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Radiographic changes in Thoroughbred yearlings in South Africa

by

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To my Mum

He who dwells in the shelter of the Most High
will rest in the shadow of the Almighty
Psalm 91vs1

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List of Abbreviations

Cd20°LCrMO	Caudal 20° lateral to cranial medial oblique
CdCr	Caudocranial
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 plantar 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
DDFT	Deep digital flexor tendon
DICOM	Digital imaging and communications in medicine
DIP	Distal interphalangeal
DIT	Distal intertarsal
Flexed LM	Flexed lateral to medial
LF	Left front
LM	Lateral to medial
MC3	Metacarpus three
MCP	Metacarpophalangeal
MT3	Metatarsus three
MTP	Metatarsophalangeal
OCD	Osteochondritis dissecans
PIP	Proximal interphalangeal
PIT	Proximal intertarsal
PSB	Proximal sesamoid bone
P1	Phalanx one
P2	Phalanx two
P3	Phalanx three
RF	Right front

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TBA	Thoroughbred Breeders Association
TC	Tarsocrural
TMT	Tarsometatarsal

Summary

Radiographic changes in Thoroughbred yearlings in South Africa

Furniss, C. University of Pretoria, 2009

A radiographic examination forms part of the pre-purchase examination of Thoroughbred yearlings at national sales in many countries. This data enables the recording of the prevalence of radiographic changes in selected Thoroughbred populations around the world and assists veterinarians in advising clients on the purchase of yearlings. This has financial implications for the client as well as the racing industry as a whole.

Radiographic examinations of the 269 Thoroughbred yearlings lodged at the 2008 National Yearling Sale in Germiston, South Africa were collected and individually evaluated. The prevalence of radiographic changes was recorded and percentages calculated. These changes were compared to studies of other yearling populations.

Radiographic changes present in the studied Thoroughbred population are: pedal osteitis 1.26%, metatarsophalangeal joint dorsal osteochondral fragmentation 1.60%, sagittal ridge changes 5.7%, ulnar carpal bone lucencies 8.33%, carpal osteophytes 1.19%, distal intertarsal and tarsometatarsal joint radiographic changes 9.92%, tarsal osteochondrosis lesions 4.4% and stifle joint osteochondrosis lesions 0.4%. These changes were found to be of lower prevalence when compared to similar studies. The prevalence of dorsal osteochondral fragments in the metacarpophalangeal joint was 1.60% which was similar to other studies. A higher prevalence of vascular channels was visible in the proximal sesamoid bones as well as irregular borders and lucencies. Palmar metacarpophalangeal and plantar metatarsophalangeal osteochondral fragments had a recorded prevalence of 2% and 7.10%, respectively, this prevalence being generally higher when compared to similar studies. There was an absence of palmar metacarpal disease, supracondylar lysis, proximal sesamoid bone fractures and carpal osteochondral fragmentation in the current study. Additional findings recorded in the current study were: proximal interphalangeal joint hyperextension (left front 15.13%, right front 18.91%), the solar angle (right front 2.38°, left front 2.79°), the prevalence of carpal bone one (30.95%) and carpal bone five (1.59%).

The study population was limited to the radiographs lodged at the sale repository. As radiographic changes may influence sale price of the yearling, radiographs of yearlings with severe radiographic changes may not have been lodged at the repository. For these reasons the prevalence of radiographic changes recorded in the current study may not be a true reflection of the entire 2006 Thoroughbred foal crop. Further work to correlate radiographic changes to differences in management, pre-sale exercise programmes and genetics needs to be done. The effect of radiographic changes on the future performance of the Thoroughbred yearling also warrants further investigation.

Chapter 1: Introduction

1.1 Background

Radiographic changes recorded from pre-purchase radiographs of Thoroughbred yearlings have been investigated in Thoroughbred populations around the world not only in terms of the prevalence of specific radiographic changes but the impact these changes have on the future racing career of the Thoroughbred[22,24,25,35]. The results of such studies will assist veterinarians, involved in the pre-purchase examinations of Thoroughbreds, on how to advise their clients. This knowledge has financial implications for the client and for the racing industry as a whole. This type of investigation had as yet not been done in our South African Thoroughbred population.

1.2 Problem statement

There is a lack of data of radiographic changes in South African Thoroughbred yearlings. This study investigates these radiographic changes and allows the comparison of our findings to similar studies of Thoroughbred yearling's radiographs in other parts of the world.

1.3 Research questions

1. What are the radiographic changes present in the South African population of Thoroughbred yearlings presented at the 2008 National Yearling Sale?
2. How do the radiographic changes present in the South African Thoroughbred yearlings compare to those of other yearling populations around the world where similar research has already been documented?
3. What conclusion can be drawn from the radiographic changes present in the South African Thoroughbred yearlings?

1.4 Hypotheses

1. Radiographic changes are present in the pre-purchase radiographic examinations of Thoroughbred yearlings in South Africa.
2. The prevalence of radiographic changes in Thoroughbred yearlings is similar to studies done in other Thoroughbred populations around the world.

1.5 Objective

This project investigates the radiographic changes present in the South African Thoroughbred yearlings of 2008 and compares the results to similar studies.

1.6 Benefits

The results of this study will provide prevalence data of the radiographic changes of the South African Thoroughbred population and allow comparison of South Africa's Thoroughbred yearlings to other Thoroughbred yearlings around the world. With this knowledge the veterinarian involved in the pre-purchase examination can more accurately inform his/her client of the normal and abnormal radiographic findings present.

Chapter 2: Literature review

2.1 Introduction

2.1.1 Comparative studies

In the Thoroughbred racing industry it has become common practice to take radiographs before or after the sale of a Thoroughbred yearling in order to provide the buyer with pertinent information on its purchase. A radiographic repository is a facility that is provided by the sale organisation which allows the viewing of the sets of radiographs. Radiography of yearlings at national yearling sales was initiated in Kentucky, USA, in 1993 with the repository system coming into effect in 1996[25]. In New Zealand the repository system was first established in January 2003 at Karaka, Auckland[35]. In South Africa the first repository was opened at the 2007 National Yearlings Sale in Germiston. The number of radiographic studies lodged at these repositories depends on the size of the sale. At the 2007 National Yearling Sale in South Africa over 300 sets of radiographs were lodged for viewing while in the same year in the Keeneland National Yearlings sale, 4700 sets of radiographs were viewed[25]. These radiographs are a rich source of data for research. There are many papers investigating the prevalence of radiographic changes in different populations of Thoroughbred yearlings although this research has, as yet, not been done in our South African population of Thoroughbred racehorses [20,25,35,47].

2.2 Pre-purchase radiographic examinations

2.2.1 Radiographic views

The sale authorities standardize the radiographic views to be made to evaluate each joint. Recommendations vary from 34 to 46 views in order to make up a comprehensive radiographic examination[13,22,25]. In South Africa the Thoroughbred Breeder's Association (TBA) standardizes the views. Each radiographic examination per yearling comprises a minimum of 36 radiographs evaluating the front digit, metacarpophalangeal (MCP) joint, metatarsophalangeal (MTP) joint, carpus, tarsus and stifle joint (Table 2.1).

	Radiographic views
Digit	LM (lateral to medial)
MCP joint	LM flexed (lateral to medial 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)
MTP joint	LM(lateral to medial) 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(lateral to medial 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(lateral to medial) D65°MPlLO(dorsal 65° medial plantar lateral oblique) D10°LPlMO(dorsal 10° lateral plantar medial oblique)
Stifle joint	LM(lateral to medial) Cd20°LCrMO(caudal 20° lateral cranial medial oblique) CdCr(caudal to cranial)

Table 2.1: Radiographic views forming part of the pre-purchase radiographic examination in Thoroughbred yearlings in South Africa (MCP: metacarpophalangeal, MTP: metatarsophalangeal)

2.2.2 Radiographic interpretation

Interpretation of radiographic changes is liable to subjectivity. In some research studies, bias to the interpretation of changes is minimal by having more than one opinion[15,22,35]. In Kane's research where 1162 sets of Thoroughbred pre-purchase radiographs were evaluated, two independent authors evaluated each radiograph and categorized changes present. If there was a discrepancy over the categorisation of radiographic changes, a third assessment was made and the consensus opinion was used to categorize the changes present [25]. Another study only used one opinion being that of the primary author [20].

2.2.3 Digital radiography

In recent years there has been a transformation from film based radiographic image capture to the production of digital radiographic images. Besides the advantages of storage and ease of distribution, digital images have improved quality when compared to traditional films[51]. The latitude, which is the range of exposures that results in a diagnostic image, is greater in digital radiography. The contrast and blackness can be adjusted after the image has been processed making it possible to view both soft tissue and bone on the same image[43,53]. These advantages of digital radiography have been shown to increase the likelihood of identifying radiographic changes present [41,51].

2.3 Radiographic changes

The changes identified on pre-purchase radiographs can be classified into two main categories: developmental or traumatic in origin. The distinction between these categories is not always clear [33].

2.3.1 Developmental orthopaedic disease

Developmental orthopaedic disease applies to growth disorders in horses and is divided into many subcategories which includes cervical vertebral malformation, flexural limb deformities, angular limb deformities, physitis, cuboidal bone malformation, subchondral bone cysts and osteochondritis dissecans (OCD)[13,33]. The term osteochondrosis is a syndrome which encompasses the process of abnormal bone and cartilage development[33]. To describe osteochondrosis lesions extending into the articular surface which result in inflammation of the joint, the term osteochondritis is used[13]. Osteochondritis dissecans (OCD) refers to an osteochondrosis lesion and is in the form of a dissecting flap of tissue on the joint surface[13]. Osteochondritis indicates inflammation of the bone and cartilage and dissecans originates from the Latin word “dissecant” meaning dissecting or separation[33]. Osteochondrosis may manifest as a focal area of irregularity of the subchondral surface, osteochondritic fragments or as a focal round radiolucency that may communicate with the joint known as a subchondral cyst-like lesions although the relationship between osteochondrosis and subchondral cyst-like lesions is contraversial[13,33]. Defective endochondral ossification results in a typical histopathological appearance, pattern of distribution, radiographic signs and often a typical signalment[13,39]. The lateral trochlear ridge of the distal femur, medial femoral condyle, distal intermediate ridge of the tibia, lateral trochlear ridge of the talus, medial and lateral malleolus of the tibia, sagittal ridge and condyles of the metacarpus and metatarsus, palmar and plantar eminences of phalanx 1(P1) and humeral head are common sites for OCD lesions [4,33].

There are many theories on the development of OCD lesions. Cellular differentiation failure in growing cartilage has been considered, resulting in retention of a core of thickened cartilage. This thickened growth cartilage undergoes necrosis and results in fissures and flaps. The flaps may break off and form osteochondral fragments[33]. On fissure formation in the joint surface, synovial fluid may be forced through this slit-like opening with weight-bearing and bone resorption follows. The adjacent subchondral bone retains the insult by the deposition of new bone resulting in a subchondral cyst-like lesion with a sclerotic border seen radiographically[6]. Direct mechanical shearing of cartilage blood vessels resulting in epiphyseal necrosis and resultant OCD lesions has also been hypothesised[33]. Through these many theories one can appreciate the heterogeneity of the osteochondrosis syndrome which may be influenced by multiple factors[33].

Factors which may lead to the osteochondrosis syndrome are nutrition, management, genetics and biomechanical factors, with nutrition receiving the most attention as it is one of the factors that can more easily be controlled[3,17,37]. Nutritional factors such as excessive levels of copper or phosphorus in the diet has found to lead to a reduction in cross linking of collagen in cartilage and bone resulting in increased tissue fragility and subsequent OCD lesions[33]. Osteochondrosis of the tarsus was recorded to have a higher incidence in foals born in the latter half of the breeding season, taller foals and foals with a greater circumference of the carpus[44]. Pre-purchase radiographic examinations done on 80 feral horses, from the Wild Horse and Burro Facility in Nebraska, demonstrated a lower incidence of osteochondrosis than what has been reported in domestic horses. The prevalence of tarsocrural (TC) osteochondrosis, in the above mentioned study, was 2.5%. This suggests that both management practices and genetic makeup may have an influence on the development of osteochondrosis in our domestic horses[54]. Trauma or excessive mechanical forces in a normal joint may also lead to damage to the cartilage and or cartilage blood vessels and lead to OCD lesions. With injury to the cartilage, the first and most generic response is cartilage thickening which, as discussed above, is one of the initiating causes of the development of OCD lesions[33].

An increase in frequency and severity of OCD lesions has been associated with cervical stenotic mylopathy or cervical vertebral malformation[10,49]. The same factors that influence osteochondrosis namely genetic ability to grow fast, over-nutrition and abnormal biomechanical forces have also been implicated in the pathogenesis of cervical vertebral malformation[10].

A differentiation must be made between signs of immaturity and an OCD lesion. In an immature animal a more diffuse subchondral bone irregularity is seen as the chondroepiphysis ossifies. Ossification occurs from the central region towards the periphery such that the last region to ossify is the more peripheral joint surface[4].

2.3.2 Traumatic injuries

Radiographic changes in pre-purchase radiographs of yearlings may be attributed to trauma. New born foals may be born with laxity of tendons and ligaments which renders their unsupported joints at risk of becoming injured[13]. Another high risk period of injury is during the preparation period prior to the sale. During this preparation period, yearlings are halter trained and an exercise programme may be initiated. Yearlings may also be placed on a rising plane of nutrition. All these factors together may increase the risk of injury.

The radiographic changes will be described according to their specific anatomical sites.

2.4 The digit

Studies show that there is large variation in the radiographic appearance of the digit of the horse[42]. In Kane's study two radiographic views were made of the front digit, that being the dorsal 65° proximal palmar distal oblique (D65°Pr-PaDiO) view and the lateral to medial (LM) view. A broad range of radiographic changes were identified including: pedal osteitis, changes to the extensor process of P3, fragmentation of the palmar process of P3 and synovial invaginations in the distal navicular bone[25]. Some normal and abnormal findings of the digit commonly identified on pre-purchase radiographs are discussed in further detail below.

2.4.1 The digital axis

The digital axis, also known as the hoof pastern axis is best evaluated on a LM view of the digit where a line is drawn through the centre of phalanx two (P2) bisecting it into equal dorsal and palmar halves. Ideally this line similarly bisects P1 and is parallel to the dorsal cortex of P3 (see figure 2)[53]. It is assumed that a straight digital axis is optimal for mechanical function, as malalignment of these digital bones is seen in 72.8% of horses with front limb lameness [28,36]. This statement is supported by the fact that with digital hyperextension, greater stress is placed on the deep digital flexor tendon (DDFT) and superficial digital flexor tendon (SDFT) and their insertions as well as the distal sesamoidean ligaments, thus leading to injury[13].

An injury sustained to the pastern area resulting in rupture of both the straight sesamoidean ligament and the SDFT will result in hyperextension of the PIP joint and thus disruption of the normal straight digital axis. Hyperextension of the PIP joint may be linked to a congenital deformity in foals but usually affects all 3 joints in the digit[53]. The digital axis can be affected by trimming the toe of the hoof, decreasing the break over distance, which in turn improves the alignment of P2 to P3[36]. The position of the limb caudal or cranial to the shoulder will also change the digital axis. A hyperextended or flexed digital axis seen on radiographs may be due to incorrect positioning of the horse on acquisition of the radiographs.

2.4.2 The solar angle of phalanx three

In the normal hoof the solar border of P3 slopes such that the palmar processes are slightly more proximal then the dorsal distal aspect of P3[13]. This angle of inclination, or solar angle, is between 5° and 10° in a normal horse[4,8,53]. Linford *et al* reported this angle to be approximately 2° in their group of Thoroughbred racehorses[30]. This downward inclination of P3 can be reflected not only as an angle but also in a set of measurements of the solar thickness, with that at the toe being less than at the heel[31]. These solar measurements can be altered by hoof trimming with the P3 to heel distance reduced more than the P3 to toe distance. This may occur with excessive rasping of the soft horn of the heels[28]. This alteration of the solar angle of P3 such that the palmar processes of P3 are closer to the solar surface is common to the long-toe low heel syndrome (underrun heels). Long-toe low-heel syndrome occurs commonly in the Thoroughbred racehorse and is indicative of poor dorsopalmar hoof balance and may be associated with lameness[4].

2.4.3 Pedal osteitis

Pedal osteitis is defined as inflammation of P3[4,25]. Because of the broad spectrum of radiographic abnormalities present and many theories as to the cause of the radiographic changes some authors prefer to use the term "pedal osteitis complex[4,13]. The most common radiographic change in this complex is remodelling of the solar margin of P3 which is best observed on a D65°Pr-PaDiO view. This remodelling is seen as areas of bone resorption and widening of vascular channels in the area affected[4,25]. Other radiographic changes seen are radiolucent areas and new bone formation in the palmar processes and new bone formation on the dorsal surface of P3[4,25]. Changes in P3 indicative of pedal osteitis were observed in 33 yearlings in Kane's study with half of these cases being bilateral[25]. A similar study recorded a prevalence of new bone formation on P3 in 20.6% of Thoroughbreds radiographed[22].

2.4.4 Laminitis

Chronic laminitis results in radiographic changes related to the separation of P3 from the hoof wall[4]. In Linford *et al's* study, horses with 1 or more of the following subtle signs of laminitis: 2-4° palmar rotation of P3, palmar cortex resorption, active bone formation along the distal aspect of the dorsal cortex of P3, curved or undulant hoof wall, had a significant decrease in earnings per month and per race[31]. The degree of palmar rotation of P3 has been found to be inversely correlated with return to former athletic function[7,13,50].

2.5 The metacarpophalangeal and metatarsophalangeal joint

The front and hind MCP and MTP joints are hinge joints with a relatively large range of motion. A galloping Thoroughbred racehorse places all its body weight on a single limb in one phase of the stride[40]. This results in severe hyperextension of the MCP/MTP joints. Four radiographic views are made of each MCP/MTP joint during a pre-purchase examination. The greatest number of radiographic changes in a pre-purchase examination is found in the MCP/MTP joints and these changes are discussed below[20,22,25,47].

2.5.1 Proximodorsal osteochondral fragments of phalanx one

Proximodorsal osteochondral fragments of P1 are common in Thoroughbred racehorses affecting the medial eminence more than the lateral. These fragments are more common in the MTP joint in Thoroughbred yearlings[6,22,26]. It is speculated to be as a result of hyperextension of the MCP/MTP joint in which P1 strikes the distal third metacarpus/metatarsus resulting in subsequent fragmentation. This usually occurs following repeated trauma in high speed horseracing[6,27]. Proximodorsal osteochondral fragments of P1 may have been acquired as a young foal where laxity of the ligaments and tendons are inadequate to guard against hyperextension of the MCP/MTP joint increasing the risk of fragmentation with exercise. These osteochondral fragments have been identified as early as 3 months of age in Standardbred trotters[5]. Osteochondral fragments have been identified in association with wear lines and articular cartilage erosion as well as chronic proliferative synovitis due to the degenerative process the fragments initiate[27].

In Thoroughbred yearling populations the prevalence of proximodorsal osteochondral fragments of the MCP joint ranges from 0.7% to 1.7% [20,22,25,47.] In a population of Swedish Standardbreds the recorded prevalence was higher at 4.2% and 4.4%[35]. In Thoroughbred yearlings proximodorsal P1 fragments and proximoplantar fragments were found to be twice as common in the hind limb[25].

2.5.2 Palmar/Plantar osteochondral fragments of phalanx one

Palmar/plantar osteochondral fragments arise from the palmar/plantar aspect of P1 and have been categorized as type I (axial, articular, rounded) and type II (abaxial, partially articular, larger) osteochondral fragments[33]. These fragments have been considered manifestations of osteochondrosis as they are recognised in young untrained horses. It is speculated that these fragments may result from avulsion of a portion of the incompletely ossified P1 followed by the development of a traumatic secondary centre of ossification[13]. Another study examined these palmar/plantar osteochondral fragments histologically and proved them to be traumatic in origin with the injuries more likely sustained in the first years of the horse’s life, as reported for proximodorsal osteochondral fragments[29]. In a survey study of Thoroughbred yearlings these fragments on the palmar/plantar aspect may be bilateral and symmetrical and have been identified in yearlings without clinical signs. For this reason these changes have been classified as an incidental finding[25]. Palmar/plantar fragments have a recorded incidence between 0.4% to as high as 49% depending on the population of horses studied[21,22,25,47]. Palmar/plantar osteochondral fragments have been classified as ununited palmar/plantar eminences and cannot be considered permanent until the age of 1-2 years[9]. Ununited palmar/plantar eminences of P1 were found to have an incidence of 4.3% and 4.2% in a population of 1.5 year-old Swedish Standardbreds and were more common laterally in the MTP joint[44]. In Standardbreds there is a recorded incidence of 20% plantar/palmar osteochondral fragments identified in pre-purchase radiographs of which most were found in the MTP joints medially[9,45]. These fragments are also known as Birkeland fractures are thought to be more traumatic in origin due to the outward rotation of the hind limb in the Standardbred [9,46].

2.5.3 Subchondral cyst- like lesions

Subchondral cyst-like lesions, described as an area of lucency that extends through the subchondral bone, have been identified in the MCP joint, either affecting the distal MC3 or proximal P1. In the study done by Kane *et al* 0.7% of Thoroughbred yearlings had subchondral cyst- like lesions in the distal MC3 and 0.81% in proximal P1[25].

2.5.4 Sagittal ridge changes

The sagittal ridge of MC3 and MT3 is described as a common site for the development of OCD lesions[13]. These lesions may appear as irregular shaped lucencies (Type I), fragments (Type II) or loose bodies (Type III)[25]. Type I lesions generally have a good prognosis with conservative management. With type II and type III lesions, surgery is indicated to improve the prognosis for an athletic career[34]. Lesions involving the more proximal aspect of the sagittal ridge are said to have a better prognosis than lesions distally[13]. A well defined semicircular notch on the proximal dorsal saggital ridge of the distal MC3 has a recorded prevalence of 37.1% and 65% in 2 studies in Thoroughbred yearlings[22,25]. The prevalence of this lesion in the MTP joint was lower in both studies (6.6% and 27%)[22,25]. Sagittal ridge lesions in general have been linked to joint effusion and lameness in some studies while others found no correlation between racing performance and the presence of the lesion[13,22,24,39].

2.5.5 Palmar metacarpal disease

A common area for the development of subchondral bone injury in the working Thoroughbred racehorse is the distal palmar aspect of MC3. The lesion is a result of subchondral microfractures occurring on the condyles of MC3 between the articulation of P1 and the PSB. These microfractures cause a painful ischaemia resulting in a gradual sloughing in the area. A crater-like defect on the palmar articular surface of the distal MC3 can be identified in the LM view[2]. Flattening of the distal palmar MC3 condyles was seen as the most common change in the MCP joint of Thoroughbred yearlings in one study[25].

2.5.6 Palmar supracondylar lysis

Palmar supracondylar lysis of distal MC3 is seen as narrowing of the cortical bone proximal to the condyles and is often indicative of severe and recurrent joint inflammation. Chronic synovitis, as seen in chronic osteoarthritis of the MCP or MTP joint, causes the release of inflammatory mediators which causes the recruitment of osteoclasts, and bone resorption follows[13,40]. This radiographic change has also been found in a survey of radiographic studies of Thoroughbred yearlings and can be graded slight to moderate or extreme. It was seen bilaterally and was one of the most common changes seen involving the MCP joint in one study[25]. The proportion of horses starting races was significantly lower for yearlings with moderate to extreme supracondylar lysis of distal MC3 (14 started of 24 affected, 58%)[24].

2.5.7 Proximal sesamoid bone changes

The PSBs form part of the suspensory apparatus supporting the MCP and MTP joints as well as forming part of the articulation surface in both joints. Changes in the PSBs identified in pre-purchase radiographic studies include abnormal shape, irregular abaxial border, fractures, enthesopathies, osteophytes, lucencies, and regular and irregular vascular channels[22,25].

In the survey done by Kane *et al*, abnormal shape was defined as proximal (apical), distal (basilar) or abaxial enlargement of the PSB. This radiographic change was recorded more commonly in the medial PSB of the left MCP and in the medial PSB in the MTP joints[25].

PSB fractures are classified into apical, mid-body, basilar, axial, abaxial and comminuted fractures. Due to the supporting function that the PSB plays, fractures of the PSB often result in obvious clinical signs[13]. In a study of Thoroughbred yearlings PSB fractures were more commonly seen in the MTP joint and most of these were apical fractures[25]. A transverse radiolucent line through the apex of the PSBs can however be classified as a separate centre of ossification or a bipartite PSB with both regarded as clinically insignificant[14].

An enthesophyte of the PSB is bone production within the insertion of the interosseus medius tendon or in the origin of the distal sesamoidean ligaments[25]. The examination of Standardbred trotters in Norway aged 6-21 months, revealed enthesopathy and demineralization in 2.8% of trotters. Changes present were not linked to lameness and therefore seen as of minor long term clinical significance[14]. The proportion of horses starting races was significantly lower for yearlings with enthesophyte formation on the PSB of the MCP joint[24].

Osteophytes on the PSBs are defined as peri-articular new bone production at the apex and base[25]. This finding is an indication of MCP/MTP joint osteoarthritis and can be considered a poor prognostic sign[13]. A study in Thoroughbred yearlings recorded a prevalence of 0.3% in the MTP joint PSBs with no osteophyte formation in the PSBs of the MCP joint[25].

Vascular channels in PSBs are linear lucencies with a radial orientation and interpretation is somewhat subjective[13]. These linear lucencies have been divided into regular (linear lucencies that have parallel sides for their entire length and are less than 2 mm in width) and irregular (linear lucencies that have non-parallel sides for any portion of their length or are more than 2 mm in width) vascular channels in the study done by Kane *et al*[25]. In the same study almost all of the yearlings (98%) had visible vascular channels in at least one PSB and most of these vascular channels were recorded as being irregular[25]. Another classification system divides vascular channels into types where a Type 3 lesion (wide, abnormally shaped linear defects) was found to be consistently associated with lameness during training[18,48]. Type 1 lesions (1 or 2 linear defects less than or equal to 1 mm wide) were clinically irrelevant, while type 2 lesions (3 or more linear defects less than or equal to 1 mm wide) were found in 66% of horses affected with disease of the suspensory apparatus[18]. Radiographically enlarged vascular channels are linked to sesamoiditis which is defined as periostitis and osteitis affecting the abaxial surface of the PSBs[13,18]. An increase in the number and size of vascular channels has been linked to an increase in training and to disease of the soft tissue of the suspensory apparatus[18]. The survey done by Howard *et al* recorded abnormal vascular channels, defined as large linear defects more than 1mm in width on the abaxial surface of the PSB with an ill-defined margin, in 18.6% of the MCP joints examined[20].

2.6 The carpus

The carpus is composed of 2 rows of carpal bones and is divided into 3 main articulations; the antebrachiocarpal, middle carpal and carpometacarpal joints. This complex anatomy can make radiographic interpretation a challenge due to the superimposition of bones[53]. Osteochondral damage in these joints frequently occurs in the racing Thoroughbred[53]. Since training has not begun at the time of the pre-purchase radiographic examinations, few radiographic changes are identified in the carpus in yearlings.

2.6.1 First and fifth carpal bones

The presence of C1 or C5 is a normal variation. Carpal bone one has been described as a small inconsistent bone embedded in the distal part of the medial collateral ligament of the carpus palmar to the second carpal bone (C2)[32]. It has a recorded prevalence of between 10 and 30%[4,22,32]. This articulation of C1 with C2 may be associated with radiolucent lesions which are normal[53]. There is no recorded prevalence of C5[32].

2.6.2 Ulnar carpal bone lucencies

Small radiolucent zones or subchondral cyst-like lesions may occur in the ulnar carpal bone (Cu) which is also a normal variation. They are usually non-articular and have sclerotic borders[13]. The incidence of these lucencies in Cu has been recorded as 20.1% and 22%[22,25].

2.6.3 Osteoarthritis of the carpus

Osteoarthritis of the carpus is seen in the mature Thoroughbred racehorse as it is linked to high impact exercise and hyperextension and often precedes the development of carpal osteochondral fragments. During the racehorse's career there is a continuum of stress-related bone injury and cartilage damage in the carpus which leads to sclerosis. This commonly involves the third carpal bone (C3). Sclerosis may lead to resorption and necrosis followed by osteochondral fragmentation and ultimately more advanced osteoarthritis[13]. Kane *et al* recorded radiographic changes indicative of osteoarthritis of the carpal joints of Thoroughbred yearlings and categorised these changes under the heading dorsal medial intercarpal disease. He defined dorsal medial intercarpal disease as rounding or dorsal cortical thickening of the radiocarpal bone, as well as proliferative changes involving the radiocarpal or third carpal bones[25]. Another study recorded osteophytes and enthysophytes in the carpus with a prevalence of 5.9% [22]. The presence of these degenerative changes present in young Thoroughbreds may be indicative of the introduction of training prior to the sales although these changes cannot be fully appreciated in pre-purchase radiographs as the skyline (DPrDDiO) view does not form part of the standardized views. This skyline view highlights the third carpal bone allowing evaluation of sclerosis in this area which is a sign of repetitive strain and degeneration of the joint[4,13]. The proportion of horses starting races was significantly lower for yearlings with dorsal medial intercarpal joint disease (19 of 30, i.e. 63%)[24].

2.6.4 Enthesophytosis of the dorsal aspect of the carpal bones

Enthysophytes may occur on the dorsal aspect of the carpal bones and is a result of strain on the dorsal intercarpal ligaments. This may occur after direct trauma but may also be associated with osteoarthritis.[14]

2.6.5 Osteochondral fragmentation

In the Thoroughbred racehorse osteochondral fragmentation occurs in the following anatomical locations in descending order of prevalence: the proximal aspect of C3, distal aspect of the radial carpal bone (Cr), proximal aspect of the intermediate carpal bone (Ci) and the distal lateral aspect of the radius[13,38,53]. These changes are usually seen in Thoroughbred racehorses in training and are not a common finding in yearling pre-purchase radiographs[57]. A prevalence of 0.7% was recorded in Thoroughbred yearlings in a study[22].

2.7 The Tarsus

The tarsus of the horse consists of 4 joints. The TC joint between the tibia and the talus is known as a ginglymus joint due to its relative high range in motion. The proximal intertarsal

(PIT), distal interphalangeal (DIT) and tarsometatarsal (TMT) joints are plane joints with restricted horizontal movement[33]. The tarsus of the Thoroughbred yearling has been found to have radiographic changes indicative of osteochondrosis mainly in the TC joint and degenerative joint disease in the distal joint[20,22,25,35].

2.7.1 Osteochondrosis

Osteochondrosis lesions are a common radiographic finding in the TC joint with the distal intermediate ridge of the tibia most commonly affected[20,22]. The trochlea of the talus, in particular the lateral trochlear ridge more common than the medial, is the next most common site followed by the lateral and medial malleoli of the tibia[53]. These OCD lesions may be bilateral[46]. Thirty-three of 48 Thoroughbred yearlings with changes in the distal intermediate ridge of the tibia had fragments visible[25]. The prevalence of OCD in the TC joint of Standardbred trotters, between 1 and 30 months, varies from 10.4% to 48% [5,7,14,46]. In Thoroughbred yearlings this prevalence ranged between 3.7 and 12.2%[20,22,25,35]. Osteochondritis dissecans lesions can be identified as early as 1 month of age and, once identified radiographically, these changes persist[5].

Subchondral cyst-like lesions have been identified in the distal tibia and tarsal bones in the horse but to a lesser extent than in the stifle[33]. These subchondral cyst-like lesions can either be part of the osteochondrosis complex or develop secondary to trauma or sepsis[53].

2.7.2 Degenerative joint disease

Degenerative joint disease of the distal tarsal joints is the most common cause of hind limb lameness in the horse and is seen radiographically as peri-articular osteophyte formation, subchondral lucencies and sclerosis in the DIT and TMT joint margins[13,22,25]. In spite of this the clinical significance of radiographic findings indicative of this condition varies. It more commonly affects the DIT and TMT joint individually or in combination. The condition is usually bilateral and often begins dorsolaterally. Uneven biomechanical forces are an important aetiological factor although in a study of necropsy specimens, evidence was found linking this condition to osteochondrosis in the juvenile horse[1,53,55].

The prevalence of degenerative joint disease in pre-purchase radiographs of the tarsus varies from 6.1% to 31%[22,25,35]. In a study of Thoroughbred yearlings this radiographic change was usually identified unilaterally[13,25].

Horses with changes consistent with degenerative joint disease of the distal joints of the tarsus were found to have less starts[26]. Another study showed no correlation between changes in the distal joints of the tarsus and racing performance[22]. In a study of young trotters, 50% were diagnosed clinically with degenerative joint disease of the distal tarsus had no radiological evidence of the disease[19].

2.7.3 Wedging/collapse of the tarsal bones

Incomplete ossification of the central and third tarsal bones, most common in immature foals, may be identified in the yearling as wedge-shaped central and third tarsal bones and may be associated with fractures and osteoarthritis[12,35]. The condition may be classified as a type I (incomplete ossification with < 30% collapse of the affected bones) or a type II (incomplete ossification with > 30 % collapse and pinching or fragmentation of the affected bones)[12]. Incomplete ossification of the tarsal bones can contribute to valgus deformity in the tarsus[11,12]. Foals diagnosed with type II incomplete ossification of the tarsal bones have a guarded prognosis for athletic soundness[12].

2.8 The stifle joint

The stifle is the largest of the joints radiographed in a pre-purchase examination. It consists of the femoropatellar joint, representing the articulation between the patella and the trochleas of the femur, and the medial and lateral femorotibial joints[13]. The fact that the proximal stifle is covered by large muscles masses and the position one has to assume to acquire the radiograph of the stifle, makes obtaining a complete radiographic set a challenge. In Kane's study, 600 out of 1152 Thoroughbred yearlings had complete radiographic examinations and of these only 170 could both the medial femoral condyle and tibia be examined[25]. The limited number of complete radiographic sets could account for the low percentage of changes recorded in the stifles. The stifle shows a low percentage of radiographic changes in the pre-purchase examinations of

Thoroughbred yearlings[22,25]. In Howard *et a*l's study only 4.3% of stifles radiographed showed lesions[20].

2.8.1 Osteochondrosis

Osteochondritis dissecans lesions of the femoropatellar joint are a common and significant finding in young and older horses[13]. Radiographic signs are flattening and or irregularity of the subchondral surface with or without bony fragments[13,53]. In a study of Thoroughbred yearlings the lateral trochlear ridge was more commonly affected (5.7%) than the medial trochlear ridge (0.3%)[25]. The trochlear groove and the patella may also be affected (0.2-0.3%)[25]. The overall prevalence of OCD lesions in the stifle of Thoroughbred yearlings was found to be between 2.7% to 10.1%[22,25,35]. In Bramlage's opinion major osteochondral lesions of the stifle in general have a high probability of affecting performance of the Thoroughbred racehorse[3].

2.8.2 Subchondral cyst-like lesions

Subchondral cyst-like lesions are often associated with the femorotibial joints of the stifle[13,53]. The higher weight-bearing medial femoral condyle has a higher risk for subchondral cyst-like lesions to develop due to tendency towards infarction followed by disturbance in ossification[17]. These vascular insults may be traumatic in origin rather than developmental defects[33]. It has been found that trauma to the articular surface may progress to a subchondral cyst-like lesion[33]. The lateral femoral condyle and proximal tibia are less common locations[53].

Whitman *et al* examined a total of 2915 radiographic reports of Thoroughbred sale yearlings and of these, found 25 medial femoral condyle subchondral cyst-like lesions. Most of these lesions were unilateral affecting the right limb. Similar studies examining Thoroughbred yearling pre-purchase radiographs recorded a prevalence of 3.4 and 5.6%[4,22]. Although these changes were found to lower sale price, none of these findings in the stifles had an effect on the racing performance evaluated[22,56].

Out of 1505 Thoroughbred yearlings studied, 52% were found to have a subjective flattening of the distal medial femoral condyle that was less then 1mm deep to the articular surface. This was considered to be a normal anatomical variation and unlikely to have a clinical significance[35].

2.9 Prognosis of conditions with radiographic changes

Following the above brief overview of the common radiographic findings in Thoroughbred yearling pre-purchase radiographs, the question arises as to the significance of these changes. Studies have researched the effect of radiographic changes on the athletic ability of the Thoroughbred racehorse by following the career of the racehorse after the sales[22,26]. 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[6,16,22,24,35]. In a study of 753 Standardbred trotters radiographed as yearlings, horses with osteochondrosis of the TC joint (48%) and palmar/plantar osteochondral fragments of the MCP/MTP joint (49%) raced less often, but achieved almost similar race earnings as radiographically normal yearlings[14]. Radiographic changes indicative of osteochondrosis in Thoroughbred yearlings, in the study done by Kane *et al*, did not have a detectable effect on future racing performance[24]. Jorgensen *et al* found no link between radiographic changes present in the MCP joints and tarsus and racing performance in Standardbred trotters and thus questioned the reason for carrying out such pre-purchase radiographic examinations[23] Very few associations between lesions and race performance at 2 and 3 years of age were identified by Jackson *et al*[22].

2.10 Conclusions from literature review

- Extensive literature on radiographic changes in Thoroughbred yearlings has been published in major racing countries around the world.
- No research has as yet been done on the radiographic changes in the Thoroughbred yearlings in South Africa
- Collecting this data will enable the comparison of the South African population of Thoroughbred yearlings to other yearling populations around the world.
- Data may be used to help veterinarians performing pre-purchasing examinations to make informed decisions on behalf of their clients.

Chapter 3: Materials and methods

3.1 Experimental design

Six hundred yearlings were presented at the 2008 National Yearling Sale in Germiston, South Africa. Of these 600 yearlings, 269 had radiographs made prior to sale by various private veterinary practitioners in South Africa. The radiographs form part of a pre-purchase examination and were requested by the owner or buyer of the yearling. The pre-purchase radiographs assist the buyer in making an informed decision in relation to his/her purchase. All radiographs were made between 1 month and 1 day before the date of sale of the yearling. The pre-purchase radiographs were then lodged at the sales repository with the owner's consent.

Inclusion criteria:

- Thoroughbred yearlings.
- Age range from 14-19 months.
- Owners or buyers must have requested pre-purchase radiographs to be made of their yearlings.
- All radiographs were to be made 1 month to 1 day before the date of sale of the yearling.
- The owner/buyer chose which radiographic studies to lodge at the repository. This selection process is independent from this research assignment.
- Radiographic evaluations and the results thereof were only incorporated in the current research assignment with the owner's consent.
- Radiographs to be of diagnostic quality.

Exclusion criteria:

- Poor quality radiographs, i.e. those of suboptimal positioning or affected by movement.

All owners of Thoroughbred yearlings were fully informed as to the nature of the study and were required to sign a consent form (Appendix A) to include the radiographic studies in the research assignment.

The information pertaining to the yearlings, for example age, sex and stud of origin; was obtained from the sales itinerary booklet published by the Thoroughbred Breeder's Association (TBA).

3.2 Experimental procedures

3.2.1 Acquisition of radiographs

The pre-purchase radiographic examinations are listed in Table 2.1.

3.2.2 Evaluation of radiographs

The radiographic studies were loaded from the repository at the 2008 National Yearling Sales onto an external hard drive, in digital imaging and communications in medicine (DICOM) format, by the TBA. This hard drive was collected from the TBA in Germiston by the primary researcher. Each radiograph was independently evaluated by the primary researcher by going through a checklist – see Appendix B. The checklist is a list of common changes identified in pre-purchase radiographic examinations of Thoroughbred yearlings based on existing studies[21,25,35,47]. Full reports were written for each yearling. Approximately 10% of all radiographs were scrutinized by the promoter, A Carstens (AC) to assess the evaluation by the primary researcher, C Furniss (CF). All differences pertaining to the radiographic changes were discussed between CF and AC, and CF re-evaluated all areas where differences in opinion were found and adapted the reports accordingly.

3.3 Categorisation of radiographic changes

All radiographic changes identified in each anatomical area are listed in Appendix B. The radiographic changes which require further explanation for better understanding are discussed below.

3.3.1 The digit

Radiographic changes recorded on the LM view of the right and left front digit included the solar angle, the angle of the digital axis and enthesophytes/osteophytes/periosteal reactions on the phalanges. The solar angle of P3 was measured using the callipers provided by DICOM viewer programme (Interview 2D version 99.29)(Figure 1). The digital axis was evaluated. The PIP joint and the DIP joint were classified as normal, hyperextended or flexed. A normal axis was represented by a line drawn that bisects P2 into equal dorsal and palmar/plantar halves, being parallel to the dorsal cortex of P3[53]. Figure 2 shows a normal digital axis.

Enthesophytes/osteophytes were identified as new bone formation 2mm or greater in height and present in specific areas such as the extensor process of P3 and the distal and proximal aspects of P2.

Figure 1: Lateral to medial radiograph of the digit showing the solar angle of 4.79°

Figure 2: Lateral to medial radiograph showing the measurement of a normal digital axis

3.3.2 The metacarpophalangeal and metatarsophalangeal joints and proximal sesamoid bones

Dorsal and palmar/plantar osteochondral fragments were classified as articular or non-articular. The diameter of the osteochondral fragments were measured. Osteochondral fragments were considered originating from P1 when they were found in close proximity to P1 and often a fracture bed was identified in the parent bone (see Figure 3).

The flexed LM view of the MCP joint highlighted the dorsal aspect of the sagittal ridge. The presence of a well defined semicircular notch or flattening of the visible sagittal ridge was recorded (see Figure 4). This change could also be identified in the dorsopalmar/dorsoplantar view of the MCP and MTP joints.

Subchondral cyst-like lesions were defined as an area of lucency in the subchondral bone. The diameter of the cyst was measured.

The medial and lateral PSBs of the MCP and MTP joints were highlighted on the oblique views of these joints. Linear lucencies on the abaxial surface of the PSBs were recorded as vascular channels and counted. The vascular channels were further classified into regular and irregular vascular channels. Regular vascular channels were defined as linear lucencies that had parallel sides for the entire length and were less than or equal to 2mm in width. Irregular vascular channels were defined as linear lucencies that had non-parallel sides for any portion of their length or were more than 2 mm in width[25]. Lucent areas on the abaxial surface of the PSBs were measured. Osteophytes, which were defined as new bone formation on the articular surface of the apices and bases of the PSBs, were recorded[25]. Enthesophytes differed from osteophytes as they were defined as new bone formation at the insertion of the interrosseus medius or origin of the distal sesamoidean ligaments[25]. These changes were also recorded.

Figure 3: Dorsal 30° lateral palmar medial oblique radiograph of the metacarpophalangeal joint with a palmar osteochondral fragment off the proximal lateral phalanx one

Figure 4: Flexed lateral to medial radiograph of the metacarpophalangeal joint showing a typical sagittal ridge lesion

3.3.3 The carpus

Lucencies identified in the Cu were measured and recorded. The presence of C1 and C5 were also recorded.

3.3.4 The tarsus

All osteochondral fragments were measured and recorded. Variation in appearance of the distal aspect of the trochlear ridges were ignored as they were seen as normal variations.[14] Radiographic changes involving the DIT and TMT joints which included new bone formation, irregularity of the joint surfaces and or lucencies were recorded. These changes were grouped together.

3.3.5 The stifle joint

Subchondral cyst-like lesions and osteochondral fragments were measured and recorded.

3.4 Data analysis

The pre-purchase radiographs were analyzed on a medical grade screen. The results of the checklists (Appendix B) were added together and then transferred to Excel spread sheets (Microsoft Excel 2007, Microsoft Corp, and Redmond, WA, USA).

Radiographic changes were described and the percentages of the total radiographic changes noted. The mean and the largest and smallest solar angle for each P3 were calculated. All findings and measurements were entered into an Excel spreadsheet (Microsoft Excel 2007, Microsoft Corp, and Redmond, WA, USA) (see Table 4.1 to 4.8).

The radiographic changes identified in the South African yearlings were compared to other yearling populations.

3.5 Ethical considerations

No ethical problems were foreseen as the study used standard clinical material. The protocol was evaluated and approved by the Research and Animal Use and Care Committee of the University of Pretoria (V020/08).

Chapter 4: Results

4.1 Study population

The study population researched in the current study were South African Thoroughbred yearlings selected by their owners for the 2008 National Yearlings Sale in Germiston, South Africa. All radiographic studies were acquired 1 month to 1 day prior to the sale and with the owner's consent, lodged at the repository. The age of Thoroughbred yearlings was between 14 and 19 months. Signalment and lineage were recorded by the TBA and printed in the sales booklet. These data were not used in the present study.

4.2 Data acquisition

Pre-purchase radiographs were made by various private practitioners around South Africa. Most were obtained at the breeding farms while a few were obtained at the sale grounds. All radiographs submitted to the repository at the 2008 National Yearling sale were in DICOM format.

4.3 Data analysis

A total of 14 of 269 radiographic studies were incomplete and not included in the fetlock radiographic studies. A further 15 sets of inferior quality digit radiographs were not included. A total of 17 of 269 radiographic sets from the carpus, tarsus and stifle were also not included due to poor quality.

4.4 Results of radiographs examined

4.4.1 The digit

Two hundred and forty radiographic sets of the LM views of the front digits were included in this study (see Table 4.1).

The average solar angle of the RF (right front) and LF (left front) was 2.38° and 2.79° respectively. The lowest angle recorded was - 2.34° in the RF P3 and - 4.38° in the LF P3. The highest angle recorded was 7.97° in the RF P3 and 8.70° in the LF P3.

The digital axis was evaluated for both the DIP and PIP joint individually in 238 radiographs. Two of the 240 sets of digit radiographs were excluded because P1 and P2 were excluded from the collimated area. The majority of the digits had a normal digital axis (185 of 238, 77.73% in the LF digit and 173 of 238, 72.67% in the RF digit). Hyperextension of the PIP joint was found in 36 of 238 cases in the LF digit (15.13%) and 45 of 238 cases in the RF digit (18.91%) (see Figure 5). Hyperflexion of the PIP joint was recorded. Hyperextension in the DIP joint was identified in 18 of 238 cases in the LF digit (7.56%) and in 23 of 238 cases in the RF digit (9.66%). Only 1 of 238 LF digit, 0.42% and 2 of 238 in the right digit, 0.84% were radiographed in a flexed position. Enthesophytic and osteophytic reactions were recorded as well as new bone formation on the dorsal aspect of P3.

Radiographic change		Category	Left front No.	%	Right front No.	%
Digital axis	Normal	Yes	185	77.73%	173	72.67%
		No	53	22.27%	65	27.31%
	PIP joint hyper-extended	Yes	36	15.13%	45	18.91%
		No	202	84.87%	193	81.09%
	PIP joint flexed	Yes	0	0.00%	0	0.00%
		No	238	100%	238	100.00%
	DIP joint hyper-extended	Yes	18	7.56%	23	9.66%
		No	220	92.44%	215	90.34%
	DIP joint flexed	Yes	1	0.42%	2	0.84%
		No	237	99.58%	236	99.16%
	PIP & DIP joint hyper-extended	Yes	4	1.68%	5	2.10%
		No	234	98.32%	233	97.90%
Enthesophytes/osteophytes	Extensor process	Yes	7	2.94%	9	3.78%
		No	231	97.06%	229	96.22%
		No	230	96.64%	229	96.22%
	Dorsal proximal P2	Yes	5	2.10%	6	2.52%
		No	233	97.90%	232	97.48%
P3 dorsal mineralization reactions		Yes	2	0.84%	1	0.42%
		No	236	99.16%	237	99.58%
Total bony changes		Yes	16	6.72%	18	7.56%
		No	222	93.28%	220	92.44%
Bony changes and abnormal digital axis		Yes	5	2.10%	8	3.36%
		No	233	97.90%	230	96.64%
Bony changes and normal digital axis		Yes	11	4.62%	10	4.20%
		No	227	95.38%	228	95.80%

Table 4.1: Radiographic changes recorded in the lateral to medial views of the left front and right front digits of Thoroughbred yearlings (n=240). PIP = proximal interphalangeal , DIP = distal interphalangeal, P2 = phalanx two, P3 = phalanx 3.

Figure 5: Lateral to medial radiograph showing the measurement of hyperextension of the digital axis at the proximal interphalangeal joint

4.4.2 The metacarpophalangeal joint and proximal sesamoid bones

Two hundred and fifty-five complete MCP joint radiographic studies were evaluated and radiographic changes are represented in Table 4.2 The most common radiographic change recorded were changes on the sagittal ridge with 30 of 255 LF MCP joints affected (11.80%) and 29 of 255 RF MCP joints affected (11.40%). Of the total of 40 yearlings affected, 19 of these were bilateral (47.50%). Proximopalmar osteochondral fragments were more common than proximodorsal osteochondral fragments with a total of five yearlings affected (1.96%).

The largest proximopalmar osteochondral fragment measured 74mm in length while the smallest measured 23mm. Four yearlings had proximodorsal osteochondral fragments in the MCP joint (1.57%) measuring 10mm, 20mm, 21mm and 35mm in length respectively. All osteochondral fragments in the MCP joints were found to be articular.

Radiographic change	Category	Left front No.	%	Right front No.	%	Horses No.	%	Bilateral No.	%
Fragment proximodorsal P1	Yes	2	0.80%	2	0.80%	4	1.57%	0	0.00%
	No	253	99.20%	253	99.20%	251	98.43%	4	100.00%
Fragment proximopalmar P1	Non-articular	0	0	0	0	0	0	0	0.00%
	Articular	1	0.40%	4	1.60%	5	1.96%	0	0.00%
	None	254	99.60%	251	98.40%	250	98.04%	255	100.00%
Changes sagittal ridge MC3	Yes	30	11.80%	29	11.40%	40	15.69%	19	47.50%
	No	225	88.20%	226	88.60%	215	84.31%	21	52.50%

Table 4.2: Radiographic changes recorded in the metacarpophalangeal joints of Thoroughbred yearlings (n= 255) P1 = phalanx one, MC3 = metacarpal three.

The most common radiographic change in the PSBs was the visible vascular channels (see Table 4.3). Most PSBs had 2 or 3 vascular channels present on their abaxial surface with a combination of regular and irregular vascular channels. The medial PSB in both LF and RF MCP joints had an irregular abaxial border (57 of 255, 22.4% and 32 of 255, 12.50%) respectively more often than the lateral PSB (15 of 255, 5.90% and 17 of 255, 6.70%) respectively. Only a few PSB osteophytes were seen with 1 of 255 (0.40%) recorded in the medial PSB of the LF MCP joint and 3 of 255 (1.20%) in the medial PSB of the RF MCP joint.

Figure 6: Dorsal 30° lateral palmar medial oblique radiograph of the metacarpophalangeal joint highlighting the lateral proximal sesamoid bone and its vascular channels (arrowhead).

Radiographic change	Categ					Right MCP joint			
					SB	Lateral PSB		Medial PSB	
		No.	%	No.	%	No.	%	No.	%
Irregular border	Yes	15	5.90%	57	22.40%	17	6.70%	32	12.50%
	No	240	94.10%	198	77.60%	238	93.30%	223	87.50%
Lucencies	Yes	7	2.70%	14	5.50%	13	5.10%	4	1.60%
	No	248	97.20%	241	94.50%	242	94.90%	251	98.40%
Osteophytes	Yes	0	0.00%	1	0.40%	0	0.00%	3	1.20%
	No	0	0.00%	254	99.60%	0	0.00%	252	98.80%
Total vascular channels	1	48	18.80%	32	12.50%	55	21.60%	35	13.70%
	2	91	35.70%	73	28.60%	94	36.90%	69	27.10%
	3	57	22.40%	77	30.20%	51	20%	70	27.50%
	>3	30	11.8	55	21.60%	30	11.80%	65	25.50%
	None	29	11.4	18	7.10%	25	9.70%	16	6.20%
Regular vascular channels	1	31	12.10%	23	9.00%	35	13.70%	25	9.80%
	2	35	13.70%	25	9.80%	38	14.90%	28	11.00%
	3	8	3.10%	8	3.10%	7	2.70%	9	3.50%
	>3	0	0.00%	0	0.00%	1	0.40%	2	0.80%
Irregular vascular channels	1	17	6.70%	9	3.50%	20	7.80%	10	3.90%
	2	30	11.80%	23	9.00%	32	12.50%	16	6.30%
	3	27	10.60%	35	13.70%	23	9.00%	30	11.80%
	>3	20	7.80%	34	13.30%	18	7.10%	28	11.00%
Regular & irregular vascular changes		58	22.70%	80	31.40%	56	22.00%	91	35.70%
	None	29	11.40%	18	7.10%	25	9.70%	16	6.20%

Table 4.3: Radiographic changes in the metacarpophalangeal joint proximal sesamoid bones of Thoroughbred yearlings (n=255). MCP = metacarpophalangeal, PSB = proximal sesamoid bone.

4.4.3 The metatarsophalangeal joints and proximal sesamoid bones

Two hundred and fifty five complete MTP joint radiographic studies were evaluated (see Table 4.4). The most common radiographic change recorded was articular proximoplantar fragments of P1 which were more prevalent in the LH MTP joint (12 of 255, 4.71%) than in the RH MTP joint (5 of 255, 1.96%). The length of these osteochondral fragments ranged from 22-85mm in the LH MTP joint and 20-69mm in the RH MTP joint. Proximodorsal osteochondral fragments of P1 were recorded in the same frequency in the LH and RH MTP joints with a total of 4 yearlings affected (1.57%). The dorsal osteochondral fragments in the LH MTP joint were 20 and 47mm in length while the in the RH MTP joint these osteochondral fragments were 5 and 32mm in length. Subchondral cyst-like lesions were identified in the LH P1 in 2 yearlings. Changes on the sagittal ridge were only identified in 1 yearling (0.40%).

Radiographic change	Category	No.	%	No.	MTP joint %	Horses No.	Horses %	Bilateral No.	Bilateral %
Fragment proximodorsal P1	Yes	2	0.80%	2	0.80%	4	1.57%	0	0.00%
	No	253	99.20%	253	99.20%	251	98.43%	255	100.00%
Fragment proximoplantar P1	Articular	12	4.71%	5	1.96%	16	6.27%	1	0.40%
	Non-articular	0	0.00%	2	0.78%	2	0.78%	0	0.00%
	None	243	95.29%	248	97.25%	237	92.94%	254	99.60%
Subchondral cyst-like lesions	Yes	2	0.80%	0	0.00%	2	0.78%	0	0.00%
	No	253	99.20%	255	100%	253	99.22%	255	100.00%
Changes on sagittal ridge of MT3	Yes	1	0.40%	0	0.00%	1	0.40%	0	0.00%
	No	254	99.60%	255	100%	255	100.00%	255	100.00%

Table 4.4: Radiographic changes in the metatarsophalangeal joints of Thoroughbred yearlings (n=255)
P1 = phalanx one, MTP = metatarsophalangeal, MT3 = metatarsus three

Table 4.5 shows the radiographic changes recorded in the PSB of the MTP joint in Thoroughbred yearlings. An irregular border of the PSBs was seen more frequently in the medial PSB in both the LH MTP joint (23 of 255, 8.98%) and the RH MTP joint (22 of 255, 8.59%) respectively. Lucencies showed a similar pattern of distribution. Osteophytes were identified on the PSBs with a prevalence of 5.47% to 8.59%. Visible vascular channels were also recorded but the prevalence of this radiographic change was not as high as in the MCP joint.

		Left MTP joint				Right MTP joint			
		Lateral PSB		Medial PSB		Lateral PSB		Medial PSB	
Radiographic changes	Category	No.	%	No.	%	No.	%	No.	%
Irregular border	Yes	16	6.25%	23	8.98%	16	6.25%	22	8.59%
	No	240	93.75%	233	91.02%	240	93.75%	234	91.41%
Lucencies	Yes	6	2.34%	26	10.17%	11	4.30%	16	6.25%
	No	250	97.66%	230	89.84%	245	95.70%	240	93.75%
Osteophytes	Yes	14	5.47%	18	7.03%	22	8.59%	21	8.20%
	No	242	94.53%	238	92.97%	234	91.41%	235	91.80%
Total vascular channels	1	38	14.84%	44	17.19%	52	20.31%	33	12.89%
	2	64	25.00%	64	25.00%	60	23.44%	58	22.66%
	3	51	19.93%	52	20.31%	44	17%	38	10.94%
	>3	46	17.97%	29	11.33%	40	15.63%	48	18.75%
	None	57	22.27%	67	26.17%	60	23.44%	79	30.86%
Regular vascular channels	1	19	7.42%	19	7.42%	28	10.94%	14	5.47%
	2	16	6.25%	8	3.13%	18	7.03%	2	0.78%
	3	7	2.73%	3	1.17%	7	2.73%	0	0.00%
	>3	1	0.34%	1	0.34%	0	0.00%	0	0.00%
Irregular vascular channels	1	19	7.42%	25	9.77%	24	9.38%	19	7.42%
	2	41	16.02%	48	18.75%	34	13.28%	49	19.14%
	3	28	10.94%	40	15.63%	31	12.11%	31	12.11%
	>3	37	14.45%	23	8.98%	31	12.11%	36	14.06%
Regular & irregular vascular changes		31	12.12%	22	8.59%	23	8.98%	26	10.16%
	None	57	22.27%	67	26.17%	60	23.44%	79	30.86%

Table 4.5: Radiographic changes in the metatarsophalangeal joint proximal sesamoid bones of Thoroughbred yearlings (n=255). MTP = metatarsophalangeal, PSB = proximal sesamoid bone.

4.4.4 The carpus

A total of 252 sets of radiographic studies of the carpus were evaluated. The radiographic changes identified in the carpus of Thoroughbred yearlings are shown in Table 4.6. The most common finding in the carpus was the presence of C1 which was present in 78 yearlings (30.95%). Exactly half of these yearlings had first carpal bones bilaterally. Carpal bone 5 was found less commonly (4 of 252, 1.49%). A circular lucency in the Cu was identified in 21 Thoroughbred yearlings (8.33%) with only 5 of these being bilateral (23.81%). These circular lucencies varied in size ranging from 22-70mm in length. Osteophytic new bone formation on the carpal bones was recorded in a total of 3 yearlings (1.19%) (see Figure 7).

Radiographic changes	Category	Left carpus		Right carpus		Horses		Bilateral	
		No.	%	No.	%	No.	%	No.	%
Circular lucency in ulnar carpal bone	Yes	13	51.59%	21	8.33%	21	8.33%	5	23.81%
	No	239	94.84%	231	91.67%	231	91.67%	16	76.19%
Osteophytes	Yes	1	0.40%	2	0.79%	3	1.19%	0	0.00%
	No	251	99.60%	250	99.21%	249	98.81%	3	100.00%
C1 one present	Yes	59	23.41%	58	23.02%	78	30.95%	39	50.00%
	No	195	76.59%	194	76.98%	174	69.05%	39	50.00%
C5 present	Yes	3	1.19%	3	1.19%	4	1.59%	2	50.00%
	No	249	98.81%	249	98.81%	248	98.41%	2	50.00%

Table 4.6: Radiographic changes in the carpus of Thoroughbred yearlings (n=252). C1= carpal bone one, C5 = carpal bone 5.

Figure 7: Dorsal(30°-40°) lateral palmar medial oblique radiograph of a carpus showing a lucency in the ulnar carpal bone (arrowhead)

4.4.5 The tarsus

Two hundred and fifty-two complete sets of radiographic studies of the tarsus were evaluated. The radiographic changes in the tarsi of Thoroughbred yearlings were recorded and are shown in Table 4.7. Radiographic changes in the DIT and TMT joints were present in 25 of 252 yearlings (9.92%)(Figure 8). Forty eight percent of these radiographic changes were bilateral. Concavity and or fragmentation of the distal intermediate ridge of the tibia indicative of osteochondrosis was present in 5 of 252 left tarsus (1.98%) and 6 of 252 right tarsus (2.38%) and 33% of these being bilateral (Figure 9). The largest osteochondral fragment recorded was 19mm x 6mm while the smallest osteochondral fragment recorded was 23mm in length. Four tarsal joints affected had multiple fragments. Other manifestations of osteochondrosis were found such as lucencies in the medial malleolus (1 of 252 yearlings, 0.40%) and in the lateral and medial trochlear ridges of the talus (8 of 252 yearlings, 3.17%). Wedging or collapse of the central and third tarsal bones was identified in 4 of 252 yearlings (1.59%) 50% being bilateral.

Radiographic changes	Category	Left tarsus No	%	Right tarsus No.	%	Horses No.	%	Bilateral No.	%
Lucencies in the medial malleolus	Yes	0	0.00%	1	0.40%	1	0.40%	0	0.00%
	No	0	0.00%	251	98.60%	252	98.60%	1	100.00%
Concavity/fragmentation distal intermediate ridge of tibia	Yes	5	1.98%	6	2.38%	8	3.17%	2	33.33%
	No	247	98.02%	246	97.62%	244	96.83%	4	66.66%
Changes lateral/medial trochlear ridge of talus	Yes	2	0.79%	0	0.00%	2	0.79%	0	0.00%
	No	250	99.21%	0	0.00%	250	99.21%	2	100.00%
Changes in the DIT and TMT joints	Yes	23	9.13%	14	5.56%	25	9.92%	12	48.00%
	No	229	90.87%	238	94.44%	227	90.08%	13	52.00%
Wedging or collapse of tarsal bones	Yes	4	1.59%	2	0.79%	4	1.59%	2	50.00%
	No	248	98.41%	250	99.21%	248	98.41%	2	50.00%

Table 4.7: Radiographic changes in the tarsus of Thoroughbred yearlings (n=252). DIT = distal intertarsal, TMT = tarsal metatarsal.

Figure 8: Lateral to medial view of the tarsus showing new bone formation involving the tarsometatarsal joint (arrowhead)

Figure 9: Dorsal 65° medial plantar lateral oblique radiograph of the tarsus showing an osteochondral fragment originating off the distal intermediate ridge of the tibia (arrowhead)

4.4.6 The stifle

There were 252 complete radiographic studies included in the current study with the radiographic findings shown in Table 4.8. Two radiographic changes were identified. One subchondral cyst-like lesions was recorded in the right stifle of a yearling (0.40%). Lucency and fragmentation of the patella was the second radiographic finding identified in the right stifle of a yearling (0.40%).

Radiographic changes	Category	Left stifle		Right stifle		Horses	
		No.	%	No.	%	No.	%
Lucency and fragmentation of the patella	Yes	0	0.00%	1	0.40%	1	0.40%
	No	252	100.00 %	251	99.60%	251	100.00%
Subchondral cyst-like lesions of the femoral condyles	Yes	0	0.00%	1	0.40%	1	0.40%
	No	252	100.00 %	251	99.60%	251	100.00%

Table 4.8: Radiographic changes in the stifle in Thoroughbred yearlings (n=252)

Figure 10: Caudal to cranial radiograph femorotibial joint showing a subchondral cyst-like lesion in the medial femoral condyle (arrowhead)

4.5 Comparisons to similar studies

Similar studies done on pre-purchase radiographs in Thoroughbred yearlings were compared with the current study. These studies are listed in Table 4.9

Primary Researcher	Geographical area	No. of Thoroughbred yearlings	Date
Kane *et al*[25,26]	Kentucky	1162	1993-1996
Howard *et al*[21]	Kentucky	582	1986-1991
Jackson *et al*[22]	Australia	2401	2003
Scott *et al*[47]	Australia	755	2003
Olivier *et al*[35]	New Zealand	1505	2003-2006
Furniss *et al*	South Africa	269	2008

Table 4.9: Comparative studies of radiographic changes in Thoroughbred yearlings.

It is apparent from the comparisons made in Table 4.9 that the current study has the smallest study population. This may influence the prevalence of radiographic changes recorded. Three out of the five other studies span at least 3 years of data collection.

The radiographic findings of each study were compared to the current study in South African Thoroughbred yearlings (Tables 4.10 and 4.11)

	MCP joints			MTP joints		
Primary Researcher	Prox. P1 fragments Dorsal	Prox. P1 fragments Palmar	Sagittal ridge OCD	Prox. P1 fragments Dorsal	Prox. P1 fragments Plantar	Sagittal ridge OCD
Kane *et al*[25]	1.60%	0.50%	60.80%	3.30%	3.90%	40.10%
Howard *et al*[21]	1.20%	0.10%	7.50%	3.40%	2%	1.10%
Jackson *et al* [22]	0.7%	0.4%	37%	2.2%	6.2%	6.6%
Scott *et al*[47]	1.70%	0.50%	37.1%	3.30%	6.20%	5.40%
Furniss *et al*	1.60%	2%	15.70%	1.60%	7.10%	0%

Table 4.10 Comparative selected studies of common radiographic changes identified in the metacarpophalangeal and metatarsophalangeal joint in Thoroughbred yearlings. MCP = metacarpophalangeal, MTP = metatarsophalangeal, OCD = osteochondrosis, Prox = proximal, P1 = phalanx one.

	Carpus			Tarsus		Stifle	Digit
Primary Researcher	Osteophytes	Cu lucencies	Fragments	Distal joints changes	OCD	OCD	P3 osteitis
Kane *et al*[25]	Not recorded	20.10%	0.80%	24.80%	12.20%	6.20%	11%
Howard *et al*[21]	Not recorded	0.10%	0.30%	2.30%	3.70%	4%	2%
Jackson *et al*[22]	3.3%	22.2%	0.7%	45.9%	8.7%	10.2%	20.6%
Scott *et al*[47]	2.60%	Not recorded	2.20%	26.50%	0.30%	8.10%	4.40%
Olivier *et al*[35]	Not recorded	Not recorded	Not recorded	31%	4%	3%	Not recorded
Furniss *et al*	1.19%	8.33%	0%	9.92%	4.40%	0.40%	1.26%

Table 4.11 Comparative collective studies of radiographic changes identified in the carpus, tarsus and stifle in selected studies of Thoroughbred yearlings. Cu = ulnar carpal bone, OCD = osteochondrosis, P3 = phalanx three

4.6 Inter-evaluator results

Radiographic changes described by the primary researcher were found to be similar to the radiographic changes described by the promoter. Conflicting results were found in terms of radiographic changes in the distal joints of the tarsus. The promoter found 70.37%, of the 10% of radiographic studies evaluated (19 of 27), of Thoroughbred yearlings to have radiographic changes involving the distal joints of the tarsus. The primary researcher found only 3.70% (1 of 27) in the same sample of Thoroughbred yearlings affected. The promoter identified the hyperextension of the PIP and DIP joint and the solar angle abnormalities.

4.7 Summary of results

In summary, one can make the following conclusions:

Hypothesis 1 is proven true in that radiographic changes are present in the pre-purchase radiographs of Thoroughbred yearlings in South Africa.

Hypothesis 2 cannot be fully accepted as the prevalence of radiographic changes in Thoroughbred yearlings in South Africa differed in some areas in comparison to other Thoroughbred populations around the world.

Chapter 5: Discussion

5.1 Introduction

Pre-purchase radiographs of South African Thoroughbred yearlings entered in the 2008 National Yearling Sale were evaluated and radiographic changes were recorded. The following section discusses the radiographic changes recorded and how they compare to similar studies done in other parts of the world. It also discusses the pitfalls and limitations of this study, the clinical applications that the radiographic findings of this study, and suggestions for further research.

5.2 Study population

The National Yearling Sale is held annually in Germiston, South Africa, and is the biggest yearling sale in South Africa[52]. One of the main reasons why Thoroughbred yearlings were selected as a study model breed, was due to the financial impact of the industry on the country. The 2008 National Yearling Sale had a gross income of R201 050 000 with the highest priced yearling sold at R3 million[52]. As the radiographic changes present may influence the price of the yearlings sold, the radiographic changes need to be investigated and prevalences of abnormalities established[25,35].

The ages of the yearlings were between 14 and 19 months. Thus yearlings in the current study are part of the foal crop of the year 2006, starting on the 1st August and ending on the 31st December.

Owners/buyers of the Thoroughbred yearlings selected the yearlings to be radiographed. The study population of Thoroughbred yearlings in the current study are thus yearlings that were favoured by the owners and or buyers representing yearlings, with probable superior genetics and athletic potential. Radiographic studies are the property of the owner/buyer as he/she pays for these radiographs to be made. The owner of the radiographic studies has a choice whether to lodge these radiographic studies at the repository or not. Radiographic studies of yearlings with significant radiographic changes may have not been lodged, as radiographic findings would likely affect the price of the yearling to be sold or result in no sale. This is very important as it indicates that the population of yearlings under study are not a true representation of the entire 2006 Thoroughbred foal crop. A random selection process of Thoroughbred yearlings would have been a better representation. The current study is thus biased. Other studies based on radiographic studies lodged at a repository are governed by the same principles and thus have the same limitations as the current study[25,35].

Although the radiographs were done as part of the pre-purchase examination, the researcher did not examine the yearlings at any stage. The assumption was thus made that all yearlings entered into the sale were not lame. One can then further assume that all radiographic changes found in the current study were clinically silent at the time of sale. Further research would need to be done in order to monitor radiographic changes and the future influence these changes have in these horses.

5.3 Evaluation of radiographs

5.3.1 The evaluators

Radiographic studies included in the current study were evaluated by one researcher and only 10% (27 Thoroughbred yearlings) of these radiographs were evaluated by a second researcher. This may introduce some subjectivity in radiographic changes recorded. This can be seen in the mild discrepancies between the 2 evaluators found in terms of the prevalence of radiographic changes found in the distal joints of the tarsus. This differing of opinion of the two authors is reflected in their field of speciality as the primary researcher (CF) is an equine surgeon and the promoter, a specialist radiologist (AC). In a similar study identifying radiographic changes in Thoroughbred yearlings by Kane *et al,* 2 independent authors evaluated 100 % of the radiographs included in the study. If there were any discrepancies between the two authors a third assessment was made and the consensus opinion was used[25]. This technique eliminated to a greater extent the difference of opinion that may occur between evaluators. Radiographs were reviewed by a single radiologist in the study done by Howard *et al* which may account for a more subjective result when compared to studies using the opinion of more than one person[20].

5.3.2 Categorisation of radiographic changes

The categorisation of radiographic changes was based on the study done by Kane *et al*[25]. Any additional radiographic changes were added into the check list (Appendix B). The categorisation scheme varied in two areas. In part 1 of Kane's study, changes on the sagittal ridge were subdivided into changes affecting the proximal third of the sagittal ridge and changes affecting the distal sagittal ridge. The radiographic changes were further subdivided according to their appearance[25]. In the current study changes on the sagittal ridge were placed in one broad category when radiographic changes were tabulated, and not subdivided according to site or appearance. The sagittal ridge change was fully described in one yearling's individual report in the current study which included dimensions measured. The second categorisation that differed was radiographic changes of the DIT and TMT joints where again Kane *et al* divided radiographic changes into proliferative changes and lucencies involving these joints[25]. These radiographic changes in the current study were combined under 1 broad category. In spite of these differences in categorisation, results can still be compared with one another as the results of the sub categories can be added together and compared to the results obtained in the current study of South African Thoroughbred yearlings. The study done by Olivier *et al* and Jackson *et al* described radiographic changes in the same way as Kane's study[22,25,35]. Differences in describing the PSB radiographic changes made Howard *et al's* study incomparable to the above studies[20].

The digital axis and solar angle findings were additional information recorded in the current study of Thoroughbred yearlings and were not recorded in selected studies used as a comparison.

5.3.3 Measurement technique

All measurements of the radiographic changes were attained by using the measurement tools provided by DICOM viewer programme (Interview 2D version 99.29) and were found to be simple and repeatable.

5.4 Quality of radiographs

The radiographic studies were part of a pre-purchase examination done by various private practitioners around South Africa. Although this did bring some variation into the technique of acquisition, the overall quality of the radiographs were good. As discussed above, radiographic sets of inferior quality were disregarded. The highest amount disregarded was in the digit sets of radiographs, due to collimation and positional errors, and movement blurring.

One factor which did play an important role was the correct positioning of the yearling during acquisition of the radiographs. An incorrectly positioned limb can affect the diagnostic quality of the radiograph. This was especially important in the views of the carpus, tarsus, stifles and the digits. The x-ray beam should be angled 10° distally in radiographing the tarsus to allow the beam to reliably cut through the lateral to medial sloping joint spaces[13]. If the x-ray beam is directed incorrectly these joint surfaces may appear irregular. In such a case an incorrect diagnosis of osteoarthritis of the distal joints of the tarsus can be made. Without the horse standing square on all four limbs during acquisition the digital axis can be affected[4].

5.5 A comparison of results

5.5.1 The digit

The most significant finding in the digit in the study done by Kane *et al* was signs of pedal osteitis recorded as being present in 11% of radiographs evaluated[25]. Howard *et al* recorded a prevalence of pedal osteitis of 2%[20]. In the current study these radiographic changes were not grouped together under the name pedal osteitis but evaluated individually. The only radiographic change identified, in the current study, in terms of pedal osteitis, was new bone formation on the dorsal aspect of P3. This radiographic change was recorded in the left P3 in 2 yearlings and in the right P3 in 1 yearling. The overall prevalence in the current study was 1.26%. Therefore the prevalence of pedal osteitis is lower in the current study when compared to similar studies done in Thoroughbred yearlings[25]. An explanation for this could be the difference in the number of radiographic views. In Kane's study a D65°Pr-PaLDiO view or upright pedal view of P3 was also included. The addition of this view would increase the likelihood of identifying changes of pedal osteitis[4,53]. In the latter view, P3 is seen dorsopalmarly in its entirety and signs of bone resorption, marginal fractures or widening of the vascular channels of P3 would be more readily identified[4]. The digit radiographic sets in the current study were limited to a LM view only, since this was the only view required by the TBA.

Deviations in the digital axis were the most common radiographic finding recorded in the evaluation of the digits of the South African Thoroughbred yearlings. Hyperextension of the PIP joint was seen in 18.91 % of RF digits and 15.13% of LF digits. Hyperextension of the DIP joint was seen in 9.56% of LF digits and 7.56% of RF digits. The digital axis was not recorded in selected studies used as a comparison. This radiographic finding recorded in the current study of Thoroughbred yearlings may be significant as it may have an influence on the future soundness and thus the future athletic career of the yearling. Malalignment of the digital bones is seen in 72.8% of horses with front limb lameness[28,36]. With hyperextension of these joints, greater stress is placed on the DDFT and the navicular bone and has been associated with heel bruising, lamellar tearing at the toe, pedal osteitis, navicular disease, distal sesamoidean ligament injury, DDFT tenopathy as well as injuries to tendons proximal to the digit[13]. The disruption of the digital axis shown in a percentage of Thoroughbred yearlings in the current study may progress to the long-toe low heel syndrome commonly seen in Thoroughbred race horses. This condition delays break-over and contributes to increased compression of the dorsal joint margins of the carpus as well as the MCP, PIP and DIP joints[38]. The digital axis may be corrected with balanced trimming of the hoof which will re-align the digits[13]. Without early correction of the digital axis in long-toe low heel syndrome chronic changes may develop which may negatively affect a future athletic career. The prevalence of deviations of the digital axis in this young group of Thoroughbreds should be further investigated as it may originate from incorrect hoof trimming done on the stud farms. The higher prevalence of hyperextension in the PIP joint compared to the DIP joint also warrants further investigation. One should take into account that although the PIP and DIP joints were evaluated by drawing a line through the axis of the phalanges as described in chapter 3, no exact angle measurements were made. Thus these results describing these joints as flexed, normal or hyperextended is qualitative.

Another significant finding in the digit in the current study of South African Thoroughbred yearlings, and not recorded in other studies, was the low angle of P3 or solar angle. The average solar angle in the RF and LF digit was 2.38° and 2.79° respectively. This angle in normal horses has been recorded to be between 5-10°[4,8,53]. This discrepancy in the angle of P3 has been suggested to be breed related as low angles have been recorded in Thoroughbred populations[8,30]. The other studies of radiographic changes in Thoroughbred yearlings did not measure the solar angle, therefore our results cannot be compared to others. The solar angle has been found to be influenced by trimming of the hoof with the P3 to heel distance reduced more than the P3 to toe distance thus decreasing the angle of the P3[28]. The horn of the hoof is softer at the heel area and thus more easily rasped than the horn in the toe area. This may result in more horn removed from the heel area and may account for the low P3 angle. With this observation it may again be worthwhile investigating the trimming that occurs on the stud farms.

5.5.2 The metacarpophalangeal and metatarsophalangeal joints

The prevalence of proximodorsal osteochondral fragments in the MCP joints of South African Thoroughbred yearlings was recorded as being 1.57% of Thoroughbred yearlings evaluated which is similar in frequency to other studies which recorded the prevalence between 1.2 and 1.6%[20,26,47]. Prevalence of proximodorsal osteochondral fragments was found in similar frequencies in both MCP and MTP joints. In other studies these fragments were found to be twice as common in the MTP joint[20,26]. Why there is this difference between the population of Thoroughbred yearlings may be attributed to management, as these fragments have been linked to trauma[13].

Proximopalmar osteochondral fragments had a recorded prevalence of between 0.3% and 0.5% in similar studies done while the current study showed a higher prevalence of 1.96%[20,25]. Proximoplantar osteochondral fragments were found to be more common in the MTP joints which was similar to other studies with an overall incidence of between 2% and 6.27%[20,25]. As these osteochondral fragments have been attributed to osteochondrosis and trauma, it is difficult to explain the relatively higher prevalence of palmar/plantar fragments in this study population[13]. Palmar/plantar osteochondral fragments have been shown to have a genetic predisposition in Standardbreds[13]. As the genetic contribution is unknown, it is difficult to speculate whether or not this factor plays a role in the prevalence of palmar/plantar osteochondral fragments in the current study. In this foal crop of 2006 there are no other radiographic changes in other joints that suggest that trauma plays a role. This increase in palmar and plantar osteochondral fragments is difficult to explain.

The most common radiographic change seen on the dorsal distal MC3 in South African Thoroughbred yearlings were changes in the sagittal ridge best seen on the flexed LM view. A total of 40 yearlings showed radiographic changes on the sagittal ridge (15.69%). In other studies of Thoroughbred yearlings the prevalence of sagittal ridge lesions varied between 7.5 and 60.8% in the MCP joint[20,22,25,47]. In the study done by Kane *et al*, the prevalence of sagittal ridge radiographic changes was near to four times the amount recorded in this study (60.6%)[25]. These changes in the sagittal ridge were only identified in the MTP joints in 1 South African Thoroughbred yearling (0.40%). In other studies the prevalence of this radiographic change was recorded between 1.1 and 40.1%[20,22,25,47]. The lack of a flexed view of the MTP joint in pre-purchase radiographic sets could account for the lower prevalence of sagittal ridge lesions in the hind limbs. Sagittal ridge lesions have been linked to joint effusion and lameness and thus are likely a significant finding[58]. A limitation of the current study is the fact that sagittal ridge lesions were not classified into types and thus one cannot accurately prognosticate on sagittal ridge findings here. As discussed above, these sagittal ridge lesions have been classified under osteochondrosis although it is difficult to distinguish between osteochondrosis and trauma[13]. In the current study 47.50% of sagittal ridge changes identified were found to be bilateral and this characteristic may tend more towards a developmental aetiology. Factors which influence the development of osteochondrosis such as nutrition, biomechanics and genetics may play less of a role in our South African Thoroughbreds thus resulting in a lower incidence.

The most common and unique change seen in the MCP joints in Kane's study was flattening of the distal palmar third of MC3 condyles with a prevalence of 41.3% with half of these changes being bilateral[25]. These changes have been seen in working Thoroughbred racehorses[2]. These radiographic changes were not seen in the South African yearling population. As this radiographic change is linked to exercise, the exercise programmes of the various Thoroughbred populations should be further investigated.

Palmar supracondylar lysis is a unique radiographic change identified in MCP joints of Thoroughbred yearlings in Kane's study with a total of 54 of 1127 Thoroughbred yearlings affected (4.8%)[25]. Signs of supracondylar lysis were not recorded in the population of South African Thoroughbred yearlings. Similarly to palmar metacarpal disease, supracondylar lysis is also linked to exercise and again the exercise programmes of the different Thoroughbred populations warrant further investigation[13]. This is discussed further below.

The most common change recorded in the PSBs in the South African Thoroughbred yearlings was the mild increase in visible vascular channels. A combination of regular and irregular vascular channels was the most common finding in the MCP joints with the medial PSB in the left and right MCP joints having more vascular channels visible. The PSBs in the MTP joints showed a greater tendency to have no vascular channels present. Although vascular channels are a common finding in the present study and in the study done by Kane *et al*, no other study recorded the numbers of vascular channels present in the PSBs [25]. Kane's study showed that 1 or 2 vascular channels were most common on any individual PSB while in the current study 2 or 3 vascular channels were more common in the MCP joint PSBs[25]. This change could be present due to an increase of exercise prior to the sale but may also be associated with excessive strain in the interrosseus medius[18]. Howard *et al* described radiographic changes in the PSBs as sesamoiditis with 9.5% and 10.9% of front and hind fetlocks affected respectively. Only grade III sesamoiditis was found in this study, and this was defined as large linear defects with ill-defined margins that exceeded 1 mm in width on the abaxial surface of the PSB [20]. This classification system was not applied in the current study and thus the vascular channels recorded can only be compared to the study done by Kane *et al*[25].

Other changes recorded in the PSBs of South African Thoroughbred yearlings were an irregular abaxial border which was more commonly noted in the medial PSB in both the MCP and MTP joints. This radiographic change was not recorded in other studies of radiographic changes in Thoroughbred yearlings. The prevalence of an irregular abaxial border in the PSBs in the current study could be linked to pathology of the origin of the interrosseus medius. The medial PSBs were more commonly affected than the lateral PSBs. This may suggest medial to lateral hoof imbalance or conformational abnormalities.

Lucencies in the PSBs of the MCP and MTP joint were also recorded in the current study. The MTP joint showed a slightly higher prevalence of this radiographic change. Other studies of Thoroughbred yearlings did not record this radiographic change. These lucencies are indicative of lysis in the sesamoids and have been linked to sesamoiditis[13]. The percentage of horses with this radiographic change is small and similar to the study done by Kane *et al* [25]. The aetiology behind this change may also be part of interrosseus medius tendon pathology as discussed above.

Kane's studies showed the presence of fractures of the PSBs which was more frequent in the MTP joints with 27 of 1102 yearlings affected (2.5%)[25]. This prevalence of PSB fractures may reflect the management practices at the studs in the Kentucky region. There may be an increased risk of injury during rearing of the horse to preparation for the sales. Fractures of the PSBs were not identified in the population of South African Thoroughbreds or in any other study of Thoroughbred yearlings.

5.5.3 The carpus

In the current study of the South African Thoroughbred yearlings the presence of C1 and C5 was recorded. This radiographic finding was not recorded in the other studies of Thoroughbred yearlings used as a comparison. A total of 78 yearlings had C1 present (30.95%) and half of these radiographic changes were bilateral. This percentage correlates with the findings of Butler who reported a prevalence of 30%[4]. The South African Thoroughbreds thus fall into the normal reference range for this radiographic change. Carpal bone five was present in 4 yearlings and half of these were bilateral. There is no normal reference range for the presence of C5.

In both Kane's study and in the current study, circular lucencies in Cu was the most common radiographic change recorded in the carpal radiographic studies evaluated[25]. Howard *et al* recorded 1 circular lucency in Cu out of 1030 carpal radiographs (0.001%)[20]. The prevalence of this radiographic change varied from 8.33% recorded in the South African Thoroughbred yearlings to 20% recorded in the yearlings in Kane's study. There is very little information pertaining to the cause of these lucencies and it is difficult to explain this lower prevalence in the South African Thoroughbred yearling population. One may speculate that these lucencies may represent osteochondrosis lesions.

Osteophytes on the carpal bones in the current study had a prevalence of 1.19% and similar studies had a prevalence of between 1.7% and 2.6%[25,47]. Thus the prevalences in the South African Thoroughbred yearling population is slightly lower. This radiographic change, being a sign of a degenerative process in the joint, may reflect the differences in the exercise programmes of the different Thoroughbred populations. Poor conformation may also play a role.

Osteochondral fragments associated with the joints in the carpus were not found in South African Thoroughbred yearlings. Other studies of Thoroughbred yearlings had a prevalence of 0.3 to 2.2% of carpi examined[20,25,47]. Again the presence of this radiographic change in other groups of Thoroughbred yearlings may reflect the level of exercise to which they are exposed.

5.5.4 The tarsus

Radiographic changes involving the DIT and TMT joints were the most common changes identified in the tarsi in the South African Thoroughbred yearlings and were recorded in 25 Thoroughbred yearlings (9.92%); half of these changes were bilateral. These radiographic changes were lower than other studies where the recorded prevalence was 17.5 % and 30 % respectively[25,35]. The reason why the radiographic changes involving the DIT and TMT joints are lower in the South African population of Thoroughbred racehorses may again be attributed to the amount of exercise the yearling had been exposed to prior to the sale. Again the pre-sale exercise programmes in the different population of Thoroughbred yearlings needs to be investigated further. Another factor is the evaluation of the radiographs and the categorisation of the radiographic changes of the distal joints of the tarsi. In the current study there was a discrepancy in the results of radiographic changes affecting the distal tarsal joints between the two researchers. This will be elaborated upon in 5.5.6.

Osteochondrosis lesions recorded in the South African population of Thoroughbreds (4.37%) fell in the lower part of the scale of the prevalence recorded in similar studies (3.7-12.2%)[20,25,35,47]. Concavity/fragmentation of the distal intermediate ridge of the tibia was the most common osteochondrosis lesion and was present in 4.4 % of yearlings in Kane's study compared to 3.17 % in the current study[25]. Other OCD lesions such as lucencies in the medial malleoli and changes in the lateral and medial trochlear ridges of the talus were all of a lower prevalence in the current study when compared to the population of Thoroughbred yearlings in Kane's study. The lower prevalence of lesions indicative of osteochondrosis may be attributed to differences in management, genetics or nutrition or a combination of these factors in the South African population of Thoroughbred yearlings. This will be discussed further in 5.5.6.

5.5.5 The stifle

Very few radiographic changes were identified in the radiographs of the stifle joint in the current study. The prevalence of OCD lesions in the current study was recorded at 0.8% which is lower than the prevalence reported in similar studies (2.7%-8%)[20,25,35,47]. Again the lower prevalence of lesions indicative of osteochondrosis may be attributed to a difference in management, genetics or nutrition or a combination of these factors. Other reasons for this low prevalence recorded could be attributed to the low sample population in the current study or the fact that yearlings with stifle lesions may not have been lodged in the repository.

5.5.6 Causative factors affecting radiographic changes

From the discussion above one can clearly conclude that there is a lower prevalence of most radiographic changes in the South African population of Thoroughbreds as compared to Thoroughbred populations used in similar studies.

In the current study there are less lesions indicative of osteochondrosis affecting the MCP and MTP joints, tarsi and stifles. Although the aetiopathogenesis of osteochondrosis is often multifactorial and poorly understood, genetics, nutrition and biomechanics are factors that have been implicated in the development of this condition[33]. Let's first consider the genetics of the different Thoroughbred populations compared. The South African Thoroughbred population is not an isolated genetic pool. Seventy percent of the top 100 yearlings at the 2008 National yearling sale were sired from stallions from the USA. There is a great deal of movement of Thoroughbred racehorses in and out of South Africa for breeding and racing purposes. In 2008 a total of 295 Thoroughbreds were imported into South Africa for breeding and racing purposes[52]. This suggests that our Thoroughbred racehorses do not have an isolated gene pool and thus this factor is unlikely to play a role in the low prevalence of OCD lesions present. Another factor influencing the development of osteochondrosis is nutrition. Further investigation of this factor in the different Thoroughbred populations is warranted. Individual management practices may also play a role in the lesions seen in the current study. The differing management practices may be reflected in the amount of time foals spend on pasture or in the veld, or confined in a stable as well as the exercise programme of the yearling prior to the sale[33]. Management practices in the various study populations should be further investigated to try account for the low osteochondrosis lesions seen in the current study.

Many of the radiographic changes recorded may be trauma related. The prevalence of flattening of the distal palmar third MC3, supracondylar lysis, sesamoid fractures, osteophytes and fragmentation of the carpus and radiographic changes in the distal joints of the tarsus are higher in other population of Thoroughbreds and are all related to exercise. The exercise programme of yearlings in preparation for the sales may account for the traumatic and degenerative radiographic changes. As discussed above, the prevalence of palmar metacarpal disease and supracondylar lysis in the fetlocks of the USA Thoroughbreds may be due to a more intensive training programme prior to the sale. In South Africa the yearling's pre-sale training programme is restricted to walking and trotting. In South Africa, due to a large amount of labour available studs usually employ one handler per yearling. This may decrease the risk of injury during the pre-sale exercise programme. The differences in the exercise programmes between Thoroughbred populations in other parts of the country still need to be investigated further.

Another trauma-related factor, are the radiographic changes that may be related to disease of the suspensory apparatus or interrosseus medius pathology. This may account for the mild increase in vascular channels seen as well as the irregular borders of the PSBs noted. One may speculate that due to the high percentage of Thoroughbred yearlings with hyperextension of the PIP joint in the current study (15.13% in the LF digit and 18.9% in the RF digit) there may be a higher strain on the interrosseus tendon in this population of Thoroughbred yearlings. This may lead to an increase in the number of vascular channels seen in the PSBs and or result in an irregular border at the insertion of the interrosseus tendon on the PSB. This is speculation as no attempt was made to link the radiographic changes in the PSBs to hyperextension in the PIP joint but may be investigated in future studies. One may further speculate that the long-toe low-heel syndrome may also play a role in increasing the number of vascular channels in the PSBs by the same principles discussed above.

As discussed above, the trimming of the hooves of the horses on the stud farms may play a role in the radiographic changes seen affecting the digital axis, solar angle and sesamoid changes. Incorrect hoof trimming or an excessively long interval between trims could lead to mediolateral and dorsopalmar hoof imbalance and may lead to radiographic changes seen[13].

The yearlings in the current study were not examined prior to the radiographic examination and thus an opinion on conformation playing a role in the radiographic changes seen cannot be given.

Similar studies in Thoroughbred yearlings had study populations between 582 and 1505 yearlings[20,25,35,47]. The South African study population consisted of only 269 Thoroughbred yearlings. This is a relatively small study population and this may also play a role in the low prevalence of radiographic changes recorded. For example, only 2 yearlings showed lesions in the stifle and thus the recorded prevalence of osteochondrosis lesions in the stifles of South African Thoroughbred yearlings was 0.8%.

The study done by Kane *et al* was done from radiographs that were made over 4 years from 1993 to 1996[24]. The study done by Howard *et al* was done over 6 years from 1986 to 1991 with other studies done in the new milenium[20,25]. The current study is limited to radiographic studies made in 2008. This may have an influence on the prevalence of radiographic changes seen in the South African population of Thoroughbred yearlings as different years vary in seasonal weather conditions which may influence the quality and quantity of nutrition of the Thoroughbred yearling. A more representative study population would be represented by radiographic studies of Thoroughbred yearlings made over a number of years in order to eliminate variation of seasonal weather conditions.

The history of the population of Thoroughbred yearlings under investigation was not noted. The practice of radiographing weanlings has recently gained popularity in South Africa resulting in some horses undergoing arthroscopic and other surgery prior to the sales. This would result in a decrease in the prevalence of radiographic changes present in pre-purchase radiographic examinations performed.

As mentioned earlier, the owner of the radiographs has a choice whether to lodge the radiographs at the repository or not. This principle applies to other repositories around the world[3]. Radiographic studies of yearlings with many radiographic changes may not have been submitted to the repository as radiographic findings affect the price of the yearling to be sold, similar to other studies whose study population depends on the lodging of radiographs at a repository. Therefore studies which base their study population on Thoroughbred yearlings whose radiographs appear in the sales repository are biased studies as they do not represent entire Thoroughbred yearling populations. Whether South Africans are less likely to lodge all radiographic studies at the repository or not is unknown. The repository system has only recently been introduced at South African sales and therefore it may be speculated that South Africans may be more apprehensive over radiographic changes and there effect on the sale of their yearling. This may account for the lower prevalence of radiographic changes seen in current study. Jackson *et al* showed no difference in all measures of racing performance between horses whose radiographs were forwarded for research compared to those who were not. Although this sample population is a good representation of the horses radiographed, it is still a biased representation of the general Thoroughbred population[22].

Lastly there may be differing opinions on radiographic changes between various researchers. Some researchers may, for example, record any variation in the DIT and TMT joints while others may overlook small osteophytes and only record irregular and obvious disruptions to these joints. This scenario was seen in the difference in radiographic changes affecting the distal joints of the tarsus recorded by the researcher and promoter in the current study. The fact that the promoter is a specialist radiologist may account for the higher recorded prevalence. The primary researcher is a surgeon and may have been inclined to overlook small changes to these distal joints of the tarsus and thus record a lower prevalence. In the current study difference were discussed and a consensus was reached. This variation in opinion may exist between the studies compared in this study and may account for the different prevalences recorded.

5.7 Effect of radiographic changes found on athletic potential

Many studies have researched the effect of radiographic changes on the athletic ability of the Thoroughbred racehorse by following the career of the racehorse after the yearling sales[25]. The prevalence and distribution of radiographic changes has been found to have little effect on the future racing performance of the Thoroughbred racehorse[22,23,24].

A reason for this finding could be the short athletic career of the Thoroughbred racehorse. A racehorse is first raced as a two year old with the races with the highest stakes often in the first 2 years of its athletic career. It may be speculated that by the time these lesions start causing degenerative changes in the joint, the career of the animal is over.

It may be argued that, although the Thoroughbred racehorse has a successful racing career, it is not to say that the horse is sound. The radiographic changes may not affect the athletic career of the Thoroughbred racehorse if the horse is treated with intra-articular medication or receives medication and is then raced just outside of the medication’s withdrawal period. In this way the condition is managed and the horse still competes. Whether this is ethical or not is beyond the scope of this study.

Due to the above conclusion of similar studies many Thoroughbred racehorse owners have questioned the role of pre-purchase radiographic examinations. Financially the balance sheet may not justify the expense of pre-purchase radiographs but as a veterinarian our role is to take care of the animal from its first breath until its last. For this reason I personally think there is a place for pre-purchase radiographic studies.

The current study is limited to identifying pre-purchase radiographic changes. The effect these changes have on the athletic ability of the Thoroughbred racehorse was not assessed.

5.8 Future studies

Further investigation could be done in terms of the Thoroughbred digit. More measurements could be made of the digits such as recording sole thickness. This together with investigation into the trimming of hooves on the stud farms, could give us a clearer picture of the status of our South African Thoroughbred's digits.

Further studies could be done to compare the management practice and preparation of the South African Thoroughbred yearlings for sales, as compared to management practices in other Thoroughbred populations around the world, as these factors may play a role in the prevalence of radiographic changes found in this study.

The nutrition of the different groups of yearlings should also be investigated.

This dataset may be correlated with the racing performance of the South African Thoroughbred yearlings and thus study the effect of radiographic abnormalities on the animal's athletic career.

An investigation of muscoskeletal injuries in the South African racing industry can be done and linked with the radiographic changes identified in the pre-purchase examination of our Thoroughbred yearlings

Chapter 6: Conclusion

The following conclusions were deduced from this study:

- Radiographic changes are present in the pre-purchase radiographs of the 2008 South African Thoroughbred yearling population.
- The radiographic changes identified in the current study differ from similar studies done in other parts of the world. These differences are listed below:
  - There is a lower prevalence of pedal osteitis in phalanx three.
  - Hyperextension of the proximal interphalangeal joint is present in some cases.
  - The solar angle of phalanx three is generally considerably lower than normal.
  - There is a higher prevalence of proximopalmar and proximoplantar osteochondral fragments in the metacarpophalangeal and metatarsophalangeal joints.
  - There is a lower prevalence of changes on the sagittal ridge of the metacarpo-phalangeal joint.
  - Flattening of the distal third of metacarpus three condyles and palmar supracondylar lysis is not present in Thoroughbred yearlings in the current study.
  - There is a slightly higher prevalence of vascular channels, irregular abaxial borders and lucencies in the proximal sesamoid bones of the metacarpophalangeal joint.
  - No proximal sesamoid bone fractures are present in the current study.
  - The prevalence of carpal bone one and carpal bone five is 30.95% and 1.59%, respectively.
  - There is a lower prevalence of lucencies in the ulnar carpal bone.
  - There is a lower prevalence of osteophytes in the carpal joint.
  - No osteochondral fragmentation is present in the carpus.
  - There is a lower prevalence of radiographic changes in the distal intertarsal and tarsal metatarsal joints.
  - The prevalence of osteochondrosis lesions in the tarsus are on the lower range of prevalences of other studies.
  - There is a lower prevalence of osteochondrosis lesions in the stifle.

- This study's major limitation was the fact that Thoroughbred yearlings with severe radiographic changes were likely to have been withdrawn from the sale, or the radiographs of such yearlings may not have been lodged at the sale repository. Thus the current study is not a good representation of the entire 2006 yearling crop.

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APPENDIX A

UNIVERSITY OF PRETORIA
Research information and consent form

Title of the Study: Radiographic changes in Thoroughbred yearlings in South Africa

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DESCRIPTION OF THE RESEARCH

You are invited to submit your radiographs of your Thoroughbred yearlings to form part of a research project. This project investigates pre-purchase radiographs in Thoroughbred yearlings in terms of the prevalence of radiographic changes.

You are requested to submit your pre purchase radiographic examinations for analysis. All information gained is kept confidential and any changes published are anonymous.

The purpose of this research project is to record the prevalence of the radiographic changes in South African Thoroughbred racehorses. The data gained will be compared to similar studies done around the world.

This study will include all yearlings presented at the 2008 National Yearling Sale.

If you decide to participate in this research study your radiographs will be analysed by C Furniss and A Carstens after the sale. Results will be kept confidential.

The information obtained from this study will allow one to compare South African racehorses to those around the world, would offer financial gain for the racing industry as problem yearlings could be identified early, possible treatment instituted where justified while the price of yearlings with no changes present could be adjusted.

This study is anonymous. Neither your name nor any other identifiable information will be recorded.

You may ask any questions about the research at any time. If you have questions about the research contact C Furniss at Private bag x04 Onderstepoort 0110. You may also call the researcher, C Furniss at 0827704420.

Your participation is completely voluntary. If you decide not to participate or to withdraw from the study it will have no effect on any services or treatment you are currently receiving.

Your signature indicates that you have read this consent form, had an opportunity to ask any questions about your participation in this research and voluntarily consent to participate. You will receive a copy of this form for your records.

Name of Participant (please print):_______________________________

Signature:____

Date:_____________

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APPENDIX B

Check list of radiographic changes

Radiographic changes.

Stud:
Name of yearling____

Identification of the yearling:______________________________________

Age:____

Sex: Filly/Colt

Age in months____

Right front digit: LM

Changes: NAD

Angle of P3 to solar surface:_________________________________

Digital axis of PIPJ:_______________________________________

Digital angle of DIPJ:______________________________________

Signs of pedal ostietis:_____________________________________

Extensor process of the third phalanx:__________________________

Frag. Of the palmar process(es);______________________________

Synovial invaginations of the nav. bone:________________________

Medullary cavity of the nav. bone:____________________________

Flexor surface of the nav bone:_______________________________

Lucency of the wing of pedal bone:____________________________

Other changes:____

Left front digit: LM

Changes: NAD

Angle of P3 to solar surface__________________________________

Digital axis of PIPJ:_______________________________________

Digital angle of DIPJ:______________________________________

Signs of pedal osteitis:_____________________________________

Extensor process of the third phalanx:__________________________

Frag. Of the palmar process(es);______________________________

Synovial invaginations of the nav. bone:________________________

Medullary cavity of the nav. bone:____________________________

Flexor surface of the nav bone:______________________________

Lucency of the wing of pedal bone:______________________________

Other changes:______________________________

Right MCP joint: DPa, LM flexed, DLPaMO, DMPaLO

Changes: NAD

Articular proximal palmar frag:______________________________

Non-articular palmar frag:______________________________

Articular proximal dorsal frag:______________________________

Non-articular proximal dorsal frag:______________________________

Subchondral cyst-like lesions:______________________________

Changes on the saggital ridge:______________________________

Palmar metacarpal disease:______________________________

Palmar supracondylar lysis:______________________________

Proximal sesamoid bones

Irregular abaxial border:______________________________

Enthesopathy:______________________________

Vascular channels:______________________________

Lucencies:______________________________

Fractures:______________________________

Other changes______________________________

Left MCP joint: DPa, LM flexed, DLPaMO, DMPaLO

Changes: NAD

Articular proximal palmar frag:______________________________

Non-articular palmar frag:______________________________

Articular proximal dorsal frag:______________________________

Non-articular proximal dorsal frag:______________________________

Subchondral cyst-like lesions:______________________________

Changes on the saggital ridge:______________________________

Palmar metacarpal disease:______________________________

Palmar supracondylar lysis:______________________________

Proximal sesamoid bones

Irregular abaxial border:______________________________

Enthesopathy:______________________________

Vascular channels:______________________________

Lucencies:______________________________

Fractures:____

Other changes____

Left MTP joint: DPl, LM , DLPlMO, DMPlLO

Changes: NAD

Articular proximal plantar frag:____

Non-articular plantar frag:____

Articular proximal dorsal frag:____

Non-articular proximal dorsal frag:____

Subchondral cyst- like lesions:____

Changes on the saggital ridge:____

Plantar metacarpal disease:____

Plantar supracondylar lysis:____

Proximal sesamoid bones

Irregular abaxial border:____

Enthesopathy:____

Vascular channels:____

Lucencies:____

Fractures:____

Other changes____

Right MTP joint: DPa, LM , DLPlMO, DMPlLO

Changes: NAD

Articular proximal plantar frag:____

Non-articular plantar frag:____

Articular proximal dorsal frag:____

Non-articular proximal dorsal frag:____

Subchondral cyst-like lesions:____

Changes on the saggital ridge:____

Plantar metacarpal disease:____

Plantar supracondylar lysis:____

Proximal sesamoid bones

Irregular abaxial border:____

Enthesopathy:____

Vascular channels:____

Lucencies:____

Fractures:____

Other changes:____

____

Right Carpus: DPa, LM flexed, DLPaMO, DMPaLO

Changes: NAD

Rounding or dorsal cortical thickening of the radiocarpal bone:______________________________

Proliferative changes involving the radiocarpal bone:______________________________________

Proliferative changes involving the third carpal bone:______________________________________

Circular lucencies of the ulnar carpal bone:____

Osteophyts:____

Subchondral cyst- like lesions:____

Fractures:____

Cortical thickness of cannon bone:____

Signs of proximal suspensory disease:____

Other changes:____

____

Left Carpus: DPa, LM flexed, DLPaMO, DMPaLO

Changes: NAD

Rounding or dorsal cortical thickening of the radiocarpal bone:______________________________

Proliferative changes involving the radiocarpal bone:______________________________________

Proliferative changes involving the third carpal bone:______________________________________

Circular lucencies of the ulnar carpal bone:____

Osteophyts:____

Subchondral cyst-like lesions:____

Fractures:____

Cortical thickness of cannon bone:____

Signs of proximal suspensory disease:____

Other changes:____

Right Tarsus: DLPlMO, LM, DMPlLO

Changes: NAD

Lucencies in the medial malleolus:____

Fragmentation/concavity of the distal intermediate ridge of the tibia:__________________________

Flattening/lucencies/fragmentation of the lateral and medial trochlear ridges of the talus:____

Radiographic changes in distal joints:____

Wedging or collapsing of tarsal bones:____________________________________

Subchondral cyst-like lesions:____________________________________

Proximal suspensory disease changes:____________________________________

Other changes:____________________________________

Left Tarsus: DLPlMO, LM, DMPlLO

Changes: NAD

Lucencies in the medial malleolus:____________________________________

Fragmentation/concavity of the distal intermediate ridge of the tibia:____________________

Flattening/lucencies/fragmentation of the lateral and medial trochlear ridges of the talus:____________________________________

Radiographic changes in distal joints:____________________________________

Wedging or collapsing of tarsal bones:____________________________________

Subchondral cyst-like lesions:____________________________________

Proximal suspensory disease changes:____________________________________

Other changes:____________________________________

Right Stifle: CdLCrMO, CdCr, LM

Changes: NAD

Flattening/lucencies/ fragmentation of the medial and lateral trochlear ridges of the femur:____________________________________

Lucency or fragmentation in the trochlear groove:______________________________

Lucency and fragmentation of the patella:________________________________

Subchondral cyst-like lesions of the femoral condyles/ proximal tibia:____________________________________

Osteophyte production medial tibial plateau:______________________________

Osteophyte production proximal aspect of the medial condyle of the femur:________________

Lucency medial to the intercondylar eminence:______________________________

Other changes:____________________________________

Left Stifle: CdLCrMO, CdCr, LM

Changes: NAD

Flattening/lucencies/ fragmentation of the medial and lateral trochlear ridges of the femur:____________________________________

Lucency or fragmentation in the trochlear groove:______________________________

Lucency and fragmentation of the patella:________________________________

Subchondral cyst-like lesions of the femoral condyles/ proximal tibia:____

Osteophyte production medial tibial plateau:______________________________

Osteophyte production proximal aspect of the medial condyle of the femur:_______________

Lucency medial to the intercondylar eminence:______________________________

Other changes:____

LM = lateral to medial, NAD = no abnormalities detected, P3 = phalanx three, PIPJ = proximal interphalangeal joint, DIPJ = distal interphalangeal joint, nav = navicular MCP = metacarpalphalangeal, DPa = dorsal palmar, DLPaMO = dorsal lateral palmar medial oblique, DMPaLO = dorsal medial palmar lateral oblique, MTP = metatarsophalangeal, DPl = dorsal plantar, DLPlMO = dorsal lateral plantar medial oblique, DMPlLO = dorsal medial plantar lateral oblique, frag = fragment, CdLCrMO = caudal lateral cranial medial oblique, CdCr = caudal cranial