osseous proliferation on the dorsal distal surface of the distal phalanx (arrow).

2.3.1.2 Inversion

Distal phalanx inversion can be defined when the palmar/plantar processes of the distal phalanx are lower than the dorso-distal tip of distal phalanx (See Figure 2). It has been associated with more proximal sites of pain, causing lameness (Dyson & Ross 2003).

Figure 2: Lateromedial radiographic view of the distal phalanx showing inversion of distal phalanx.

2.3.1.3 Enthesophytosis and osteophytosis of extensor process of third phalanx

The extensor process of third phalanx may normally show a wide spectrum of radiological shapes that are seen on a lateromedial view and should not be confused as radiological abnormalities. Osteophytes refer to bone formation that is evident at the osteochondral margins of joints. These changes are considered important radiographic abnormalities as they occur in the presence of articular cartilage disease (Blevins & Widmer 1990). Bone formation that forms at the enthesis (common digital extensor tendon insertions on extensor process of third phalanx) is classified as enthesophytes and may be a source of pain and lameness (Blevins & Widmer 1990).

A study performed by Kane *et al.* (2003a) showed a low prevalence as only two yearlings out of a study of 300 fore feet series had radiological signs of osteophytosis and enthesophytosis of extensor process of third phalanx.

2.3.1.4 Palmar process fragmentation of third phalanx

Fragmentation of the palmar processes of the distal phalanx occurs commonly in foals (Kaneps *et al.* 1993). They are believed to be caused by shear forces generated by tension of the deep digital flexor tendon or by compression of solar cortical surface and tension on the dorsal cortical surface during weight bearing (Dyson *et al*. 2003). They are often associated with club foot appearance and lameness but may occasionally be seen without any clinical signs (Butler *et al*. 2000).

2.3.1.5 Prominent nutrient foramina (synovial invaginations) of navicular bone

Synovial invaginations are found just proximal to a notch that is formed between the articular surface of navicular bone and the ridge on the distal border of the bone which are also referred to as a synovial fossae. Synovial invaginations are usually not seen on a lateromedial view in a normal horse (Dyson *et al.* 2003). Certain shapes and number of synovial invaginations is suggestive of clinical signs of navicular disease to be present.

2.3.2 The metacarpophalangeal and metatarsophalangeal joints with proximal sesamoid bones

Radiographic changes in metacarpophalangeal joints and metatarsophalangeal joints were classified as follows: Fragment dorsoproximal phalanx one, fragment proximal palmar/plantar phalanx one (P1), cyst distal third metacarpal bone (MC3) / third metatarsal bone (MT3), proximal phalanx one, changes on dorsal aspect distal MC3/MT3, changes at

distal sagittal ridge of MC3/MT3, changes at distal palmar/plantar MC3/MT3 condyles and palmar/plantar supracondylar lysis of MC3/MT3. Prevalence of radiographic changes in proximal sesamoid bones was classified as follows: sesamoid elongation, abnormal shape, fracture, osteophytes, enthesophytes, circular lucencies, and total vascular channels of which both regular vascular channel and irregular vascular channels were identified.

2.3.2.1 Proximodorsal osteochondral fragmentation of phalanx one

Proximodorsal osteochondral fragmentation is best visualised on a flexed and/or extended lateromedial view (Figure 3) or a dorsolateral-palmaro/plantaromedial and dorsomedial-palmaro/plantarolateral 45° oblique views.

Dorsal fragments in the forelimbs of a population of Swedish Standardbreds had an incidence of 4.2% and 4.4% (Sandgren *et al.* 1993).

Figure 3: Flexed lateromedial radiographic view of metacarpophalangeal joint displaying a small proximodorsal osteochondral fragment of phalanx one (arrow).

Kane *et al.* (2003b) showed these radiographic changes were not linked to significantly reduced racing performance and this finding has also been confirmed by Head (2006). However, these findings may be an indicator that the affected horse might be suffering from recurrent joint disease during early training and racing (Pilsworth & Head 2010). According to Pilsworth and Head (2010), significant fragmentation on dorsal aspect of metacarpophalangeal joint in a yearling that has not undergone training yet, is a poor prognostic indicator for joint health but it does not rule out the horse in terms of its ability to race. In contrast, fragmentation at proximodorsal phalanx one in the metatarsophalangeal joint was associated with significant reduction in starting of races and earnings as shown by Kane *et al.* (2003b). Racing Thoroughbreds with the latter radiographic change were also 50% less likely to start a race (odds ration 0:51) versus the control group.

2.3.2.2 Palmar/plantar osteochondral fragmentation of phalanx one

Palmar/plantar fragmentation is believed to be a manifestation of osteochondrosis because they are recognized in young horses. Fragmentation is most likely the result of avulsion of a portion of the incompletely ossified proximal phalanx followed by development of a traumatic secondary ossification center (Dyson *et al*. 2003).

Fragmentation can be classified as either articular or non-articular in position. These axial osteochondral fragments from the axial proximoplantar/proximopalmar region of proximal phalanx one (also known as Type I axial fragment) have been examined histologically and proven to be traumatic in origin with the injuries more likely sustained in the first years of the horse's life (Nixon & Pool 1995). They are more common in hindlimbs compared to frontlimbs. These fragmentations are rarely linked to lameness in Thoroughbred racehorses and even quite marked changes are often not

accompanied by clinical problems (Pilsworth & Head 2010). However, in a study performed by Grondhal & Engeland (1995), this radiographic change was associated with reduced racing performance in Standardbred trotters. In the study by Kane *et al.* (2003b), 5% of Thoroughbred yearlings were affected in the hindlimb. Head (2006) and Kane *et al.* (2003a,b) studies concurred that this radiographic abnormality in hindlimb had no impact on their ability to race.

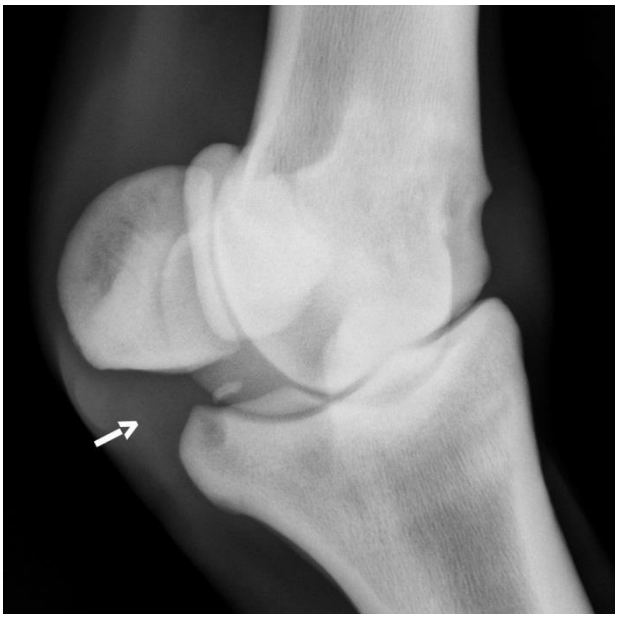

Figure 4: Dorsolateral-palmaromedial oblique radiographic view of metacarpophalangeal joint showing an articular fragmentation of proximal palmar phalanx one (arrow).

Palmar/plantar bony fragments (Type I axial fragments) in the metacarpo-and metatarsophalangeal joints have a recorded incidence between 0.5% to as high as 49% in Thoroughbreds and Standardbreds studied (Howard *et al.* 1993; Grondahl & Engeland 1995; Kane *et al.* 2003a).

Fragments classified as ununited palmar/plantar eminences (also known as Type II abaxial fragments) cannot be considered permanent until the age of 1-2 years (Carlsten *et al.* 1993).

2.3.2.3 Subchondral cyst-like lesions

Subchondral cyst-like lesions have been identified either affecting the distal metacarpus and/or proximal phalanx one, although with low incidence (0.2%) (Kane *et al.* 2003a). Osseous cyst-like lesions occur on the weight-bearing surfaces of the condyle on distal third metacarpus or distal third metatarsus and might present a manifestation of osteochondrosis. They are mostly present on the medial condyle and the horse usually show obvious lameness exacerbated by distal limb flexion (Dyson & Ross 2003).

2.3.2.4 Dorso-distal third metacarpal bone changes

Remodeling of the distal dorsal aspect of metacarpus three is a relatively common radiological change. Changes seen include a slight notch, radiolucency and fragmentation(see figure 5). While some authors consider the great variability in radiographic appearance of the distal dorsal metacarpal bone normal in Thoroughbred racehorse yearlings (Pilsworth & Head 2010), others have linked these changes to joint effusion and lameness (Yovich *et al.* 1985)

The most common (347 of 1127 yearlings, 31%) change recorded on the distal dorsal aspect of the distal third metacarpus was a well-defined semicircular notch in proximal dorsal sagittal ridge, which was usually bilateral (65% of the cases) (Kane *et al.* 2003a). These changes were not linked to a reduced ability to race for those authors or Head (2006). Sagittal ridge lesions have however been linked to joint effusion and lameness (Yovich *et al.* 1985).

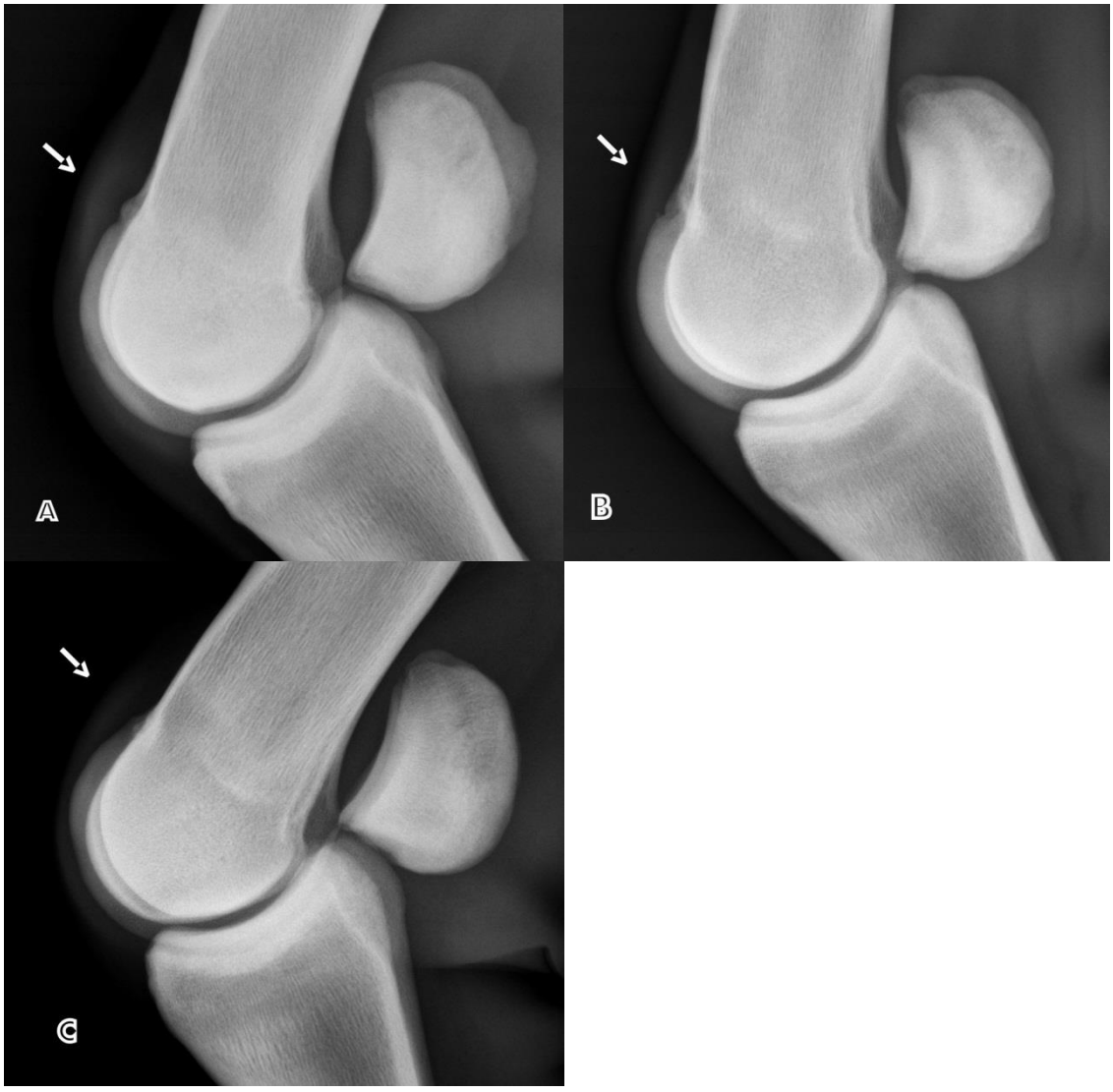

Figure 5: Flexed lateromedial radiographic view of metacarpophalangeal joint showing changes (arrows) seen on the dorsal aspect of the distal third metacarpal bone: (A) a well-defined semicircular notch, (B) lucency and (C) fragment or loose body.

2.3.2.5 Sagittal ridge changes

The dorsal sagittal ridge is the most common site of osteochondrosis in the metacarpophalangeal joint. These radiographic changes are best visualized on a dorsopalmar view or a flexed lateromedial view and is seen as a flattening or presence of a lucency (representing bone loss beneath the cartilage surface) at the dorsal sagittal ridge (Figure 6). In the study performed by Kane *et al*. (2003a) flattening of distal sagittal ridge was detected unilaterally in 67

yearlings and bilaterally in 43 (39% of those affected). Lucencies were detected unilaterally in 92 yearlings and bilaterally in 104 (53% of those affected). None of above changes were linked to decreased race performance in either of the studies performed by Kane *et al*. (2003a, b) or Head (2006).

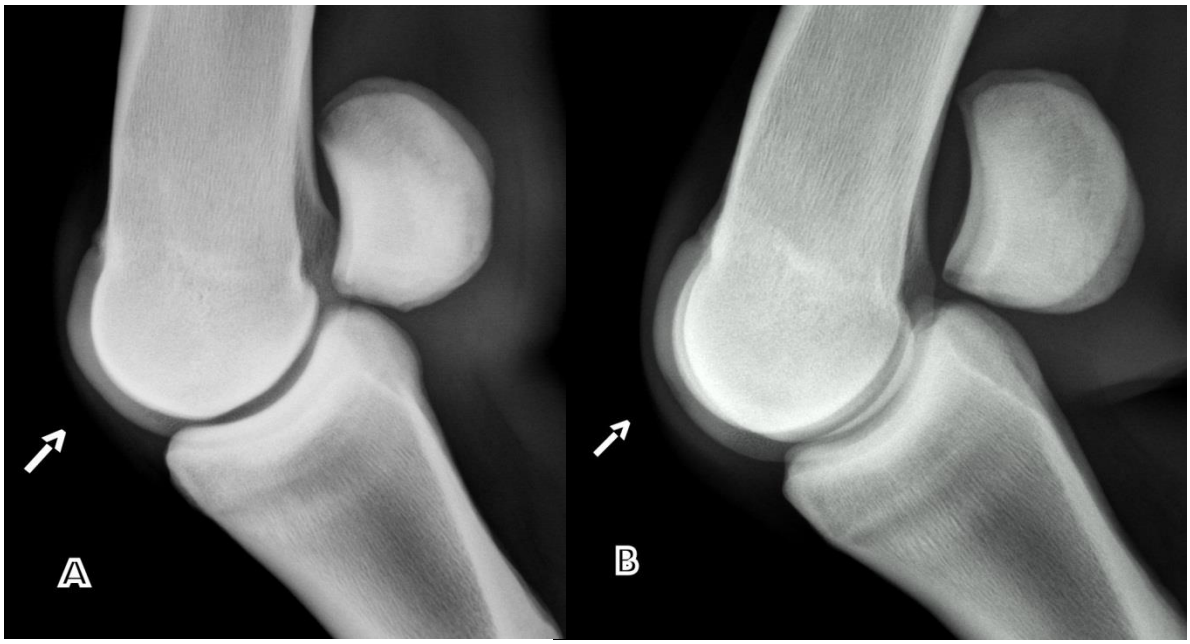

Figure 6: Flexed lateromedial radiographic view of metacarpophalangeal joint showing subchondral flattened area (A, arrow) and a subchondral lucency (B, arrow) on the distal sagittal ridge of the third metacarpal bone.

2.3.2.6 Palmar metacarpal disease/ Traumatic osteochondrosis dissecans (OCD)

The study by Kane *et al.* (2003a) revealed the most common change seen in the metacarpophalangeal joint (461 of 1127 yearlings, 41%) was flattening of the distal palmar third metacarpal condyles (Figure 7). Approximately half of these horses had bilateral changes (Kane *et al.* 2003a). Lucencies in this area have also been recorded (Kane *et al.* 2003a). These changes are classified as palmar metacarpal disease or traumatic osteochondrosis dissecans (OCD) (Kane *et al.* 2003a). These changes seen in the yearlings examined by Kane *et al.* (2003b) have also been identified in working Thoroughbred racehorses. These lesions are a result of subchondral microfractures occurring in third

metacarpus between the articulation of the first phalanx and the proximal sesamoid bones. These microfractures cause a painful ischaemia resulting in a gradual sloughing of distal third metacarpus. A crater-like defect on the palmar articular surface can be identified in the lateromedial view.

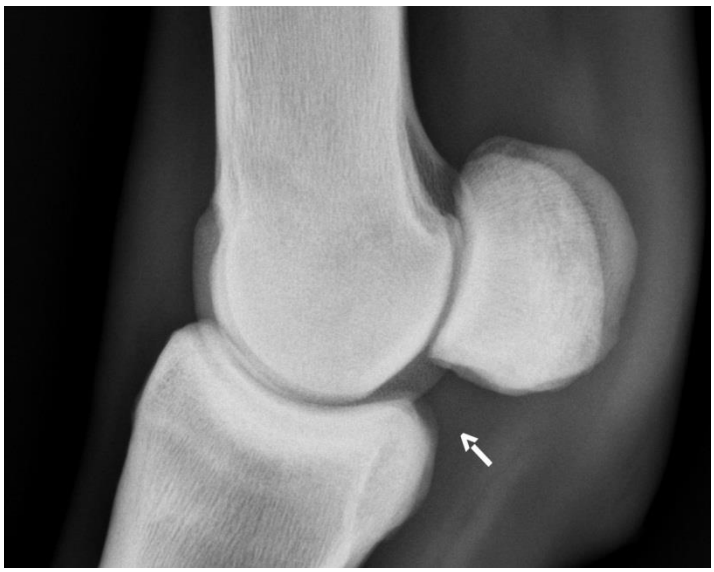

Figure 7: Flexed lateromedial radiographic view of metacarpophalangeal joint illustrating a flattening of distal palmar third metacarpal condyles (arrow).

2.3.2.7 Palmar supracondylar lysis

This is a radiological term used to describe a pattern of bone loss affecting the palmar cortex of the metacarpal bone at the level of the palmar pouch of the metacarpophalangeal joint. This area is covered by the synovial lining of the palmar pouch of the metacarpophalangeal joint. Palmar supracondylar lysis can be categorised into slight, moderate or extreme (Figure 8). Studies performed by Mcllwraith & Trotter (1996) indicated that chronic hyperaemia and the release of inflammatory mediators by a chronically inflamed synovial lining stimulate recruitment of osteoclasts and cortical bone resorption. The latter serves as a radiographic sign indicating a history of chronic inflammation of the metacarpophalangeal joint Pool & Meagher (1990). Kane *et al*. (2003a) was the first to document this condition in Thoroughbred racehorse yearling radiographs. This was one of the most significant findings

in the study performed by Kane *et al*. (2003b) in terms of reduced racing performance. Only 58% of yearlings displaying moderate to extreme palmar supracondylar lysis started a race, compared with 81% of the total population. Another study reported the odds of starting a race at two or three years of age were three times lower with presence of palmar supracondylar lysis, than without this radiological change (Pilsworth & Head 2010).

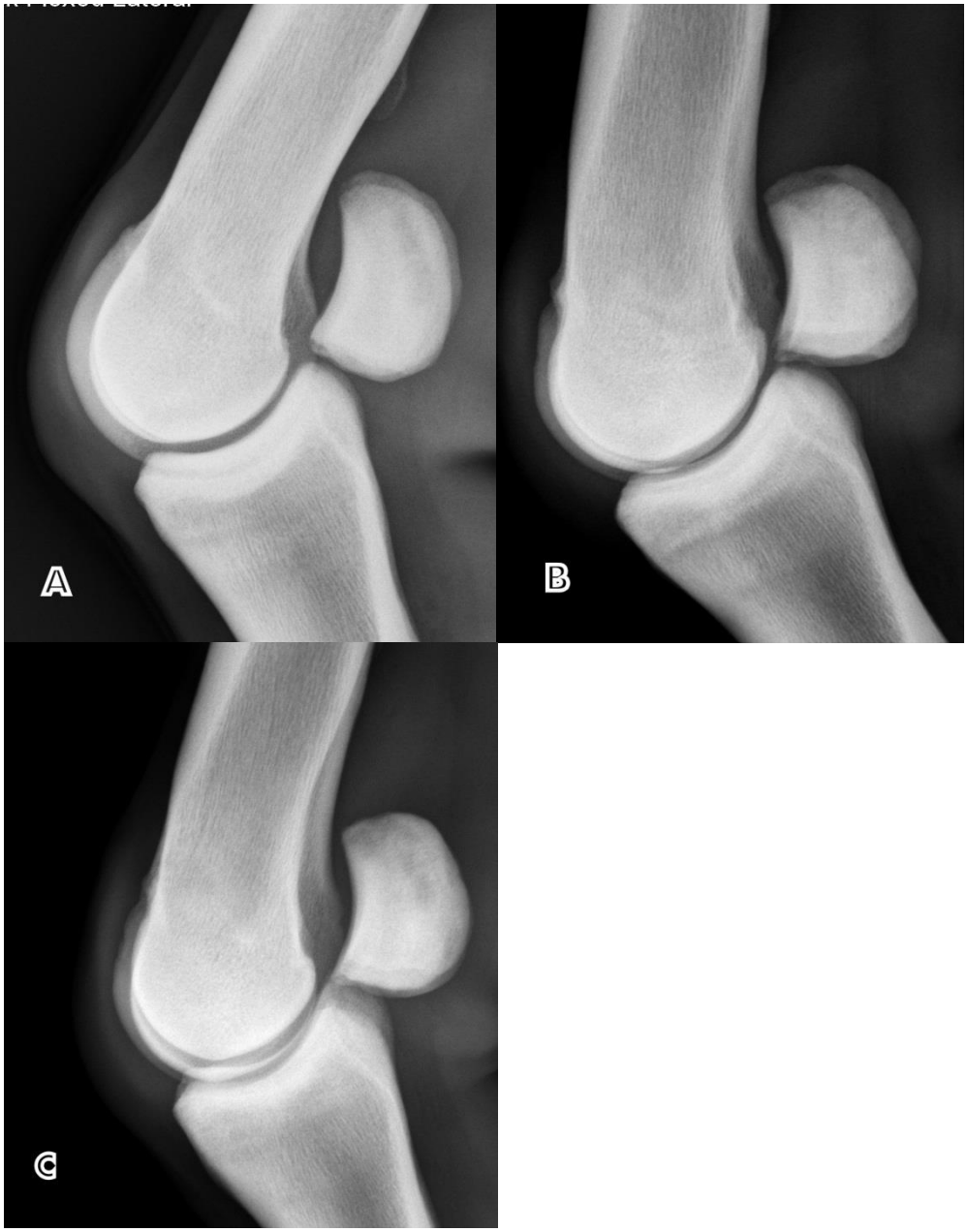

Figure 8: Flexed lateromedial radiographic view of metacarpophalangeal joint showing slight (A), moderate (B) and extreme supracondylar lysis (C).

2.3.2.8 Proximal sesamoid bone changes

Radiographic changes present in proximal sesamoid bones identified during pre-purchase radiographic studies include sesamoid elongation, abnormal shape, fracture (Figure 9), osteophytes, enthesophytes, circular lucencies, and total vascular channels of which both regular vascular channel and irregular vascular channels are identified (Kane *et al.* 2003a). In the survey done by Kane *et al.* (2003a) abnormal shape of the proximal sesamoids was usually noted on the medial side of the fore and hindlimb. This study further revealed that almost all yearlings (98%) had at least one vascular channel in a hind sesamoid bone, less than half (38%) of those examined had regular vascular channels in hind sesamoids compared with 56% that had regular vascular channels (≤ 2mm in width and parallel sides) in fore sesamoids. Of the total yearlings that had vascular channels (98%), irregular vascular channels (> 2mm in width and non-parallel sides) were more common (79%) than regular vascular channels (≤ 2mm in width and parallel sides) (56%). Irregular vascular channels were most common in the medial sesamoid bone. Fractures of the sesamoids were more frequent in hind compared to front limbs, and the majority were apical fractures (Kane *et al.* 2003a). In the hindlimb, a radiolucent line through the apical position of the sesamoids has been classified either as a separate centre of ossification or a bipartite sesamoid, with both being clinically insignificant (Grondahl *et al.* 1994).

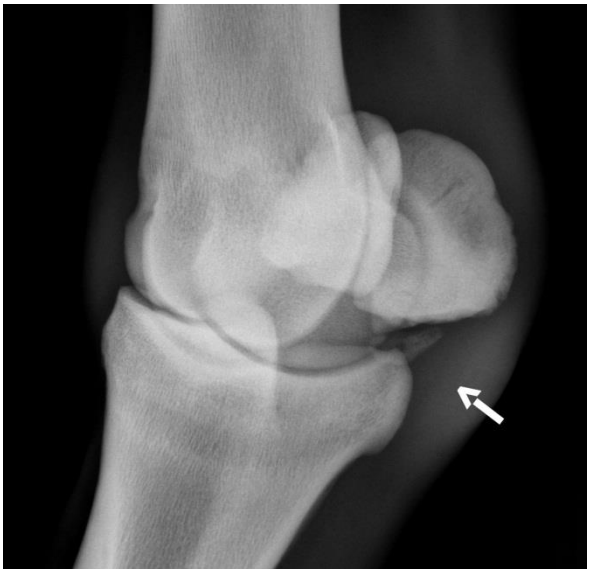

Figure 9: Dorsolateral-palmaromedial oblique radiographic view of metacarpophalangeal joint illustrating basilar fracture of lateral proximal sesamoid bone (arrow).

The percentage starts placed as well as the earnings were significantly lower for Thoroughbred yearlings with enthesophyte formation of the hind proximal sesamoid bones (Kane *et al.* 2003b), which had a prevalence of 1.3% (Kane *et al.* (2003a).

An examination of Standardbred trotters in Norway aged 6-21 months revealed non-articular radiographic changes involving the proximal sesamoids in 2.8% of horses (Grondahl *et al.* 1994). These changes included areas of demineralization as well as enthesopathy. Changes present were not linked to lameness and therefore of minor long-term clinical significance (Grondahl *et al.* 1994). The proportion of horses starting races was significantly lower for yearlings with enthesophyte formation on the proximal sesamoids of the metacarpophalangeal joint (approximately 65% raced compared with over 80% of horses that did not have this lesion) (Kane *et al.* 2003b). Head (2006) found that small fractures and fragments associated with the sesamoid bone had no negative impact on performance.

2.3.3 The carpi

Changes identified in pre-purchase radiographic studies are less commonly identified in the carpus. Changes include dorsal metacarpal disease, fragments, osteophytes, subchondral cysts, circular lucencies in the ulnar carpal bone and fracture of the accessory carpal bone (Howard *et al.* 1993; Kane *et al.* 2003a).

2.3.3.1 Dorso-medial carpal disease

Dorsomedial carpal disease is defined as a rounding or dorsal cortical thickening of the radiocarpal bone, as well as proliferative changes involving the radiocarpal or third carpal bones (Pool & Meagher 1990; Kane *et al.* 2003a). These changes are generally considered more prevalent in Thoroughbred racehorses undergoing training, although a prevalence of 8.5% was found in yearlings (Kane *et al.* 2003a). In the study performed by Head (2006), none of the affected yearlings raced as two year olds, indicating that modelling or fragmentation of the dorsodistal radial carpal bone is a poor prognostic sign for future soundness and raceability.

The study by Kane *et al.* (2003a,b) also confirmed that dorsomedial carpal disease had a significant impact on racing. Yearlings exhibiting this radiographic change were three times less likely to start a race and earned approximately half as much prize money per start than controls.

Radiographic remodelling changes of the radial and third carpal bones can include "cutting back", indicating that the dorsodistal radial carpal bone sharp 90° edge is remodelled to a rounded appearance (Figure 10), signifying advanced focal overload of the bone at this site, often as a consequence of conformation defects (Pool & Meagher 1990). This radiographic change moves

the articular surface with the third carpal bone palmarly and the dorsoproximal third carpal bone becomes more radiolucent, predisposing this site to fracture of the third carpal bone (Butler *et al*. 2000).

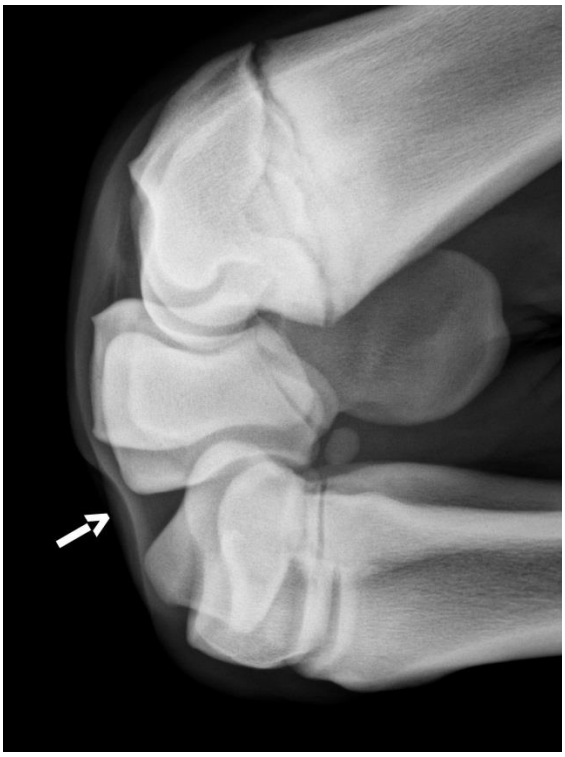

Figure 10: Flexed lateromedial radiographic view of carpus showing the dorsal surface of the radial carpal bone and 'cutting back' of the normally sharp 90° edge of the dorsodistal joint margin of this bone (arrow).

2.3.3.2 Carpal osseous cyst-like lesions

Osseous cyst-like lesions are a common finding in the carpus. Head (2006) and Kane *et al*. (2003a,b) found no association between the presence of cysts in the carpus and future ability to race. This finding is supported by Pilsworth & Head (2010).

Ulnar carpal bone lucency (of unknown etiology) (Figure 11) was the most prevalent change in the carpi in a study of Thoroughbred yearlings (Kane *et al*. 2003a). Ulnar cysts are usually situated non-articular and have sclerotic

margins (Dyson & Ross 2003) and is seen as a common finding that is rarely significant and not associated with lameness.

Figure 11: Dorsolateral-palmaromedial radiographic view of carpus displaying a subchondral cyst-like lesion in the ulnar carpal bone (arrow).

Osseous cyst-like lesions have been described in all carpal bones, the proximal end of third metacarpal bone as well as the distal radius. These lesions are frequently incidental and not associated with lameness (Butler *et al*. 2000). The lesions' significance increases when it is situated in close proximity to articular surface of the joint or in a position subjected to significant weightbearing.

2.3.3.3 Osteochondral fragmentation

Osteochondral fragmentation is primarily found in racehorses in training. Yearlings exhibit a very low percentage of osteochondral fragmentation on pre-purchase radiographic examinations (Young *et al.* 1991). The most common anatomical sites for osteochondral fragmentation in Throroughbreds includes proximal aspect of the third carpal bone and distal aspect of the

radial carpal bones, followed by the proximal aspect of the intermediate carpal bone and the distal lateral aspect of the radius (Dyson & Ross 2003; Pramer 1986; Thrall 2007).

In the study performed by Kane *et al*. (2003a) there was a 0.8% prevalence of osteochondral fragmentation in the carpi of yearlings. All of these fragments were seen unilateral. A similar prevalence (0,7%) was seen by Jackson *et al.* (2003).

2.3.4 The tarsi

Tarsal radiographic changes identified during pre-purchase radiographic examinations of Thoroughbred yearlings included lucencies in the medial malleolus, fragmentation or concavity of the intermediate ridge of tibia, flattening, lucencies or fragmentation of the lateral and medial trochlear ridges of the talus (all these radiographic changes thought to be a manifestation of osteochondrosis), and signs of distal tarsal degenerative joint disease as well as wedging or collapsing of tarsal bones (Kane *et al.* 2003a).

2.3.4.1 Osteochondrosis

Osteochondrosis of the tarsocrural joint is recognized as a common radiographic finding in Thoroughbred horses (Dyson & Ross 2000; Howard *et al.* 1993; Jackson *et al.* 2003). These lesions are most commonly on peripheral and less than completely weightbearing positions. Affected sites in order of most prevalent to least prevalent include the distal intermediate ridge of the tibia, medial malleoli of talus, the trochlea of the talus (lateral trochlea ridge more prevalent than medial trochlea ridge) followed by lateral malleoli of talus (rare) (Thrall 2007). These lesions frequently occur bilaterally (Butler 2000).

Conditions of the tarsus commonly seen on sales radiographs and evaluated for impact on racing performance in the study by Kane *et al.* (2003a,b), included lucency/fragmentation in the medial malleolus of the tibia (Figure 15) (as a result of osteochondritis dissecans), concavity/fragmentation of the intermediate ridge of the tibia (Figure 12), fragmentation/flattening of lateral trochlear ridge of the talus, fragmentation/flattening of medial trochlear ridge of the talus (Figure 13) and variations in the appearance of the distal medial trochlear ridge (Figure 14).

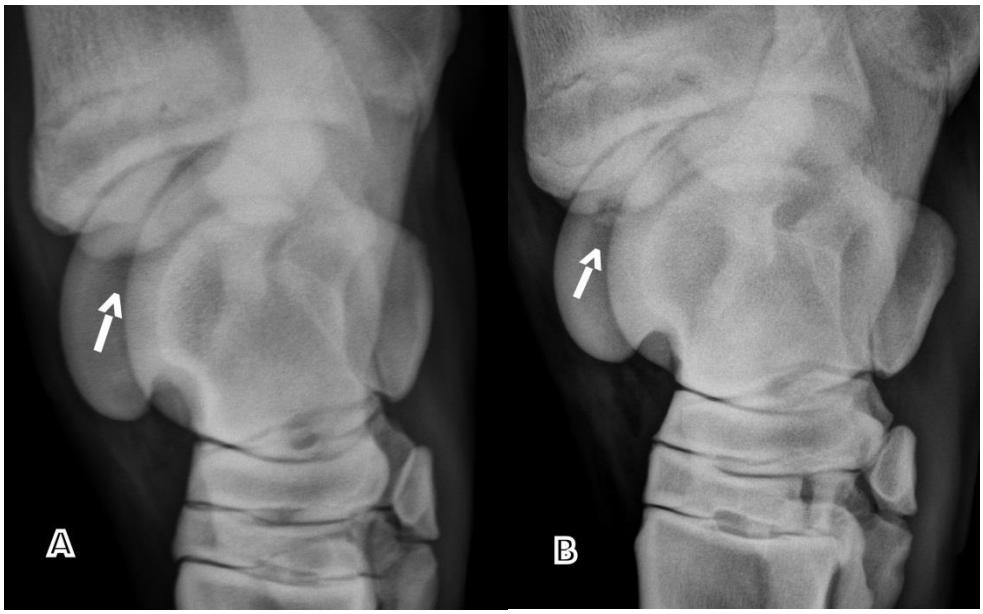

Figure 12: Dorsomedial-plantarolateral oblique radiographic view of tarsus showing changes (arrows) categorised as (A) concavity or (B) fragmentation of the intermediate ridge of the distal tibia.

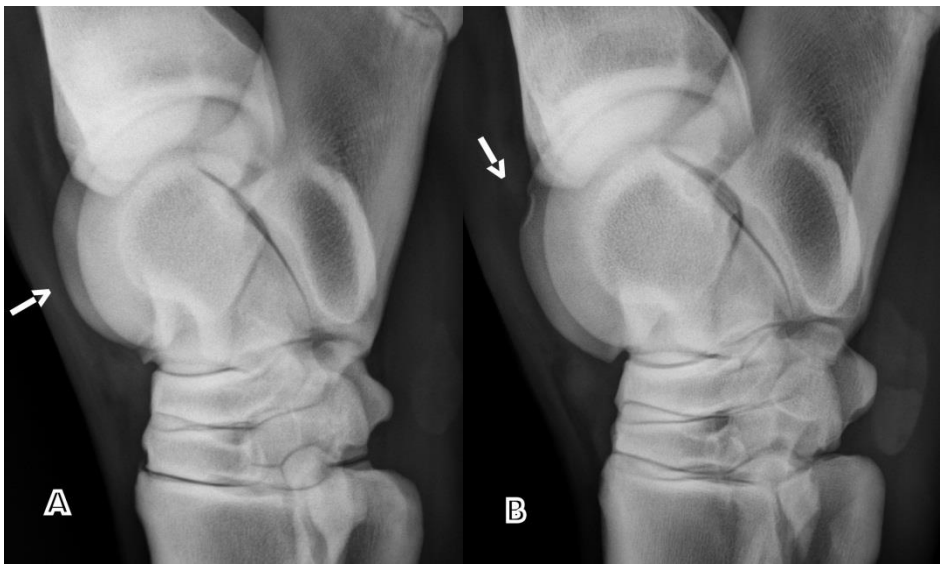

Figure 13: Lateromedial radiographic view of tarsus illustrating flattened area (A, arrow) and defect (B, arrow) at medial trochlear ridge of the talus.

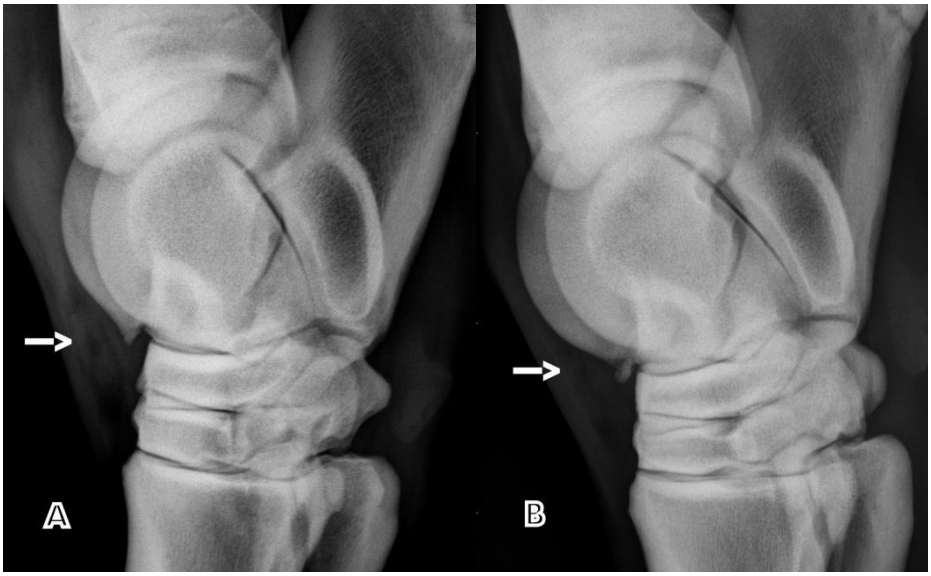

Figure 14: Lateromedial radiographic view of tarsus showing variations in the appearance of the distal medial trochlear ridge, (A) attached protruberance (arrow) and (B) a fragment (arrow).

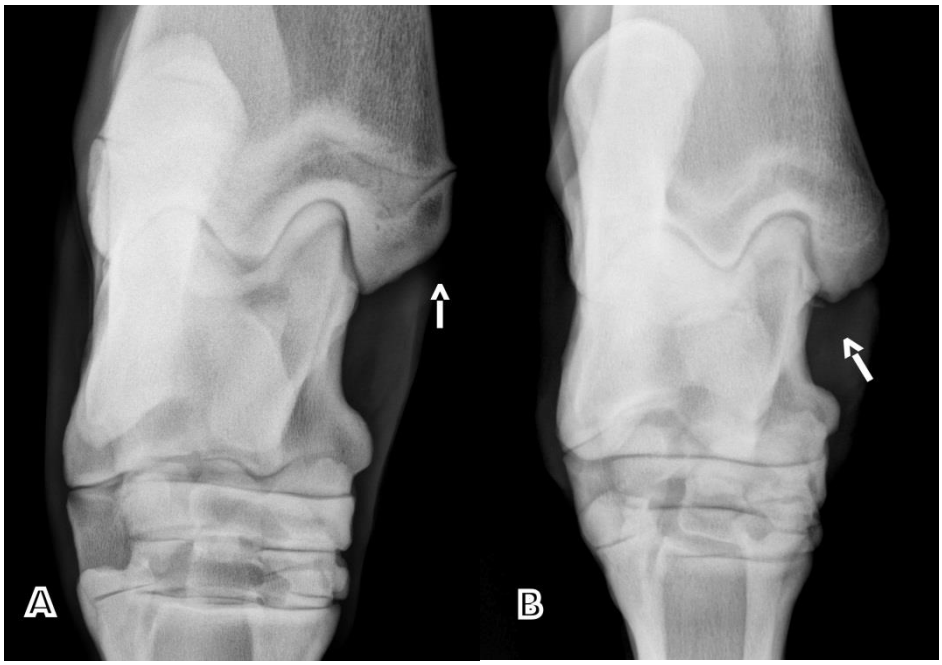

Figure 15: Dorso-plantar radiographic view of tarsus showing (A) lucency in the medial malleolus of the tibia (arrow) and (B) a discrete osseous opacity distal to the medial malleolus (arrow) of the tibia, both a manifestation of osteochondrosis.

Thirty-three of 48 Thoroughbred racehorse yearlings with changes in the distal intermediate ridge of the tibia had visible fragments (Kane *et al.* 2003a). The incidence of osteochondrosis in the tarsocrural joint of Standardbred trotters, between the ages 0-30 months, varied from 10.4% to 48% (Carlsten *et al.* 1993; Sandgren *et al.* 1993; Grondahl *et al.* 1994; Grondahl & Engeland 1995). Of 91 Swedish Standardbreds showing tarsal osteochondrosis, 45% had bilateral involvement (Sandgren *et al.* 1993). Osteochondrosis can be identified as early as 1 month of age and, once identified radiographically, these changes persist (Carlsten *et al.* 1993). Surveys performed indicate that lesions of the tarso-crural joint arise before and are permanent from the age of 5 months old (Olstad *et al.* (2007)).

Osteochondrosis of the tarsocrural joint was reported in 2/80 (2.5%) yearling feral horses in a study performed by Valentino *et al*. (1999). One yearling had a dorsal intermediate ridge lesion and the other a small fragment of distal lateral trochlear ridge of the talus. The prevalence in Thoroughbred yearlings has been reported between 3 – 6.5% (Howard *et al.* 1992; Kane *et al*. 2003a; Cohen *et al*. 2006). All osteochondral lesions, with exception of osteophytes and enthesiophytes of centrodistal joint and/or tarsometatarsal joints, were found to have a significant effect on future ability to race in the studies performed by Kane *et al* (2003b) and Head (2006).

In a study performed by Oliver *et al*. (2008), osteochondrosis was seen in the tibiotarsal joint of 66/1 505 (4%) of yearling Thoroughbred horses in New Zealand. The radiographic changes were recorded as follows: 63% had a lesion at distal intermediate ridge of the tibia, 19% a lesion at lateral trochlear ridge, 15% a lesion at medial malleolus and only 3% had a lesion on medial trochlear ridge. In this study the location of osteochondrosis lesions in the tibiotarsal joint was similar to numbers cited by Kane *et al*. (2003a) (distal intermediate ridge of the tibia 65%, lateral trochlear ridge 19%, medial malleolus 7% and medial trochlear ridge 9%), although the 15% prevalence in the medial malleolus in study by Oliver *et al*. (2008) was slightly higher.

Kane *et al*. (2003a,b) and Head (2006) concluded that common lesions of osteochondritis dissecans (OCD) did not appear to affect future racing performance. Pilsworth & Head (2010) agree with above and stated that OCD of any part of distal tibia is hardly ever a cause of lameness in Thoroughbreds. Fragmentation of the distal intermediate ridge of tibia is frequently encountered and the lesion found is of no clinical significance. Kane *et al*. (2003a,b) agrees with above statement and found that such fragmentation had no effect of racing performance.

2.3.4.2 Degenerative joint disease

The centrodistal (distal intertarsal) and tarsometatarsal joints are most frequently affected, either alone or in combination. The proximal intertarsal joint is less commonly affected and talocalcaneal joint rarely affected (Butler *et al*. 2000). Radiographic changes include periarticular osteophyte/enthesophyte formation (Figure 16), new periosteal bone formation, subchondral bone lysis (Figure 17) and/or sclerosis and narrowing/loss of joint space.

Kane *et al*. (2003a) study revealed a prevalence of 17.5% osteophytes or enthesophytes in the distal intertarsal and tarsometatarsal joints and 7.3 % lucency in 1101 Thoroughbred yearlings.

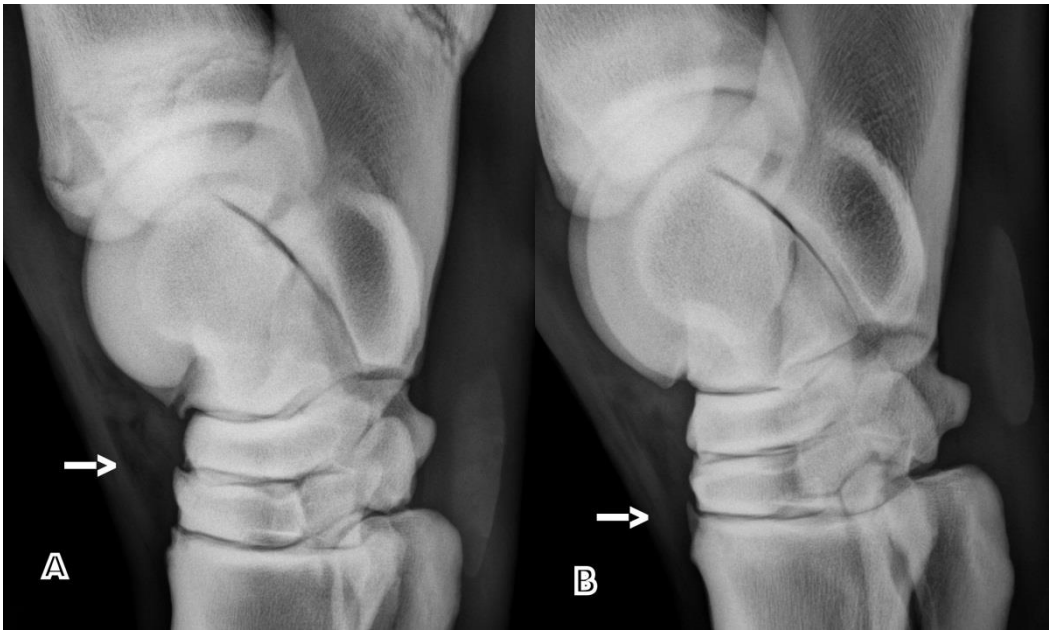

Figure 16: Lateromedial radiographic view of tarsus showing osteophytes or enthesophytes (arrows) at the (A) centrodistal (distal intertarsal) and (B) tarsometatarsal joint margins.

Figure 17: Latero-medial radiographic view of tarsus showing subchondral lucency at the dorsal aspect of tarsometatarsal joint (arrow).

Bone spavin is a chronic deformative arthrosis, mainly in dorsal and medial aspects of the proximal end of the third metatarsal bone, the third tarsal bone and the central tarsal bone (Hartung et al. 1983). In a study performed by Hartung *et al*. (1983) the prevalence of spavin in 18-23 months old Standardbred trotters, before they started training, was considered mild in 27.5%, moderate in 16.1% and severe in 6.1%. Horses with severe radiological changes may not show lameness, while some horses with subtle or no radiographic changes may show lameness that is localised to distal tarsal joints by making use of intra-articular anaesthesia (Hartung et al. 1983).

In a study performed by Oliver *et al*. (2008) lesions were confined to the dorsolateral or dorsal aspect of distal intertarsal and tarsometatarsal joints. The prevalence was diagnosed as mild (21%), moderate (9%) and severe (1%) at the distal intertarsal and tarsometatarsal joints.

Howard *et al.* (1993) showed that while osteophytes and subchondral lucencies in the distal intertarsal and tarsometatarsal joint margins were a common change noted in the tarsi, these changes were usually seen unilaterally.

Osteophyte formation involving the dorsal aspects of the centrodistal joint or the lateral aspect of this joint is often associated with lameness (Butler *et al*. 2000). Smooth osteophyte formation at the dorsal and medial aspect of tarsometatarsal joint is commonly encountered and is rarely linked to an adverse effect on training and racing, whereas osteophyte formation around the centrodistal joint can be linked to development of osteoarthritis, ultimately resulting in significant lameness (Pilsworth & Head 2010). Horses with changes consistent with distal tarsal degenerative joint disease, were found to have less starts (Kane *et al.* 2003b).

2.3.4.3 Wedging and collapse of third and/or central tarsal bones

Wedging and collapse of third and/ or central tarsal bones can be the result of incomplete ossification of these bones. It occurs commonly in premature foals but can occur in full-term singlet's (Dyson & Ross 2003). If this condition is diagnosed in neonatal foals, the limbs needs to be supported and failing to do so will result in normal weightbearing leading to compression of either or both the central and third tarsal bones. Compressed bones will appear radiologically as a wedge shaped in both lateromedial and dorsoplantar views, and may show fragmentation with narrowing of the joint spaces (Butler *et al*. 2000). Wedging and collapse are often bilateral.

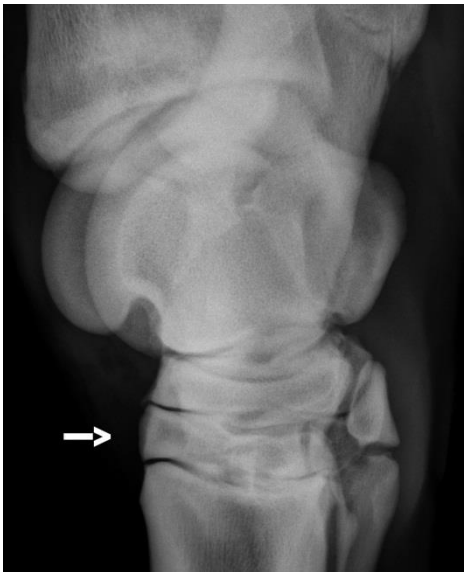

Figure 18: Dorsomedial-plantarolateral radiographic view of tarsus showing wedging of the third tarsal bone (arrow).

In a study performed by Kane *et al*. (2003a,b) prevalence of wedging or collapse of tarsal bone(s) in 1088 yearling Thoroughbred horses was 1.2% (13/1088). This abnormality has been linked to a reduced likelihood of racing successfully.

Baired & Pilsworth (2001) performed a study to explore if wedge-shaped conformation of third tarsal bone is associated with an increased risk of developing a slab fracture of third tarsal bone during training. A wedge-shaped conformation can concentrate the loading at the apex of the wedge, producing the same type of bone changes as compared to abnormal limb conformation (focal overloading leading to sclerosis and increased bone stiffness), leading to bone fracture. The study revealed that wedge shaped conformation of third tarsal bone was overrepresented in a population of horses sustaining third tarsal bone fractures when compared to controls.

2.3.5 The stifle

Radiographic changes identified in stifle joint included the following: changes in lateral and medial trochlear ridges of the femur, defect or fragment in the trochlear groove, patella lucencies and fragmentation of distal patella.

2.3.5.1 Osteochondrosis

Osteochondrosis is most commonly recognized radiographically involving the lateral trochlear ridge of the femur. Lesions can also be observed on articular facet of patella and is less commonly seen on medial trochlear ridge and trochlear groove (Butler *et al.* 2000). Osteochondrosis occurs frequently bilaterally and thus it is vital to radiograph both stifles. Radiographic indications of osteochondrosis of lateral trochlear ridge may include the following: flattening of trochlear ridge (Figure 19), irregular contour of the trochlear ridge which may be accompanied by subchondral defects that may have a sclerotic margin, radiopaque fragmentation of ridge (Figure 20) and irregular articular facet of the patella. It is important that oblique views to be included as some of above radiological abnormalities is best visualised on such views.

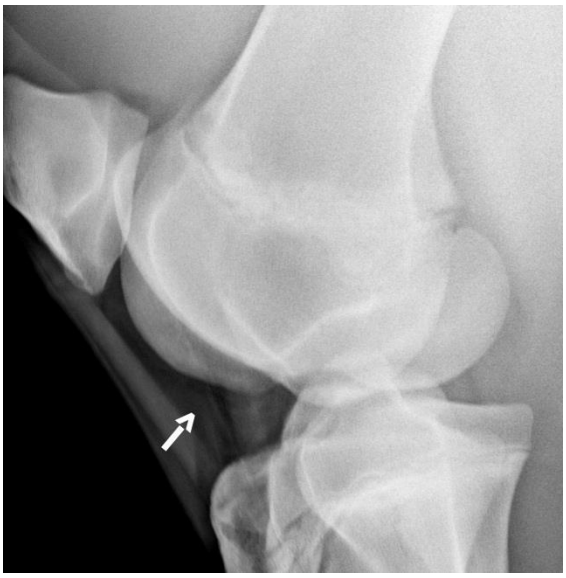

Figure 19: Lateromedial radiographic view of stifle showing flattening of lateral trochlear ridge of femur (mild positioning error).

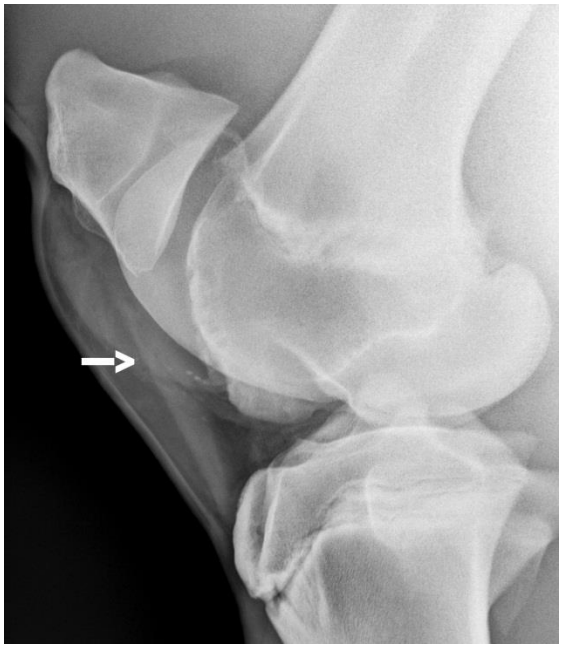

Figure 20: Lateromedial radiographic view of stifle showing radiopaque fragmentations of lateral trochlear ridge of femur.

Osteochondrosis is most frequently seen in Thoroughbreds and Warmbloods (Dyson & Ross 2003). Lesion most likely develop during the first seven months of life; clinical signs may sometimes not be evident until the horse is placed in training (Carlson *et al*. 1995).

Oliver *et al*. (2008) reported a prevalence of 2.7% of Thoroughbred yearlings exhibiting radiographic signs of osteochondrosis of the stifle. This prevalence appears to be lower than the prevalences reported by Kane *et al*. (2003a) as 3.9% and a 5.5% by Cohen *et al*. (2006). A study by McIntosh & McIlwraith (1993) revealed that one individual Thoroughbred farm had a prevalence between 10.8% and 24% over three consecutive years. These higher numbers may reflect a nutritional or genetic cause.

2.3.5.2 Subchondral bone cyst-like lesions

Subchondral bone cyst is considered by some authors to be part of osteochondrosis syndrome but are discussed here as a separate lesion.

Subchondral bone cysts are almost exclusively found in medial femoral condyle (Figure 21), and may occur bilaterally. A cyst is seen as a nearly circular lucent area within the subchondral bone and the lesion is best visualised on a caudocranial view. When a subchondral bone cyst is present in one limb, a shallow saucer-shaped lesion is occasionally present in the contralateral limb (Butler *et al*. 2000).

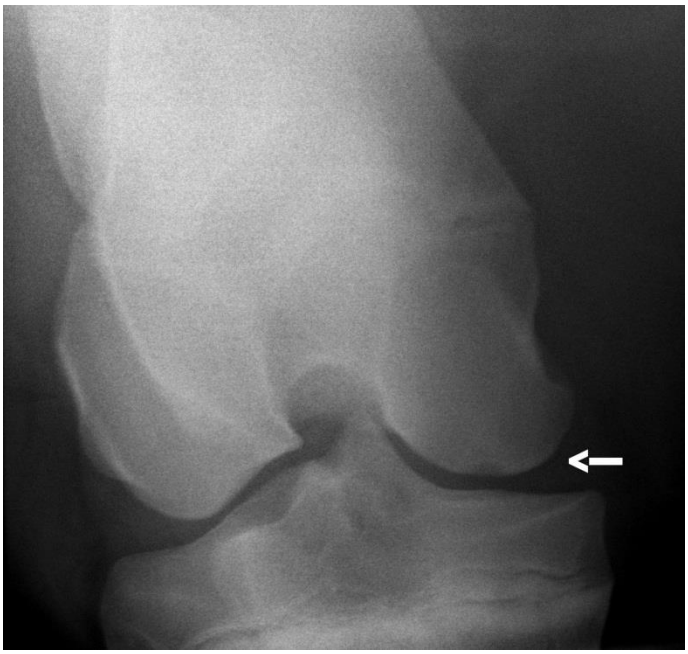

Figure 21: Caudoproximal 30° craniodistal oblique radiographic view of stifle showing a small, well demarcated subchondral bone cyst (arrow) in the middle of the medial femoral condyle.

Recent experimental evidence has shown that an elliptical full thickness cartilage plus subchondral bone defect, at the region of maximum weight bearing in the medial femoral condyle, will result in the development of an osseous cyst-like lesion within 3 weeks. This lesion may progress and enlarge over the next 9 weeks (Butler *et al*. 2000). This supports clinical evidence of subchondral bone cysts developing in the medial femoral condyle of mature horses, following known trauma (Butler *et al*. 2000).

Whitman *et al.* (2006) examined a total of 2915 radiographic reports of Thoroughbred sale yearlings and found 25 medial femoral condyle osseous cyst-like lesions. Although this change was found to lower the sales price, it had no effect on future racing performance. Neither Head (2006) nor Kane *et al*. (2003a,b) found any cases of subchondral bone cysts in the medial femoral condyle and therefore they concluded that those did not have a serious impact on future racing performance.

In contrast, Bramlage (Bramlage 1993) found that major osteochondral lesions of the stifle have a high probability of affecting performance. The medial femoral condyle is also incriminated as a high-risk site for osteochondral lesions due to tendency towards infarction followed by disturbance in ossification (Hance *et al.* 1993). Pilsworth & Head (2010) concur and state that when this lesion is present, a yearling often carries a greater significance for potential future problems.

Chapter 3: Materials and methods

3.1 Experimental design

Radiographs of 566 Thoroughbred yearlings as part of presale evaluations at the 2008 to 2010 National Yearling Sales were obtained from the TBA (Thoroughbred Breeding Association) repository.

Our inclusion criteria included Thoroughbred yearlings of 14 to 19 months of age and all radiographs of diagnostic quality. The radiographic examinations included fore feet (LM view), metacarpophalangeal joints and proximal sesamoid bones (D30°Pr-PaDiO, flexed LM, D30°Pr45L-PaDiMO and D30°Pr45M-PaDiLO views), metatarsophalangeal joints and proximal sesamoid bones (D30°Pr-PlDiO, LM, D15°Pr30°L-PlDiMO, D15°Pr30°M-

PlDiLO views), carpi (LM, D45°L-PaMO and D35°M-PaLO views), tarsi (D10°-15°L-PlMO, LM, D65°M-PlLO views) and stifles (LM and CdCr views).

Radiographic images in a series that were of non-diagnostic quality and radiographic views missing in that series were categorized as non-diagnostic and then that series were not included in the analysis.

Examination of the radiographs took place in a blinded manner by 3 observers with discrepancies settled by the consensus of opinions. Despite the large number of radiographs reviewed, it is unlikely that many lesions were missed by the 3 observers. The radiographic changes were categorised in detail without trying to judge the normality of the findings or trying to match the results to a particular diagnosis. This approach was selected as the best way to describe objectively what one should expect to see on survey radiographs without biasing the prevalence estimates for changes that may or may not be clinically important.

A checklist containing radiographic abnormalities was completed for each radiographic series by each author. The radiographic evaluation took place by using the DICOM Works software program, LG model W2243S-PF LCD HD multi-media monitor in combination with PALIT GTS250 E-GREEN 1024MB GDDR3 256 graphics card that provided superior quality of radiographic images.

3.2 Experimental procedures

Radiographs were evaluated by the first author and reviewed by the third and fourth authors. A checklist containing radiographic abnormalities was completed for each radiographic series by authors. Any differences and

discrepancies were reviewed and a consensus opinion was obtained pertaining to radiographic changes present.

3.3 Categorisation of radiographic changes

Radiographic changes datasheet (extrapolated for Kate *et al.* (2003a)) is presented in Appendix A and are discussed below.

3.3.1 The digit

Fore feet series were examined for signs of osteitis of the third phalanx, evidenced by osseous proliferation or resorption on the dorsal surface and/or solar margin. Inversion of the distal phalanx was categorised as such when the palmar/plantar processes were lower than the toe. Other radiographic changes in the fore feet such as osteophytes or enthesophytes at the extensor process of the third phalanx, fragmentation of the palmar processes of the third phalanx and prominent nutrient foramena (synovial invaginations) in the distal navicular bone were recorded as 'other' changes.

3.3.2 Metacarpophalangeal and metatarsophalangeal joint and proximal sesamoid bones

Changes recorded in the metacarpo- and metatarsophalangeal joints included proximodorsal and proximopalmar fragments of the first phalanx. Fragments of proximal palmar phalanx one were further categorised as Type I Axial fragments or Type II Abaxial fragments. These fragments were classified as nonarticular or articular with articular fragments evidenced by a visible defect in the joint margin or surface.

Subchondral cyst-like lesions in this context, were defined as any area of increased lucency that extends through subchondral bone.

On the dorsal aspect of the distal third metacarpus, which includes the proximal one-third of the sagittal ridge, the presence of a well-defined semi-circular notch at the proximal aspect of the sagittal ridge was recorded if present.

Other changes categorised at this location included irregularly shaped lucencies, fragments or loose bodies. The distal sagittal ridge of the third metacarpus was evaluated on the dorsopalmar and flexed lateromedial views for flattened or lucent areas. Elliptical areas of decreased bone density seen on either view were categorised as a lucency regardless of their appearance on other views.

Flattening of the distal palmar third metacarpal condyles was recorded with good lateromedial radiographic alignment, and lucencies in this location (often referred to as palmar metacarpal disease or traumatic OCD) were also recorded if present. If the condyles of the distal third metacarpus could not be clearly visualised due to obliquity of the flexed lateromedial view, the specific metacarpo -/metatarsophalangeal joint series of the specific limb was considered of non-diagnostic quality.

Palmar supracondylar lysis of the distal third metacarpus was recorded as slight or moderate/extreme if present. The categorisation of supracondylar lysis was subjective; the moderate/extreme category reserved for those examples considered obvious and unequivocal (extrapolated from Kane *et al.* (2003a)).

Categorisation of the forelimb proximal sesamoid bones was as follows; abnormal shapes were defined as proximal, distal or abaxial enlargement.

Fractures were recorded as apical, abaxial, basal, midbody, comminuted or other. Periarticular bone production at the proximal or distal articulation of the metacarpophalangeal joints were recorded as an osteophyte. Bone production within the suspensory or distal sesamoidean ligaments where they attach to the proximal or distal palmar aspects, respectively, was recorded as an enthesophyte. The number of well-defined circular lucencies for each proximal sesamoid bone was recorded if present as well as the number of linear lucencies.

Hindlimb proximal sesamoid bone changes were categorised in the same manner as forelimb proximal sesamoid changes. Hindlimb proximal sesamoids, with moderately pointed proximal or distal ends seen on the oblique views, were regarded as normal and were not categorised as having osteophytes or enthesophytes.

3.3.3 The carpi

Signs of dorsal medial carpal disease were recorded if the radial carpal bone had a rounded appearance and/or thickening of dorsal cortex or if there were proliferative changes, enthesophytes or fragments involving the radial carpal or third carpal bones. The presence of circular lucencies seen in the palmar region of the ulnar carpal bone on the DL-PaMO was also noted. The location of fragments, osteophytes and cysts in the carpi were recorded and accessory carpal bone fractures were recorded separately if present.

3.3.4 The tarsi

Lucencies in the medial malleolus of the tibia seen on the DL-PlMO view were recorded when present near the articular surface, as well as fragmentation or concavity of the intermediate ridge of the distal tibia.

However, a flattened intermediate ridge with no sign of concavity was not recorded as a radiographic change. Changes recorded on the lateral and medial trochlear ridge of the talus included flattened areas, lucencies or fragments. Variation in the appearance of the distal medial trochlear ridge was recorded as an attached protuberance if present and a fragment if a separate osseous opacity was seen distally. The presence of osteophytes or enthesophytes at the distal intertarsal or tarsometatarsal joint margins was classified based on size and location. Osteophytes and/or enthesophytes < 2mm were classified as mild radiographic changes and > 2mm as moderate changes. Marked osteoarthritis was classified as bridging of the tarsometatarsal joint or distal-intertarsal joint or a marked lucency of subchondral bone. Wedging or collapse of central- and third tarsal bones were also recorded.

3.3.5 The stifle

Regarding the lateral and medial trochlear ridges of the femur, flattened areas were recorded separately from subchondral lucent defects with or without fragmentation. The presence of a poorly defined soft tissue shadow in the area of the distal lateral trochlear ridge was also recorded, even though this is thought to be an artefact from overlying fatty tissue. Lucency or fragmentation in the trochlear groove was recorded, as was lucency of the patella and fragmentation of the distal patella. The proximal epiphysis of tibia, medial and lateral femoral condyles was evaluated for lucencies.

3.4 Data analysis

Frequencies of radiographic variables were obtained for each joint examined. Data was also classified as left vs. right and lateral vs. medial to classify changes which tend to be bilateral or biaxial, respectively. Yearlings were

classified as having a particular radiographic change if either a left or right pair was affected for each variable. If both sides had changes, it was classified according to the most severe change.

3.5 Ethical considerations

No ethical considerations were foreseen as this study used standard clinical materials and procedures.

Chapter 4: Results

4.1 Study population

The study consisted of 566 South African Thoroughbred yearlings all selected for the National Yearling sales from 2008 until 2010 in Germiston, South Africa. All radiographs were obtained 1 month to 1 day prior to the sales and lodged at the repository.

4.2 Data acquisition

All radiographs were obtained by private practitioners throughout South Africa, either at the breeding farm or at the sale grounds prior to the yearling sales.

4.3 Data analysis

A total of 566 horses (566 left fore/hind limbs and 566 right fore/hind limbs) were evaluated during the current study. Due to non-diagnostic radiographs (i.e. poor quality, incorrect positioning, lack of views in a series, etc) only 88.9% (503/566 yearlings) digit radiographs, 60.8% (344/566 yearlings) metacarpophalangeal joint radiographs, 59.0% (334/566 yearlings) fore proximal sesamoid bone radiographs, 78.6% (445/566 yearlings) metatarsophalangeal joint radiographs, 78.6% (445/566 yearlings) hind

proximal sesamoid bone radiographs, 86% (487/566 yearlings) carpi radiographs, 85.2% (482/566 yearling) radiographs and 56% (317/566 yearlings) stifle radiographs could be evaluated.

4.3.1 The digit

Fore feet series were available for 566 of the yearlings included in the study (See Table 2 for results). Unfortunately 62 left fore and 61 right fore series (60 bilateral) were of non-diagnostic quality and were eliminated from evaluation. Pedal osteitis was seen in 28 left fore digit (5.6%) and 21 right fore digit (4.2%) of which 11 had bilateral changes consistent with this radiographic change. The most common change in the fore feet series was inversion with 26 out of 504 (5.2%) left fore feet and 37 out of 505 (7.3%) right fore feet series showing changes (14 bilateral). No changes were recorded for the category classified as other in the fore feet.

Table 2: Prevalence of radiographic changes in the digit of Thoroughbred racehorse yearlings (n=566 horses)

		Left fore		Right fore		Horse		Bilateral
	Category	n	%	n	%	n	%	n
Digit	Total	566		566		566		
Changes in fore foot	Osteitis	28	5.6%	21	4.2%	38	6.7%	11
	Inversion	26	5.2%	37	7.3%	49	8.7%	14
	Other	0	0.0%	0	0.0%	0	0.0%	0
	None	450	89.3%	447	88.5%	479	84.6%	418
Radiographs of non-diagnostic quality	Yes	62	11.0%	61	10.8%	63	11.1%	60
	No	504	89.0%	505	89.2%	503	88.9%	506

4.3.2 The metacarpophalangeal joint and proximal sesamoid bones

A total of 566 metacarpophalangeal joint series were available for study (see Table 3 for results). Due to non-diagnostic radiographs only 389 left fore (68.7%) and 398 right fore (70.3%) metacarpophalangeal series could be evaluated. Dorsoproximal phalanx one fragments were more common than proximopalmar phalanx one fragments. All fragments from dorsal phalanx one were unilateral. In only two yearlings there were cysts detected in the distal third metacarpal bone and/or proximal phalanx one (none bilateral). The most common change recorded on the dorsal aspect of distal third metacarpus was a well-defined semi-circular notch in the proximal dorsal sagittal ridge, left distal third metacarpus 83/389 (21.3%) and right distal third metacarpus 80/398 (20.1%) of which only 48 were bilateral. A lucency of the dorsal aspect of the distal third metacarpus was detected in 32/389 (8.2%) left fore and 24/398 (6.0%) right fore series; in eight of these horses changes were bilateral. Only one yearling had a fragment of dorsal aspect of distal third metacarpus and five yearlings had flattening (all unilateral). Flattening of distal sagittal ridge of third metacarpus was detected in 50/389 (12.9%) left fore and 49/398 (12.3%) right fore and bilateral in 22 yearlings.

The most common change in distal sagittal ridge of third metacarpus was lucency, accounting for 80/389 (20.6%) left fore and 79/398 (19.8%) right fore, of which 49 were bilateral. The condyles of distal palmar third metacarpus showed flattening changes with 5.9% (23/389) left fore and 4.3% (17/398) right fore, of which 6 were 6 bilateral. Palmar sypracondylar lysis was generally seen bilaterally (68 bilateral), with slight lysis seen more commonly. The prevalence of supracondylar lysis of the left fore (29.8%) was very similar when compared to the right fore (29.9%). Supracondylar lysis was the most common change seen in metacarpophalangeal joint.

Table 3: Prevalence of radiographic changes in metacarpophalangeal joint of Thoroughbred racehorse yearlings (n=566 horses)

		Left fore		Right fore		Horse		Bilateral
	Category	n	%	n	%	n	%	n
Metacarpophalangeal joint	Total	566		566		566		
Fragment proximal dorsal P1	Yes	5	1.3%	2	0.5%	7	1.2%	0
	No	384	98.7%	396	99.5%	559	98.8%	221
Fragment proximal palmar P1	Nonarticular	1	0.3%	0	0.0%	1	0.2%	0
	Articular	1	0.3%	2	0.5%	3	0.5%	0
	None	387	99.5%	396	99.5%	562	99.3%	221
Cyst distal MC3 proximal P1	Yes	0	0.0%	2	0.5%	2	0.4%	0
	No	389	100.0%	396	99.5%	564	99.6%	221
Changes dorsal aspect distal MC3	Notch	83	21.3%	80	20.1%	115	20.3%	48
	Lucency	32	8.2%	24	6.0%	48	8.5%	8
	Fragment/loose body	0	0.0%	1	0.3%	1	0.2%	0
	Flattening	0	0.0%	5	1.3%	5	0.9%	0
	None	274	70.4%	288	72.4%	397	70.1%	165
Change distal sagittal ridge of MC3	Flat	50	12.9%	49	12.3%	77	13.6%	22
	Lucency	80	20.6%	79	19.8%	110	19.4%	49
	None	268	68.9%	270	67.8%	379	67.0%	159
Change distal palmar MC3 condyles	Flat	23	5.9%	17	4.3%	34	6.0%	6
	Lucency	0	0.0%	0	0.0%	0	0.0%	0
	Sclerosis	0	0.0%	0	0.0%	0	0.0%	0
	None	366	94.1%	381	95.7%	532	94.0%	215
Palmar supracondylar lysis MC3	Slight	75	19.3%	76	19.1%	109	19.3%	42
	Moderate/extreme	41	10.5%	43	10.8%	58	10.2%	26
	None	273	70.2%	279	70.1%	399	70.5%	153
Radiographs of non-diagnostic quality	Yes	177	31.3%	168	29.7%	222	39.2%	123
	No	389	68.7%	398	70.3%	344	60.8%	443

Table 4 shows the proximal sesamoid bone radiographs evaluation and results. Elongation of proximal sesamoid bones was detected in 11 yearlings of which only 2 had bilateral changes. Abnormal shape of proximal sesamoid bones was more common in the left fore 40/399 (10%) than right fore 28/404 (6.9%), of which only 7 were bilateral.

Six yearlings had fractures of proximal sesamoid bones of the forelimb. Two yearlings had abaxial fractures (one left fore and one right fore), four yearlings had basal fractures, three in the left fore proximal sesamoid bones and 2 in the right fore proximal sesamoid bones (1 bilateral basal fracture). A very low percentage of osteophytes noted was present in the proximal sesamoid bones of forelimb: left fore 1/399 (0.3%) and right fore 1/404 (0.2%), with both being unilateral.

Enthesophytes were more common in the left fore proximal sesamoid bones 6/399 (1.5%) and right fore proximal sesamoid bones 6/404 (1.5%) of which three were bilateral.

Singular sesamoid circular lucency was noted in 31/399 (7.8%) left fore proximal sesamoid bones and 18/404 (4.5%) in right fore proximal sesamoid bones. These changes tended to be more unilateral.

Total number of vascular channels present at a proximal sesamoid bone showed that four vascular channels was the most common number present, notably 24.6% (96/566 left proximal sesamoid bones) in the left fore proximal sesamoid bone and 26.8% (107/566 right proximal sesamoid bones) in the right fore proximal sesamoid bone (see Table4).

Table 4: Prevalence of radiographic changes in fore proximal sesamoid bones of Thoroughbred racehorse yearlings (n=566 horses)

		Left fore		Right fore		Horse		Bilateral
	Category	n	%	n	%	n	%	n
Fore proximal sesamoid bones	Total	566		566		566		
Sesamoid elongation	Yes	7	1.8%	6	1.5%	11	1.9%	2
	No	383	98.2%	393	98.5%	555	98.1%	221
Sesamoid abnormal shape	Yes	40	10.3%	28	7.0%	61	10.8%	7
	No	350	89.7%	371	93.0%	505	89.2%	216
Sesamoid fracture	Apical	0	0.0%	0	0.0%	0	0.0%	0
	Abaxial	1	0.3%	1	0.3%	2	0.4%	0
	Basal	3	0.8%	2	0.5%	4	0.7%	1
	Midbody	0	0.0%	0	0.0%	0	0.0%	0
	Comminuted	0	0.0%	0	0.0%	0	0.0%	0
	None	386	99.0%	396	99.2%	560	98.9%	222
Sesamoid osteophyte	Yes	1	0.3%	1	0.3%	2	0.4%	0
	No	389	99.7%	398	99.7%	564	99.6%	223
Sesamoid enthesophyte	Yes	6	1.5%	6	1.5%	9	1.6%	3
	No	384	98.5%	393	98.5%	557	98.4%	220
Sesamoid circular lucencies	1	31	7.9%	18	4.5%	45	8.0%	4
	2	1	0.3%	1	0.3%	2	0.4%	0
	3	0	0.0%	1	0.3%	1	0.2%	0
	None	358	91.8%	379	95.0%	518	91.5%	219
Sesamoid total vascular channels	1	19	4.9%	17	4.3%			
	2	70	17.9%	65	16.3%			
	3	89	22.8%	90	22.6%			
	4	96	24.6%	107	26.8%			
	5	60	15.4%	66	16.5%			
	6	30	7.7%	33	8.3%			
	7	12	3.1%	12	3.0%			
	8	6	1.5%	3	0.8%			
	9	1	0.3%	0	0.0%			
	None	7	1.8%	6	1.5%			
Sesamoid regular vascular channels	1	66	16.9%	71	17.8%			

	2	109	27.9%	119	29.8%			
	3	76	19.5%	85	21.3%			
	4	64	16.4%	57	14.3%			
	5	31	7.9%	32	8.0%			
	6	12	3.1%	11	2.8%			
	7	3	0.8%	2	0.5%			
	8	0	0.0%	0	0.0%			
	None	29	7.4%	22	5.5%			
Sesamoid irregular vascular channels	1	67	17.2%	66	16.5%			
	2	72	18.5%	89	22.3%			
	3	27	6.9%	43	10.8%			
	4	21	5.4%	14	3.5%			
	5	6	1.5%	5	1.3%			
	6	4	1.0%	0	0.0%			
	7	0	0.0%	0	0.0%			
	8	0	0.0%	0	0.0%			
	None	193	49.5%	182	45.6%			
Radiographs of non-diagnostic quality	Yes	176	31.1%	167	29.5%	222	39.2%	121
	No	390	68.9%	399	70.5%	334	59.0%	455

4.3.3 The metatarsophalangeal joint and proximal sesamoid bones

A total of 566 metatarsophalangeal joint series were available for the study (see Table 5 for results). Due to non-diagnostic radiographs only 460 left (81.3%) and 445 right (78.6%) metatarsophalangeal joint series could be evaluated.

Proximal plantar phalanx one fragmentation was noted in 6% (34/566 yearlings) of yearlings, while dorsoproximal phalanx one fragmentation was noted in 4.2% (24/566 yearlings) of yearlings. Most of dorsoproximal phalanx one fragmentations and proximal plantar phalanx one fragmentations were unilateral. Only one yearling had a subchondral cyst in distal third metacarpal bone and/or proximal phalanx one. The most common change recorded on the dorsal aspect of distal third metacarpus was a well-defined semi-circular notch in the proximal dorsal sagittal ridge, with 153 (27% of yearlings) showing this change and 66 of these being bilateral. Two horses displayed flattening of distal plantar third metatarsal condyles, both unilateral. Slight supracondylar lysis of plantar third metatarsal was seen in 4.4% (25/566 yearlings) of yearlings with moderate to extreme supracondylar lysis seen in 8.5% (48/566 yearlings) of yearlings with nearly half of these cases (12 cases with slight supracondylar lysis and 30 cases with moderate to extreme supracondylar lysis) being bilateral in both categories.

Table 5: Prevalence of radiographic changes in metatarsophalangeal joint of Thoroughbred racehorse yearlings (n=566 horses)

		Left fore		Right fore		Horse		Bilateral
	Category	n	%	n	%	n	%	n
Metatarsophalangeal joint	Total	566		566		566		
Fragment proximal dorsal P1	Yes	12	2.6%	13	2.7%	24	4.2%	1
	No	448	97.4%	463	97.3%	542	95.8%	369
Fragment proximal plantar P1	Nonarticular	2	0.4%	3	0.6%	5	0.9%	0
	Articular	19	4.1%	12	2.5%	29	5.1%	2
	None	439	95.4%	461	96.8%	532	94.0%	368
Cyst distal MT3 proximal P1	Yes	0	0.0%	1	0.2%	1	0.2%	0
	No	460	100.0%	475	99.8%	565	99.8%	370
Changes dorsal aspect distal MT3	Notch	100	21.7%	119	25.0%	153	27.0%	66
	Lucency	9	2.0%	17	3.6%	24	4.2%	2
	Fragment/loose body	5	1.1%	4	0.8%	7	1.2%	2
	Flattening	5	1.1%	2	0.4%	5	0.9%	2
	None	341	74.1%	334	70.2%	377	66.6%	298
Change distal plantar MT3 condyles	Flat	0	0.0%	2	0.4%	2	0.4%	0
	Lucency	0	0.0%	0	0.0%	0	0.0%	0
	Sclerosis	0	0.0%	0	0.0%	0	0.0%	0
	None	460	100.0%	474	99.6%	564	99.6%	370
Plantar supracondylar lysis MT3	Slight	17	3.7%	20	4.2%	25	4.4%	12
	Moderate/extreme	41	8.9%	37	7.8%	48	8.5%	30
	None	402	87.4%	419	88.0%	493	87.1%	328
Radiographs of non-diagnostic quality	Yes	106	18.7%	90	15.9%	121	21.4%	75
	No	460	81.3%	476	84.1%	445	78.6%	491

Radiographic changes and results for hind proximal sesamoid bones can be seen in Table 6. Elongation of proximal sesamoid bones was detected in 31 yearlings of which 11 had bilateral changes.

Abnormal shape of the proximal sesamoid bones was equally distributed between left (3.7%, 17/460) and right (3.4%, 16/476) with four yearlings having bilateral changes.

Nine yearlings had fractures of proximal sesamoid bones of the hindlimb. Three yearlings had apical sesamoidean fractures (one bilateral), two yearlings had abaxial fractures (none bilateral) and four yearlings had basilar sesamoidean fractures (none were bilateral).

An increase in osteophyte formation in hind proximal sesamoid bones were seen compared to fore proximal sesamoidean osteophyte formation. Osteophytes affected 35/566 yearlings (6.2%) with only seven having bilateral osteophyte formation.

Enthesophyte formation was more common in the left hind proximal sesamoid bones 8/460 (1.7%) compared to the right hind proximal sesamoid bones 3/476 (0.6%), of which none were bilateral.

A single sesamoid circular lucency was the most common number of lucencies present; 85/566 (15%) yearlings showed evidence of this radiographic change, of which 11 was bilateral.

Total vascular channels noted were two (left proximal sesamoid bone 17.4% and right proximal sesamoid bone 23.1%), three (left proximal sesamoid bone 26.7% and right proximal sesamoid bone 19.3%) and four (left proximal sesamoid bone 20.7% and right proximal sesamoid bone 16.6%). One or two regular and irregular vascular channels were seen mostly in left and right proximal sesamoid bones (see Table 6).

Table 6: Prevalence of radiographic changes in hind proximal sesamoid bones of Thoroughbred racehorse yearlings (n=566 horses)

		Left fore		Right fore		Horse		Bilateral
	Category	n	%	n	%	n	%	n
Hind proximal sesamoid bones	Total	566		566		566		
Sesamoid elongation	Yes	20	4.3%	22	4.6%	31	5.5%	11
	No	440	95.7%	454	95.4%	535	94.5%	359
Sesamoid abnormal shape	Yes	17	3.7%	16	3.4%	29	5.1%	4
	No	443	96.3%	460	96.6%	537	94.9%	366
Sesamoid fracture	Apical	3	0.7%	1	0.2%	3	0.5%	1
	Abaxial	1	0.2%	1	0.2%	2	0.4%	0
	Basal	3	0.7%	1	0.2%	4	0.7%	0
	Midbody	0	0.0%	0	0.0%	0	0.0%	0
	Comminuted	0	0.0%	0	0.0%	0	0.0%	0
	None	453	98.5%	473	99.4%	557	98.4%	369
Sesamoid osteophyte	Yes	21	4.6%	21	4.4%	35	6.2%	7
	No	439	95.4%	455	95.6%	531	93.8%	363
Sesamoid enthesophyte	Yes	8	1.7%	3	0.6%	11	1.9%	0
	No	452	98.3%	473	99.4%	555	98.1%	370
Sesamoid circular lucencies	1	49	10.7%	47	9.9%	85	15.0%	11
	2	6	1.3%	3	0.6%	9	1.6%	0
	3	0	0.0%	0	0.0%	0	0.0%	0
	None	405	88.0%	426	89.5%	472	83.4%	359
Sesamoid total vascular channels	1	55	12.0%	59	12.4%			
	2	80	17.4%	110	23.1%			
	3	123	26.7%	92	19.3%			
	4	95	20.7%	79	16.6%			
	5	36	7.8%	60	12.6%			
	6	23	5.0%	28	5.9%			
	7	14	3.0%	13	2.7%			
	8	8	1.7%	8	1.7%			
	9	1	0.2%	1	0.2%			
	None	25	5.4%	26	5.5%			
Sesamoid regular vascular	1	109	23.7%	112	23.5%			

channels								
	2	123	26.7%	140	29.4%			
	3	88	19.1%	72	15.1%			
	4	51	11.1%	57	12.0%			
	5	15	3.3%	18	3.8%			
	6	10	2.2%	19	4.0%			
	7	4	0.9%	3	0.6%			
	8	2	0.4%	1	0.2%			
	None	58	12.6%	54	11.3%			
Sesamoid irregular vascular channels	1	78	17.0%	77	16.2%			
	2	59	12.8%	59	12.4%			
	3	38	8.3%	28	5.9%			
	4	9	2.0%	12	2.5%			
	5	8	1.7%	9	1.9%			
	6	9	2.0%	9	1.9%			
	7	0	0.0%	0	0.0%			
	8	0	0.0%	0	0.0%			
	None	259	56.3%	282	59.2%			
Radiographs of non-diagnostic quality	Yes	106	18.7%	90	15.9%	121	21.4%	75
	No	460	81.3%	476	84.1%	445	78.6%	491

4.3.4 The carpi

A total of 566 carpal series were included in this study, but due to non-diagnostic radiographs, only 497 left carpi and 494 right carpi could be evaluated; see Table 7.

Dorsomedial carpal disease was present in 42/497 (8.5%) of the left carpus and 47/494 (9.5%) of the right carpus, 25 lesions were bilateral.

The most common radiographic change seen in carpi was a circular lucency in the ulnar carpal bone. A total of 79 horses (14%) showed evidence of this lesion, with 19 lesions being bilateral.

Most of the carpal fragments seen were unilateral. Twenty four yearlings had carpal fragments, while only one had bilateral lesions. Twenty-three fragments originated from the intermediate carpal bone, 1 fragment from radiocarpal bone and 1 from the fourth carpal bone.

Carpal osteophytes were present in 7.6% of yearlings of which 6 had bilateral changes. Five subchondral cysts were recorded (0.9%) of which none was bilateral; they were seen in the second carpal bones (two cases), radiocarpal bone (one case) and intermediate carpal bones (two cases).

No accessory carpal bone fragments were recorded.

Table 7: Prevalence of radiographic changes in carpi of Thoroughbred racehorse yearlings (n=566 horses)

		Left fore		Right fore		Horse		Bilateral
	Category	n	%	n	%	n	%	n
Carpi	Total	566		566		566		
Signs of dorsal medial carpal disease	Yes	42	8.5%	47	9.5%	64	11.3%	25
	No	455	91.5%	447	90.5%	502	88.7%	400
Circular lucency ulnar carpal bone	Yes	47	9.5%	51	10.3%	79	14.0%	19
	No	450	90.5%	443	89.7%	487	86.0%	406
Fragment	Yes	13	2.6%	12	2.4%	24	4.2%	1
	No	484	97.4%	482	97.6%	542	95.8%	424
Osteophyte	Yes	20	4.0%	29	5.9%	43	7.6%	6
	No	477	96.0%	465	94.1%	523	92.4%	419
Subchondral cyst	Yes	3	0.6%	2	0.4%	5	0.9%	0
	No	494	99.4%	492	99.6%	561	99.1%	425
Fracture accessory carpal bone	Yes	0	0.0%	0	0.0%	0	0.0%	0
	No	497	100.0%	494	100.0%	566	100.0%	425
Radiographs of non-diagnostic quality	Yes	69	12.2%	72	12.7%	79	14.0%	62
	No	497	87.8%	494	87.3%	487	86.0%	504

4.3.5 The tarsi

A total of 566 tarsal series were evaluated of which only 85.2% (482/566 tarsal series) were of diagnostic quality. This included 494 left tarsi and 488 right tarsi.

Lucency of the medial malleolus was seen in 1.2% (7/566 yearlings) yearlings of which only one case was bilateral.

Radiographic changes in the intermediate ridge noted were mostly fragmentation (2.3%, 13/566 yearlings); this included 13 cases of which 4 were bilateral. Only 1.2% (7/566 yearlings) of cases displayed concavity of intermediate ridge of talus (none bilateral).

One yearling had flattened area of lateral trochlear ridge of talus (0.2%), 3 had defects and 5 had fragmentations (1.2% defects and fragmentations, 7/566 yearlings).

Radiographic flattening of medial trochlear ridge of talus was seen in 27/566 yearlings (4.8%) of which 6 were bilateral and 2.1% (12/566 yearlings) had defect/fragmentation (none bilateral). At the most distal aspect of the medial trochlear ridge of the talus 130/566 (23%) yearlings had protuberances (66 bilateral) and 4/566 (0.7%) yearlings had fragmentations (1 bilateral).

Forty-three yearlings (7.6%) showed radiographic signs of wedging of third and central tarsal bones (mostly unilateral).

Osteophytes and subchondral lucencies at the distal intertarsal and tarsometatarsal joint margins were the most common changes observed in the tarsi (see Table 8).

Table 8: Prevalence of radiographic changes in tarsi of Thoroughbred racehorse yearlings (n=566 horses)

		Left fore		Right fore		Horse		Bilateral
	Category	n	%	n	%	n	%	n
Tarsi	Total	566		566		566		
Change medial malleolus	Lucency	4	0.8%	4	0.8%	7	1.2%	1
	Fragment	0	0.0%	2	0.4%	2	0.4%	0
	None	490	99.2%	482	98.8%	557	98.4%	415
Change intermediate ridge of talus	Concavity	2	0.4%	5	1.0%	7	1.2%	0
	Fragment	8	1.6%	9	1.8%	13	2.3%	4
	None	484	98.0%	474	97.1%	546	96.5%	412
Change lateral trochlear ridge of talus	Flat	1	0.2%	0	0.0%	1	0.2%	0
	Defect/fragment	4	0.8%	4	0.8%	7	1.2%	1
	None	489	99.0%	484	99.2%	558	98.6%	415
Change medial trochlear ridge of talus	Flat	21	4.3%	12	2.5%	27	4.8%	6
	Defect/fragment	2	0.4%	10	2.0%	12	2.1%	0
	None	471	95.3%	466	95.5%	527	93.1%	410
Change distal medial trochlear ridge of talus	Protuberance	96	19.4%	100	20.5%	130	23.0%	66
	Fragment	2	0.4%	3	0.6%	4	0.7%	1
	None	396	80.2%	385	78.9%	432	76.3%	349
Lucency distal intertarsal or tarsometatarsal joints	Yes	62	12.6%	55	11.3%	99	17.5%	18
	No	432	87.4%	433	88.7%	467	82.5%	398
Osteophyte/enthesophyte	Yes	85	17.2%	75	15.4%	115	20.3%	45
distal intertarsal joint	No	409	82.8%	413	84.6%	451	79.7%	371
Osteophyte/enthesophyte	Yes	150	30.4%	117	24.0%	204	36.0%	63
tarsometatarsal joint	No	344	69.6%	371	76.0%	362	64.0%	353
Wedging or collapse of tarsal bone(s)	Yes	25	5.1%	25	5.1%	43	7.6%	7
	No	469	94.9%	463	94.9%	523	92.4%	409
Radiographs of non-diagnostic quality	Yes	72	12.7%	78	13.8%	84	14.8%	66
	No	494	87.3%	488	86.2%	482	85.2%	500

4.3.6 The stifle

There were 566 stifle series included in the study, only 56% (317/566 yearlings) were of diagnostic quality and was subjected to further evaluation. A fat density shadow overlying the distal lateral trochlear ridge of the femur was the most common observation recorded in the stifle (see Table 9).

Eight yearlings had a defect/fragment present in lateral trochlear ridge of femur (none bilateral). Two yearlings had defects with fragments in the medial trochlear ridge.

A lucency in the patella was present in 8 yearlings (none bilateral). Four yearlings displayed lucency in medial femoral condyle (none bilateral) and only one yearling a lucency in the lateral femoral condyle that was bilateral.

Table 9: Prevalence of radiographic changes in stifles of Thoroughbred racehorse yearlings (n=566 horses)

		Left fore		Right fore		Horse		Bilateral
	Category	n	%	n	%	n	%	n
Stifle	Total	566		566		566		
Lucency in medial femoral condyle	Yes	1	0.3%	3	0.9%	4	0.7%	0
	No	336	99.7%	318	99.1%	562	99.3%	92
Lucency in lateral femoral condyle	Yes	1	0.3%	1	0.3%	1	0.2%	1
	No	336	99.7%	320	99.7%	565	99.8%	91
Lucency in proximal epiphysis of tibia	Yes	1	0.3%	1	0.3%	1	0.2%	1
	No	336	99.7%	320	99.7%	565	99.8%	91
Changes lateral trochlear ridge of femur	Distal shadow artifact	196	58.2%	190	59.2%	294	51.9%	92
	Flat	0	0.0%	1	0.3%	1	0.2%	0
	Defect/fragment	5	1.5%	3	0.9%	8	1.4%	0
	None	136	40.4%	127	39.6%	263	46.5%	0
Changes medial trochlear ridge of femur	Flat	0	0.0%	0	0.0%	0	0.0%	0
	Defect/fragment	1	0.3%	1	0.3%	2	0.4%	0
	None	336	99.7%	320	99.7%	564	99.6%	92
Defect/fragment trochlear groove	Yes	1	0.3%	0	0.0%	1	0.2%	0
	No	336	99.7%	321	100.0%	565	99.8%	92
Lucency patella	Yes	4	1.2%	4	1.2%	8	1.4%	0
	No	333	98.8%	317	98.8%	558	98.6%	92
Fragmentation of distal patella	Yes	0	0.0%	0	0.0%	0	0.0%	0
	No	337	100.0%	321	100.0%	566	100.0%	92
Radiographs of non-diagnostic quality	Yes	229	40.5%	245	43.3%	249	44.0%	225
	No	337	59.5%	321	56.7%	317	56.0%	341

Chapter 5: Discussion

The current study provides data on the prevalence of radiographic changes during the evaluation of fore digits, metacarpophalangeal joints, metatarsophalangeal joints, carpi, tarsi and stifles in Thoroughbred racehorse yearlings presented for yearling sales during three consecutive years. In South African Thoroughbred racehorse yearlings, radiographic changes were most commonly seen in metacarpo- and metatarsophalangeal joints. The current study showed a higher prevalence of supracondylar lysis, dorsomedial carpal disease, carpal osteochondral fragmentation and degenerative joint disease of tarsi when compared to similar studies performed (i.e. Kane *et al.* (2003a), Furniss *et al.* (2011)).

Caution should be taken when comparisons are made to previously published estimates for the prevalence of radiographic changes in young horses because of differences in sampling technique, radiographic examinations and categorisation schemes. For example, in earlier studies in Standardbred horses, yearlings were selected because their sires were affected by osteochondrosis in some estimates (Sandgren *et al.* 1993) or all the radiographic changes of one joint were grouped into one category (Jorgensen *et al.* 1997).
One should consider that the yearlings presented for public auction (as in the current study), are expected to be free from obvious lameness or clinical signs of orthopaedic disease. Thus the estimates are less likely to be positively biased when compared with estimates from surveys based on hospital populations, were one would expect clinical signs of lameness and orthopaedic disease (Kane *et al.* (2003a)).

Where informal comparisons with previously published data can be made, similar changes of pedal osteitis were recorded in this study, with a total percentage of 6.7% compared to 2-11% as described in studies of Howard *et al.* (1993), Kane *et al.* (2003a).

There was an 8.7% prevalence of inversion of the third pedal bone. This has been associated with more proximal sites of pain (i.e. proximal suspensory desmitis), causing lameness (Dyson & Ross, 2003). Other studies describing radiographic changes in Thoroughbred racehorse yearlings did not investigate inversion of the third pedal bone, therefore results cannot be compared, and thus this study is unique in noting inversion of the third pedal bone as a radiographic abnormality.

The prevalence of dorsoproximal phalanx one fragmentation (1.2%) of metacarpophalangeal joints were similar compared to other studies; 1.57% by Furniss *et al.* (2011), 1.6% by Kane e*t al.* (2003a) and 1.2% by Howard *et al.*(1993). According to Pilsworth and Head (2010) significant fragmentation on the dorsal aspect of metacarpophalangeal joint in a yearling Thoroughbred that has not undergone training yet is a poor prognostic indicator for joint health but it does not rule out its ability to race. In contrast, fragmentation in the metatarsophalangeal joint was associated with significant reduction in race starts and earnings as shown by Kane e*t al.* (2003b).

Osteochondral fragmentation of proximal plantar phalanx one (6%) was 8.5 times more prevalent than compared to proximal palmar phalanx one (0.7%). The latter prevalence is in agreement with similar studies that have shown that osteochondral fragmentation of proximal phalanx one is twice as common in metatarsophalangeal joint when compared to metacarpophalangeal joint (Kane e*t al.* 2003a; Howard e*t al. 1993).* This type of fragmentation has been linked to trauma (Dyson & Ross 2003) that could be attributed to stud farm management.
There were low incidences of subchondral cyst-like lesions seen in distal third metacarpus (0.4%), distal third metatarsus (0.2%) and proximal first phalanx. Other studies found similar prevalence of 0.7% in third metacarpus and 0.2% in third metatarsus (Kane e*t al.* 2003a). Subchondral cyst-like lesions might present a manifestation of osteochondrosis.

The most common change recorded on the dorsal aspect of distal third metacarpus and metatarsus were a well-defined semi-circular notch, with a prevalence of 20.3% at dorsal aspect of distal third metacarpus and 27% at dorsal aspect of distal third metatarsus, which are similar to the study by Kane e*t al. (*2003a) of 31% (347/1127 yearlings in dorsal aspect of distal third metacarpus) and 27% (299/1102 yearlings in dorsal aspect of distal third metatarsus). However, our study showed a higher prevalence of lucencies present at dorsal aspect of distal third metacarpus (8.5%) and metatarsus (4.2%) compared to 2% and 1.7% respectively, as recorded by Kane *et al.* (2003a).

There was a marked lower prevalence in the current study of flat distal palmar third metacarpal condyles (6%) compared to 40.9% by Kane *et al.* (2003a). These lesions may occur bilateral, especially in Thoroughbreds, causing a variable degree of lameness or loss of performance (Butler *et al.* (2000)). The lesion appears to develop as a focal overload injury where the base of the proximal sesamoidean bone impacts during maximal weight bearing (Dyson & Ross 2003). The low prevalence in current study may be attributed to the fact that yearling Thoroughbred racehorses are not in intensive training.

Prevalence of palmar and plantar third metacarpal and metatarsal supracondylar lysis were markedly higher in the present study. Slight palmar and plantar third metacarpus and metatarsus supracondylar lysis were seen in 19.3% of the horses versus 2.7% in study performed by Kane e*t al. (*2003a). Moderate to extreme palmar and plantar third metacarpus and metatarsus supracondylar lysis was present in 10.2% of the horses investigated (versus 2.1% in study performed by Kane *et al.* (2003a)). These findings are considered important in the current study due to exceptionally high prevalence rate. Studies performed by Mcllwraith & Trotter (1996) indicated that chronic hyperaemia of synovium and the release of

inflammatory mediators by a chronically inflamed synovial lining stimulate the recruitment of osteoclasts and cortical bone resorption, which serves as a radiographic sign indicating a history of chronic inflammation. Supracondylar lysis was the most significant finding in the study performed by Kane *et al.* (2003b) in terms of reduced racing performance. In yearlings displaying moderate to extreme supracondylar lysis, only 58% started a race compared to 81% of the total population. Pilsworth & Head (201) found the odds of starting a race at two or three years of age were three times lower with the presence of palmar supracondylar lysis than those that do not show this radiographic change.

There was a higher prevalence of dorsomedial carpal disease in our study population (11.3%) compared to 2.7% by Kane *et al.* (2003a) and 8.5% by Head (2006). These radiographic changes are considered a poor prognostic sign for future soundness and race ability and is supported by Kane e*t al.* (2003a,b) that found yearlings excibiting this radiographic change had three times lower odds of starting a race. Pool & Meagher (1990) suggest that these radiographic signs might be a consequence of conformation defects.

Prevalence of carpal osseous cyst-like lesions such as a circular lucency in ulnar carpal bone was lower (14%) when compared to other studies (Kane *et al.* (2003a). This radiographic change is seen as a common finding that is rarely significant (Butler *et al.* (1993)).

Prevalence studies showed a 0.3% to 2.2% incidence of osteochondral fragmentation of carpi examined (Howard *et al.* (1993); Kane *et al.* (2003a)). This study evaluation revealed a markedly higher prevalence of 4.2% in carpal osteochondral fragmentation. Faulty conformation such as carpus valgus, back-at-the-knee, or bench knee has been thought to contribute to carpal osteochondral fragmentations (Dyson & Ross, 2003). A study performed showed no association between back-at-

the-knee conformation and the development of carpus lameness in Thoroughbreds and Quarter horses, but only elite horses without faulty conformation were included in that (Dyson & Ross, 2003).

Osteochondrosis of the tarsocrural joint showed a similar prevalence when compared to study by Kane *et al.* (2003a). Studies performed on the occurrence of osteochondrosis in the tarsocrural joint of young Standardbred horses' prevalence ranged from 10-26% in Sweden (Sandgren *et al.* (1993)) to 15% in Denmark (Jorgensen e*t al.* (1997)). Kane *et al.* (2003a,b) and Head (2006) concluded that common lesions of OCD did not appear to affect future racing performance.

Degenerative joint disease of the tarsus most frequently affects the centrodistal (distal intertarsal) and/or tarsometatarsal joints. In our study, degenerative joint disease of tarsometatarsal joint had a higher prevalence (36%) than the centrodistal (distal intertarsal) joint (20.3%). There was also a higher incidence of degenerative joint disease in tarsometatarsal joint (36%) compared to other studies (17.5% in Kane *et al.* (2003a)). Other studies had a recorded prevalence of 17.5% (Kane e*t al.* (2003a)) and 30% (Olivier *et al.* (2008)). Howard *et al.* (1993) reported that osteophytes at centrodistal (distal intertarsal) and tarsometatarsal joint margins were a common change observed. Smooth osteophyte formation at the tarsometatarsal joint is rarely linked to an adverse effect on training and racing, whereas osteophyte formation around the centrodistal joint can be linked to the development of osteoarthritis, ultimately resulting in significant lameness (Pilsworth & Head 2010).

In the current study osteochondrosis of the stifle had a prevalence of 3.6% which is similar to other studies 2.7% by Olivier e*t al.* (2008), 3.9% by Kane e*t al.* (2003a) and 5.5% by Cohen e*t al.* (2006). McIntosh & McIIwraith (1993) revealed that an individual Thoroughbred farm had a prevalence of osteochondrosis between 10.8%

and 24% over three consecutive years, much higher than other studies. This may reflect nutritional, management and/or genetic causative factors.
Examination of the radiographs took place in a blinded manner by 3 observers with discrepancies settled by the consensus of opinions. Despite the large number of radiographs reviewed, it is unlikely that many lesions were missed by the 3 observers. The radiographic changes were categorised in detail without trying to judge the normality of the findings or trying to match the results to a particular diagnosis. This approach was selected as the best way to describe objectively what one should expect to see on survey radiographs without biasing the prevalence estimates for changes that may or may not be clinically important.

In South Africa the repository system has only recently been introduced. It therefore may account for the lower prevalence of radiographic changes seen in the current study.

A limitation to the study is the quality and consistency of the radiographs. Radiographic quality and consistency was average to poor. Radiographs of non-diagnostic quality, implying radiographs of inadequate exposure factor, incorrect positioning of radiographic views, incomplete joint series radiographs and incorrect labelling of radiographs played a key role in current study evaluation. Joint series with most non-diagnostic radiographs were stifle joint (44.0%); this is mostly due to incomplete joint series radiographs, followed by metacarpophalangeal joint (39.2%) radiographs.

Routine pre-sales radiographs of the yearling Thoroughbred sales proved to be a valuable source of information for surveying radiographic changes in young Thoroughbred racehorses. A prospective study can be performed using the data in current study to determine the association between radiographic changes and future racing performance of Thoroughbred racehorses in South Africa.

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APPENDIX

Appendix A: Radiographic changes evaluation sheet

Identification	Category
Horse Name	
Lot number	
Stud name	
Passport number	
Sex	Filly/Colt
Side	Left/Right

Radiographic changes	Category
Digit	Total
Changes in fore foot	Osteitis
	Inversion
	Other
	None
Radiographs of non-diagnostic quality	Yes
	No

Radiographic changes	Category
Metacarpophalangeal joint	Total
Fragment proximal dorsal P1	Yes
	No
Fragment proximal palmar P1	Nonarticular
	Articular
	None
Cyst distal MC3 proximal P1	Yes
	No

Changes dorsal aspect distal MC3	Notch Lucency Fragment/loose body Flattening None
Change distal sagittal ridge of MC3	Flat Lucency None
Change distal palmar MC3 condyles	Flat Lucency Sclerosis None
Palmar supracondylar lysis MC3	Slight Moderate/extreme None
Radiographs of non-diagnostic quality	Yes No

Radiographic changes	**Category**
Fore proximal sesamoid bones	Total
Sesamoid elongation	Yes No
Sesamoid abnormal shape	Yes No
Sesamoid fracture	Apical Abaxial Basal Midbody Comminuted None
Sesamoid osteophyte	Yes No

Sesamoid enthesophyte	Yes No
Sesamoid circular lucencies	1 2 3 None
Sesamoid total vascular channels	1 2 3 4 5 6 7 8 9 None
Sesamoid regular vascular channels	1 2 3 4 5 6 7 8 None
Sesamoid irregular vascular channels	1 2 3 4 5 6 7 8 None
Radiographs of non-diagnostic quality	Yes No

Radiographic changes	Category
Metatarsophalangeal joint	Total
Fragment proximal dorsal P1	Yes
	No
Fragment proximal plantar P1	Nonarticular
	Articular
	None
Cyst distal MT3 proximal P1	Yes
	No
Changes dorsal aspect distal MT3	Notch
	Lucency
	Fragment/loose body
	Flattening
	None
Change distal plantar MT3 condyles	Flat
	Lucency
	Sclerosis
	None
Plantar supracondylar lysis MT3	Slight
	Moderate/extreme
	None
Radiographs of non-diagnostic quality	Yes
	No

Radiographic changes	Category
Hind proximal sesamoid bones	Total
Sesamoid elongation	Yes
	No
Sesamoid abnormal shape	Yes
	No

Sesamoid fracture	Apical Abaxial Basal Midbody Comminuted None
Sesamoid osteophyte	Yes No
Sesamoid enthesophyte	Yes No
Sesamoid circular lucencies	1 2 3 None
Sesamoid total vascular channels	1 2 3 4 5 6 7 8 9 None
Sesamoid regular vascular channels	1 2 3 4 5 6 7 8 None

Sesamoid irregular vascular channels	1 2 3 4 5 6 7 8 None
Radiographs of non-diagnostic quality	Yes No

Radiographic changes	Category
Carpi	Total
Signs of dorsal medial carpal disease	Yes No
Circular lucency ulnar carpal bone	Yes No
Fragment	Yes No
Osteophyte	Yes No
Subchondral cyst	Yes No
Fracture accessory carpal bone	Yes No
Radiographs of non-diagnostic quality	Yes No

Radiographic changes	Category
Tarsi	Total
Change medial malleolus	Lucency Fragment None
Change lateral trochlear ridge of talus	Flat Defect/fragment None
Change medial trochlear ridge of talus	Flat Defect/fragment None
Change distal medial trochlear ridge of talus	Protuberance Fragment None
Lucency distal intertarsal or tarsometatarsal joints	Yes No
Osteophyte/enthesophyte distal intertarsal joint	Yes No
Osteophyte/enthesophyte tarsometatarsal joint	Yes No
Wedging or collapse of tarsal bone(s)	Yes No
Radiographs of non-diagnostic quality	Yes No

Radiographic changes	Category
Stifle	Total
Lucency in medial femoral condyle	Yes No
Lucency in lateral femoral condyle	Yes No
Lucency in proximal epiphysis of tibia	Yes No
Changes lateral trochlear ridge of femur	Distal shadow artifact Flat Defect/fragment None
Changes medial trochlear ridge of femur	Flat Defect/fragment None
Defect/fragment trochlear groove	Yes No
Lucency patella	Yes No
Fragmentation of distal patella	Yes No
Radiographs of non-diagnostic quality	Yes No