Original Article

Frequency distribution of carpal osteochondral fragmentation in a population of flat racing Thoroughbreds in the UK

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Summary

Lameness associated with osteochondral fragmentation of the carpus is a common injury in racing horses. Frequency distributions of sites of fragmentation have previously been published in racehorses in the USA, Australia, New Zealand and Japan but not in racing Thoroughbreds in the UK. The objectives of the study were to document sites of osteochondral fragmentation in the carpus of a population of Thoroughbred flat racehorses in the UK and compare these with other Thoroughbred populations globally and other flat racing breeds. This study was a single centre retrospective observational study: case records of flat racing Thoroughbreds with sites of carpal bone fragmentation that underwent arthroscopic surgery at Newmarket Equine Hospital between 2008 and 2013 were included. A total of 291 sites of fragmentation were identified arthroscopically within the carpal joints of 174 horses. This involved 135 (78%) middle carpal (MC) and 48 (28%) antebrachiocarpal joints (ABC), which differs from other populations reported. The most common sites of fragmentation were dorsodistal radial carpal bone (DDrC) (49%), dorsoproximal third carpal bone (DPrC3) (22%), dorsodistal radius (DDiR) (15%), dorsoproximal radial carpal bone (DPrC) (4%) and dorsoproximal intermediate carpal bone (DPiC) (4%). The dorsodistal radial carpal bone is also the most common site in the American (US) Quarter Horses (QHs) and Thoroughbreds (TBs) and Australian (AUS) TBs, while DPrC3 has a greater prevalence in US Standardbreds (SBs). Thereafter the frequency distribution differs between the reported study groups. Although all horses underwent bilateral radiographic examination, 45% of the total population had unilateral arthroscopic evaluation. This may therefore underestimate the total number of sites of fragmentation reported. In summary the frequency distribution of carpal fragmentation in flat racing Thoroughbreds in the UK appears to differ from other populations of racehorses.

Introduction

Lameness associated with osteochondral fragmentation of the distal radius and cuboidal bones of the carpus is a common training and racing injury in Thoroughbred (TB) racehorses. In some cases these present as acute injuries. In others, fragmentation appears to have resulted at the end of a pathological process (McIlwraith et al. 2014). The latter is believed to be the result of a failure of adaptation of the subchondral bone resulting in increased stiffness and bone density. Compressive forces created by carpal (hyper)

extension are suggested to lead to fatigue failure and osteochondral fragmentation (Tidswell et al. 2008). Cumulative microdamage in subchondral bone has been demonstrated experimentally (Kawcak et al. 2000) and it has been recognised that some fragments originate from articular margins previously altered by subchondral bone disease (Pool and Meagher 1990).

Osteochondral fragmentation creates incongruity of articular surfaces. Additionally, osteochondral debris is a potent mechanical and chemical irritant to articular cartilage and synovium respectively (McIlwraith et al. 2014). The resultant synovitis generates effusion with associated increased intra-articular pressure. The affected synovium also liberates a plethora of inflammatory mediators which result in a self-perpetuating cycle of inflammation that may culminate in the development of osteoarthritis. Arthroscopic removal of osteochondral fragments is therefore recommended in order to minimise articular insult and prevent development of osteoarthritis (McIlwraith and Bramlage 1996).

McIlwraith et al. (1987) reported the prevalence and location of osteochondral fragments in 580 racehorses in the United States (US), including 220 TBs and 349 Quarter Horses (QHs). Cumulative data from Palmer (1986) and Lucas et al. (1999) provided a total of 251 US Standardbreds (SBs) with multiple statistical tests being performed. Significance was at P<0.05. Odds ratio and 95% confidence intervals were calculated for each comparison to determine the likelihood of a positive outcome (UK TB more likely to have a site of fragmentation than the comparator population). The remaining epidemiological information was recorded as descriptive summaries only.

Materials and methods

Case records of all TBs in flat race training admitted to Newmarket Equine Hospital between 2008 and 2013 that

underwent arthroscopic surgery for carpal osteochondral fragmentation of the distal aspect of the carpal bones were evaluated. Both fractures and fractures of the accessory carpal bone were excluded. All cases in this study underwent arthroscopic surgery under general anaesthesia. All horses were included in the study reported by Jago et al. (2015) and therefore some received perioperative fluoroquinolones. Arthroscopy was performed by a European board certified surgeon experienced in advanced arthroscopic techniques (I.M. Wright), as previously described by McIlwraith et al. (2014), to evaluate between 1 and 4 of the available carpal joints depending upon clinical and radiographic findings.[1] For the purposes of this study, a fragment was defined as per the Oxford English Dictionary as 'a piece broken off' (Coulson et al. 1939). Specifically, osteochondral fragmentation was defined as pieces of subchondral bone with overlying articular cartilage involving a single articular surface of the cuboidal bones of the carpus or distal radius. Lesions involving articular cartilage only, subchondral erosions or areas of compromised subchondral bone without discrete lines of cleavage from the parent bone were not included. With displaced fragments, location was defined as the site of origin of the fragment(s).

In all cases information regarding signalment, whether raced or unraced, use of radiographs for diagnosis and site of fragmentation identified on arthroscopy for each horse were determined from retrospective analysis of existing case records; specific locations of fragmentation within the carpus, limb(s) involved and joint(s) affected were also recorded as positive outcome measures. Subsequently, the data was organised into relative frequency distributions for the location of sites of fragmentation identified, joint(s) involved and limb(s) affected. These were compared with previously reported frequency distributions of location of carpal fragmentation within various populations to evaluate similarities and differences in prevalence of arthroscopically confirmed fragmentation in the carpal joints (Palmer 1986; McIlwraith et al. 1987; Riddell and Wright 1996; Lucas et al. 1999). A 2-tailed Fisher's exact

test was applied to the data using the SAS[1] statistical programme to determine the likelihood of the presence of fragmentation at each of the possible locations within the carpus for the UK TB population compared to the presence of fragmentation at the same location for each of the other reported populations. A post hoc Bonferroni correction was then applied to reduce the risk of error associated with multiple statistical tests being performed. Significance was set at P<0.05. Odds ratio and 95% confidence intervals were calculated for each comparison to determine the likelihood of a positive outcome (UK TB more likely to have a site of fragmentation than the comparator population). The remaining epidemiological information was recorded as descriptive summaries only.

Results

A total of 174 horses satisfied the inclusion criteria and these comprised 83 males, 58 females and 33 geldings. There were 3 yearlings, 103 2-year-olds, 46 3-year-olds, 16 4-year-olds and 6 horses ≥5 years old. Of all horses included in the study, 45% (78) had unilateral carpal arthroscopy and 55% (96) had bilateral arthroscopy subsequent to bilateral carpal radiographic evaluation. Negative arthroscopic findings (e.g. no sites of fragmentation identified) were present in one limb in 36 (38%) of those horses evaluated bilaterally.

Carpal osteochondral fragmentation was found at 291 sites: 234 (77%) sites of fragmentation were identified in the middle carpal (MC) and 47 (23%) in the antebrachiocarpal joints (ABC); in 135 (78%) horses, fragmentation was identified in the MCj only, in 39 (22%) horses the ABCj only and in 5 (3%) horses both the MC and ABCj were affected. A single site of fragmentation was identified in a total of 171 carpal joints (76% MCj; 24% ABCj), 2 sites of fragmentation in 54 joints (65% MCj; 35% ABCj) and 3 sites of fragmentation in 4 joints (25% MCj; 75% ABCj). The relative frequency distribution (%) of the site of fragmentation in this study is demonstrated in Table 1 alongside the frequency distributions for other published
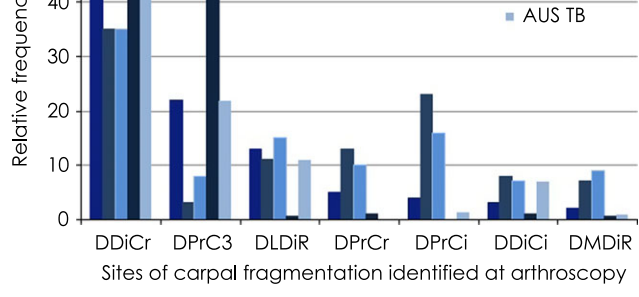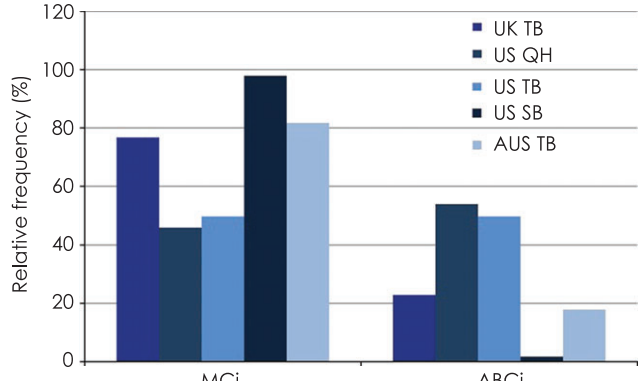
TABLE 1: Statistical comparison of location of osteochondral carpal fragments in UK Thoroughbreds compared with US Thoroughbreds, Quarter Horses and Standardbreds (Palmer 1986; McIlwraith et al. 1987; Lucas et al. 1999) and AUS Thoroughbreds (Riddell and Wright 1996)

Fragment location	UK TB vs. US TB			UK TB vs. US QH			UK TB vs. US SB			UK TB vs. AUS TB		
	P value	Odds ratio	95% CI	P value	Odds ratio	95% CI	P value	Odds ratio	95% CI	P value	Odds ratio	95% CI
DDiCr	0.003*	1.7	1.4–2.5	0.0006*	1.8	1.6–2.8	<0.0001*	1.2	0.9–1.6	1.000	1.2	0.8–1.7
DDiCl	0.4	0.5	0.3–0.9	0.07	0.4	0.3–0.8	0.3	3.9	1.1–14.5	0.8	2.0	0.9–4.3
DPrC3	0.0004*	3.4	2.3–5.6	0.0006*	4.7	3.1–7.1	0.0006*	0.3	0.2–0.4	0.0003*	0.4	0.2–0.6
DPiC	0.0006*	2.8	1.8–4.3	0.0006*	2.0	1.3–3.2	0.6	0.8	0.4–1.6	0.6	0.8	0.3–1.1
DDiR	1.000	0.6	0.3–1.2	1.000	0.9	0.5–1.5	0.7	0.8	0.4–1.4	0.06	0.7	0.5–1.1
DMDiR	0.001*	0.6	0.1–0.6	0.02*	0.3	0.2–0.7	0.3	8.2	1.0–67.3	1.000	0.4	0.1–1.90
DPrC	0.5	0.5	0.3–1.0	0.0006*	0.3	0.2–0.4	0.0007*	0.3	0.1–0.6	—	—	—
ABCj	<0.0001*	6.3	3.3–4.4	<0.0001*	0.3	0.3–0.3	<0.0001*	7.8	4.9–8	0.2	1.3	0.9–2.07
PRC	<0.0001*	6.3	2.3–4.4	<0.0001*	6.9	3.0–15.5	<0.0001*	0.1	0.0–0.3	0.2	—	—
Left limb	0.001*	1.7	1.2–2.1	0.04*	1.3	1.0–1.7	—	—	—	—	—	—
Right limb	0.001*	0.6	0.4–0.8	0.04*	1.0	0.6–1.0	—	—	—	—	—	—

UK lesion more likely if odds ratio >1. P values determined from Fisher's exact test with Bonferroni adjustment. *denotes significance. DDiCr, dorsodistal radial carpal bone; DDiCl, dorsodistal radial carpal bone; DPrC3, dorsoproximal third carpal bone; DPiC, dorsoproximal intermediate carpal bone; DDiR, dorsodistal radius; DMDiR, dorsomedial distal radius; DPrC, dorsoproximal radial carpal bone; DPrC, dorsoproximal intermediate carpal bone; DDiR, dorsodistal radius; DMDiR, dorsomedial distal radius; ABCj, antebrachiocarpal joint. US, United States; UK, United Kingdom; US QH, US Quarter Horse; US SB, US Standardbred; AUS TB, Australian Thoroughbred.

populations. Supplementary Item 1 summarises specific fragment location distributions for each population; fragmentation was identified bilaterally in 57 (33%) horses and unilaterally in 117 (67%) horses, of which 78 (67%) horses were evaluated unilaterally and 39 (33%) bilaterally with negative arthroscopic findings in one limb. A total of 42 of 57 (74%) of the horses bilaterally affected had at least one location where fragments were located at the same site between limbs; the most common bilaterally symmetric site of fragmentation was the dorsodistal radial carpal (DDrC) bone (32/42; 76%). Where ≥3 sites of fragmentation were identified the most common combination included distal radial carpal bone (32/42; 76%). Where ≥3 sites of fragmentation were identified, the most common combination included distal radio and carpal confidence intervals presented in Supplementary Items 2–5.

Fig 1: Relative frequency distribution of sites of arthroscopically confirmed osteochondral fragmentation in UK flat racing Thoroughbreds compared with other populations of flat racing horses.

Fig 2: Relative frequency distribution of joints containing arthroscopically confirmed osteochondral fragments in reported populations of flat racing horses.

Fig 3: Relative frequency distribution of sites affected by arthroscopically confirmed osteochondral fragmentation to each reported population of racing horses. Note data not available for AUS TB.

The UK TBs were 1.7 and 1.8 times more likely to have sites of DDiCr bone fragmentation and 3.5 and 8.7 times more likely to have DPrC3 bone fragmentation than US TBs and QHs respectively. In addition, the UK population were less likely to have ABCj pathology, but 6.3 and 3.9 times more likely to have ABCj pathology compared to the US TBs and QHs, respectively. Finally, UK TBs were 1.7 and 1.3 times more likely to have left forelimb injuries and less likely to suffer from right forelimb injuries than the US TB and QH populations reported, but the UK population showed a greater loading (increased distribution of the carpal joint being loaded). In comparing the UK TBs with US SBs (Palmer 1986; Lucas et al. 1999), the former were 8.4 times more likely to have sites of dorsoproximal radial carpal (DPrC) bone fragmentation and were less likely to have dorsoproximal intermediate carpal (DPiC) bone fragmentation, 4.2 times more likely to have dorsodistal distal radial (DDiR) fragmentation and 8.40 times more likely to have dorsomedial distal radial (DMDiR) fragmentation than US SBs. The ABCj was 77 times more likely to be affected in US TBs and the MCj less likely to be affected compared to US SBs.

European and AUS racing TBs appear to have similar distributions of sites of carpal fragmentation (Riddell and Wright 1996); no differences in location of fragmentation distribution were identified. Comparisons between left and right limbs were not made for AUS TBs or US SBs as no comparable data were available.

Discussion

This study documents the frequency distribution of sites of carpal fragmentation in a population of flat racing TBs in the UK admitted to a single referral hospital. Several risk factors for osteochondral fragmentation have previously been described and should be considered when assessing the differences in distribution from geographically distinct TBs and other populations reported. Differences in skeletal

morbidity, speed, conditioning, fatigue, farriery, conformation and training surface and direction (Palmer 1986; McIlwraith et al. 1987, 2014; Radtke and Wright 1996; Shimozawa et al. 2000). Severity of joint disease may enhance prediction of fragmentation (Poulos et al. 2003). The data presented could not be directly compared to frequency distributions in the UK, US and AUS populations reported in this study, but the breeds and distances involved are different (Palmer 1986; McIlwraith et al. 1987; Radtke and Wright 1996; Lucas et al. 1999).

Racial carpal, Cl and C3 are perceived to undergo the greatest loading of the 3 axial weightbearing carpal bones (Bramlage et al. 1988; Ruggles 2012). Intercarpal articulations are arranged so that this load is partially dissipated by transferring force through joint displacement by mediolateral displacement of the bones. This protects the articular surfaces, but requires conditioning of the ligaments through training. Similarly, the capacity of the palmar joint capsule, ligaments and flexor muscles to limit displacement of the dorsal aspect of the joint in hyperextension must be developed through conditioning exercise. These self-protective properties are anticipated to increase with age and training (Bramlage et al. 1988).

In this study, involvement of the MCj was greatest in UK TBs than US TBs and QHs (McIlwraith et al. 1987) but less likely than in US SBs (Palmer 1986; Lucas et al. 1999). Similarities in frequency distributions of specific locations of fragmentation within the MCj were identified between UK and AUS TBs (Radtke and Wright 1996), which suggests aetiological factors common to both populations. In both the UK and AUS TB, training is typically on artificial or turf surfaces with the majority of racing on turf (Hansen et al. 2004). Racing speeds and distances and significant variation in breed on these surfaces with less 'bone adaptation' than seen on dirt (Kobluk 1995). As the race speeds are similar to that achieved in US populations, the greater and more susceptible to injury as it is less protected by overlying muscle and tendon, undergoes greater loading (Bramlage et al. 1988; Barr 1994) and is less able to attenuate weightbearing stress by transfer of load by interosseous displacement through intercarpal ligaments (Bramlage et al. 1988).

The reported frequency distribution of sites of fragmentation in Japanese TBs identified a high proportion of distal radius fragmentation (Shimozawa et al. 2000). Radius fragmentation (Shimozawa et al. 2000). The data presented could not be directly compared to frequency distributions in the UK, US and AUS populations reported in this study, but distinct differences are evident. In Japan both the proportion of distal radius fragmentation and sites of fragmentation in relation to age and gender. No statistical differences were identified between reported data in age, gender and breed populations; the only differences recorded was that in UK TBs the DDiC bone was more likely to have both a greater degree of frequency of loading and higher proportion of carpal hyperextension than those training at slower speeds (Palmer 1986). As the proportion of entrant to be registered for races on dirt surfaces is small, it was not possible for this study to draw conclusions about the direction of the influence of training on the carpus, but the proportion of distal radius lesions in such a low prevalence of

Cr involvement. If the previously discussed pathogenic proposals are accepted then the Japanese TBs, which race at speeds greater than the European and AUS racing TBs (Anon 2014b), appear to suffer more 'acute' hyperextension injuries than similar populations elsewhere in the world.

In all reported groups except the Japanese population (Shimozawa et al. 2000) DDiC lesions were most frequent, accounting for almost half of all sites of fragmentation in UK and AUS TBs and US SBs (Palmer 1986; McIlwraith et al. 1987; Riddell and Wright 1996; Lucas et al. 1999). The high prevalence of fragmentation in the DDiC bone and the opposing radial facet of the DPrC3 bone individually, paired, or in cases of multiple sites of fragmentation, appears to be related to the medial position of these bones. It has been suggested that the medial aspect of the carpus may be more susceptible to injury as it is less protected by overlying muscle and tendon, undergoes greater loading (Bramlage et al. 1988; Barr 1994) and is less able to attenuate weightbearing stress by transfer of load by interosseous displacement through intercarpal ligaments (Bramlage et al. 1988).

Sites of DPrC3 bone fragmentation were most common in US SB, followed by UK and AUS TB. The US SB and QH have relatively low prevalence of DPrC3 bone fragmentation compared with UK TBs and US SBs. Training regimens in US SBs, which predispose longer periods of slower speed intensity exercise (Lucas et al. 1999) may be a risk factor for fragmentation in the MCj. Standardbreds also race at a lower pace, pulling a sulky rather than carrying a jockey. This reduces vertical loading (Lucas et al. 1999). This may therefore displace the centre of gravity caudally and reduces loading of the carpus with the distance of forelimbs (Lucas et al. 1999). At slower speeds these stance phase has a greater duration within stride (Barr 1994), during which the carpus is loaded. Additionally, the third carpal bone is therefore loaded for longer at slower speeds, which may be associated with the greater frequency distribution, changes noted in the US SB (Lucas et al. 1999; Hopper et al. 2004).

In the current study, 45/57 (74%) of multiple sites of carpal fragmentation were symmetrically located in 2 limbs. Of this population, sites of fragmentation were identified in 165 (57%) left and 126 (43%) right limbs. In other limbs in this study, 54 left and 126 right forelimbs affected. In US TBs but not AUS populations, the incidence of left and right carpal fragmentation, being symmetrical in one limb related to (i.e. McIlwraith et al. 1987; Kobluk and AUS populations) fragmentation in the MCj. Radtke and Wright 1996). Geographical limb race has also been demonstrated in Australia where there is a difference between territories in direction of affected limbs, linked to clockwise direction (Radtke and Wright 1996).

A weakness of this study was that 45% of the total number of horses undergoing surgery did not have both limbs evaluated arthroscopically. Identification of all limbs affected and total sites of fragmentation was therefore be underestimated. However, all horses underwent bilateral radiographic examination and all joints considered radiographically appropriate by the surgeon were also evaluated arthroscopically. Of horses which underwent bilateral arthroscopy, 38% had fragmentation identified arthroscopically in only one limb. Differences may stem from radiographically undetectable lesions, subclinical disease and

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