FULL PAPER
Surgery

A retrospective study of radiographic abnormalities in the repositories for Thoroughbreds at yearling sales in Japan

Daisuke MIYAKOSHI[1)]*, Hiroyuki SENBA[2)], Mitsumori SHIKICHI[1)], Masaya MAEDA[1)], Ryo SHIBATA[1)] and Kazuhiro MISUMI[3)]

[1)]Hidaka Horse Breeders Association, 175-2 Shizunai Kamimori Shinhidaka-cho, Hokkaido 056-0002, Japan
[2)]The Japan Bloodhorse Breeders' Association, 517 Shizunai Tahara Shinhidaka-cho, Hokkaido 056-0144, Japan
[3)]Faculty of Veterinary Medicine, Kagoshima University, 1-21-24 Korimoto, Kagoshima 890-0065, Japan

ABSTRACT. This study aimed to evaluate whether radiographic abnormalities at yearling sales were associated with the failure to start racing at 2–3 years of age. Radiographic abnormalities in the carpal (n=852), tarsal (n=976), metacarpophalangeal (n=1,055), and metatarsophalangeal joints (n=1,031) from 1,082 horses, recorded at yearling sale, were reviewed. Eighty-two horses (7.6%) failed to start racing. Radiographic abnormalities such as wedged or collapsed tarsal bones, irregular lucency of a sagittal ridge at the distal aspect of the distal third metatarsal bone, and proximal dorsal fragmentation of the first phalanx in metatarsophalangeal joints were associated with failure to start racing in these horses. In the follow-up survey of 12 horses with one or more these radiographic abnormalities, the horses failed to start racing due to reasons unrelated to these radiographic abnormalities such as pelvic fractures (2 horses), fracture of a distal phalanx (1 horse), cervical stenotic myelopathy and proximal sesamoid fracture (1 horse), superficial digital flexor tendonitis (2 horses), laryngeal hemiplegia (1 horse), economic problems (2 horses) and unknown causes (3 horses). Although radiographic abnormalities at yearling sales can be associated with failure to start racing at 2–3 years of age, these radiographically detected abnormalities might not necessarily cause that failure.

KEY WORDS: racehorse, radiographic repository, radiography, Thoroughbred, yearling

In Japan, limb radiographs of Thoroughbreds on yearling sales lists have been kept since 2006. Buyers and their veterinarians can review these radiographs to help them select from the horses that are sold. Because radiographic abnormalities can decrease the contract price and sometimes these abnormalities are needed medical management of a horse, the prevalence of these abnormalities and the effects of these abnormalities on their future performances should be investigated. The prevalence of radiographic abnormalities at the time of yearling sales has already been reported in the U.S.A. [9], Australia [8], New Zealand [13] and South Africa [6], but not in Japan.

A radiographic study on 1,162 yearlings suggests that the ones with moderate to extreme palmar supracondylar lysis of the third metacarpal bone (MC3), dorsal medial intercarpal joint disease defined by a rounded appearance and/or thickened dorsal cortex of the radial carpal bone or proliferative changes, enthesophytes on proximal sesamoid bones, and proximal dorsal fragmentation of the first phalanx (P1) were less likely to start racing at 2–3 years of age than those without these abnormalities [10]. Another study on 2,401 yearlings suggested that a bone defect greater than 10 mm in length at the sagittal ridge of a metatarsus or sesamoid modeling in forelimbs could affect future racing performance [8]. It has been also reported that yearlings with enlarged vascular canals in their sesamoids could start fewer races and earn less prize money than horses with normal vascular canals [14]. However, a report on 348 yearlings presented no significant association between radiographic abnormalities and future performance [4]. There were some articles published about the relationship between radiographic abnormalities of horses at yearling sales in other parts of the world and the future performances of those horses; however, no data on Thoroughbred yearlings in Japan have been presented.

The aim of this study was to determine the prevalence rates of radiographic abnormalities in repositories at Thoroughbred yearling sales in Japan and to examine whether these abnormalities prevent yearlings from starting races at 2–3 years of age.

*Correspondence to: Miyakoshi, D.: active1982415@yahoo.co.jp

MATERIALS AND METHODS

Radiographic examination

Radiographic repositories for the limbs of 1,082 horses listed at yearling sales in Japan between 2007 and 2010 were examined. Radiographs of the carpal, tarsal, metacarpophalangeal (MCP) and metatarsophalangeal (MTP) joints of the left, right, fore, and hind limbs were evaluated. Three projections of the carpal joints were reviewed including the standing lateromedial, the dorso-lateral 35–45° to palmaromedial oblique, and the dorso-medial 25–35° to palmarolateral oblique views. Three projections of the tarsal joints were reviewed including the lateromedial, the dorsal 10–15° lateral-plantar medial oblique, and the dorsal 45° medial-plantar lateral oblique views. Also, four projections of the MCP and MTP joints were reviewed including the standing lateromedial, the dorsal 30° proximal-palmar/plantar distal oblique, the dorsal 15° proximal 45° lateral-palmar/plantar distal medial oblique, and the dorsal 15° proximal 45° medial-palmar/plantar distal lateral oblique views. Incomplete views and radiographs inadequate for diagnosis were excluded from the statistical analysis. Four investigators (DM, MS, MM and RS) evaluated the radiographs. Divergent diagnoses among the investigators were re-evaluated, and the final diagnosis was approved by the agreement of all investigators.

Confirmation system of radiographic abnormalities

The following findings on the radiographs were recorded as abnormalities.

On the carpal joints: In dorsomedial views of the carpal joints (=the dorso-lateral 35–45° to palmaromedial oblique views), signs of dorsal medial carpal disease were recorded if the radial carpal bone had a rounded appearance and/or thickened dorsal cortex or there were proliferative changes, enthesophytes or fragments involving the radial carpal or third carpal bones [8]. We recorded fragmented carpal bones, as well as those with osteophytes and circular lucency [9]. Fractured accessory carpal bones that including full vertical fractures and small radial facet fractures were recorded.

On the tarsal joints: lucency and fragments of the distal intermediate ridge and medial malleolus of a tibia were recorded. Lucency and fragments of the medial and lateral trochlear ridges of a talus were recorded [9]. Osteophytes in the intertarsal and tarsometatarsal joints, tarsal bones that were wedged or had collapsed and those with slab fractures were recorded [9].

On the MCP and MTP joints: Proximal dorsal, proximal palmar, and proximal plantar fragments of P1s were seen. Subchondral cystic lesions on the distal third metacarpal (MC3) and metatarsal (MT3) bones and on proximal P1s were also observed. A well-defined, semicircular notch on the proximal aspect of an MC3/MT3 sagittal ridge was seen [9]. Irregular lucency of a sagittal ridge at the distal aspect of an MC3/MT3 was defined as a defect only if the radiographic abnormality was visible at the midsagittal ridge of that MC3/MT3. Fragmentation of the distal aspect of an MC3/MT3 was defined as a fragment on the proximal aspect of the dorsal sagittal ridge of an MC3/MT3. Elongation of a proximal sesamoid bone was recorded if the bone was at least 2 mm longer than another proximal sesamoid of the same limb [9]. A proximal sesamoid bone was considered abnormally shaped if it showed proximal, distal or abaxial enlargement [9]. Fractures of proximal sesamoid bones were classified into apical, abaxial, basal, midbody and comminuted types [8]. Enthesophytes and osteophytes of proximal sesamoid bones were observed [9]. Vascular channels in medial and lateral proximal sesamoid bones were evaluated with respect to their shapes and the number of lesions that they had. A channel was considered linear if its width was less than 2 mm, and irregularly shaped if its width was greater than 2 mm [14]. On the basis of the characteristics of the vascular channels, the horses were classified into the following six groups: those with no regular vascular channels (group 1), those with one or two linear vascular channels (group 2), those with three or more linear vascular channels (group 3), those with one or two irregularly shaped vascular channels (group 4), those with three or more irregularly shaped vascular channels (group 5) and those with linear vascular channels that are not classified in groups 1–5 (group 6) [8].

Racing results and follow up survey

Horse racing data were obtained from the Japan Bloodstock Information System (Japan Bloodhorse Breeders' Association, Tokyo, Japan). From this database, 1,082 horses had radiographs in repositories. For these horses, the dates of first races and the number of race entries at 2–3 years of age were recorded. The horses were divided into the following groups based on whether they began racing between the ages of two and three: the "starter" group, in which horses had been in at least one race, and the "failure to start" group, in which horses had not been in a race.

A follow-up survey of 12 horses from the "failure to start" group with the radiographic abnormalities was conducted to determine the reasons that the horses did not start racing at 2–3 years of age. Follow-up information was obtained by telephone with veterinarians, breeders, trainers and owners. We asked them why the horses did not start racing at 2–3 years of age.

Statistics

Data in the present study were analyzed by using statistical software (JMP version 7.0, SAS Institute Inc., Cary, NC, U.S.A.).

The prevalence rates of types of radiographic abnormalities in the two groups were compared by using Fisher's exact tests. A P value <0.05 was considered statistically significant. Radiographic abnormalities present in under 10 cases were excluded from statistical analysis due to inadequate statistical power. In the six grouping of sesamoid bone vascular channels, the most popular group was used as a control and the other groups were compared to controls using Fisher's exact tests.

Table 1. Prevalence of radiographic abnormalities in carpus of starters and failure to start a race; 852 horses

Radiographic abnormalities	Over all incidence	Category	Starters		Failure to start a race		Odds ratio	95% confidence interval	P value
			Numbers	Prevalence	Numbers	Prevalence			
Dorsal medial intercarpal joint disease	16 horses	Present	14	87.5	2	12.5	1.7	0.4–7.6	0.36
	1.9%	Absent	771	92.2	65	7.8			
Circular lucencies at an ulnar carpal bone	109 horses	Present	107	98.2	2	1.8	0.2	0.05–0.8	0.007[a]
	12.8%	Absent	678	91.3	65	8.7			
Fragments	6 horses	Present	6	100.0	0	0.0			
	0.7%	Absent	779	92.1	67	7.9			
Osteophytes	24 horses	Present	22	91.7	2	8.3	1.1	0.2–4.6	0.70
	2.8%	Absent	763	92.1	65	7.8			
Circular lucencies at a carpal bone	10 horses	Present	10	100.0	0	0.0	N/A	N/A	1.00
	1.2%	Absent	775	92.0	67	8.0			
Fracture of an accessory carpal bone	2 horses	Present	2	100.0	0	0.0			
	0.2%	Absent	783	92.1	67	7.9			

N/A=Not applicable, All P values are for Fisher's exact test. a) Prevalence (%) was significantly (P<0.05) difference.

Table 2. Prevalence of radiographic abnormalities in hocks of starters and failure to start a race; 976 horses

Radiographic abnormalities	Over all incidence	Category	Starters		Failure to start a race		Odds ratio	95% confidence interval	P value
			Numbers	Prevalence	Numbers	Prevalence			
Lucency/fragment at the medial malleolus of a tibia	12 horses	Present	12	100.0	0	0.0	N/A	N/A	1.00
	1.2%	Absent	894	92.7	70	7.3			
Lucency/fragment at the intermediate ridge of a tibia	66 horses	Present	62	93.9	4	6.1	0.8	0.3–2.3	1.00
	6.8%	Absent	844	92.7	66	7.3			
Lucency/fragment at the lateral trochlear ridge of a talus	9 horses	Present	7	77.8	2	22.2			
	0.9%	Absent	899	93.0	68	7.0			
Lucency/fragment at the medial trochlear ridge of a talus	85 horses	Present	83	97.7	2	2.4	0.3	0.07–1.2	0.08
	8.7%	Absent	823	92.4	68	7.6			
Osteophytes in tarsometatarsal joints	91 horses	Present	81	89.0	10	11.0	1.7	0.8–3.4	0.14
	9.3%	Absent	825	93.2	60	6.8			
Osteophyte in distal intertarsal joints	295 horses	Present	270	91.5	25	8.5	1.3	0.8–2.2	0.34
	30.2%	Absent	636	93.4	45	6.6			
Wedging or collapse of tarsal bones	11 horses	Present	8	72.7	3	27.3	5.0	1.3–19.4	0.04[a]
	1.1%	Absent	898	93.1	67	6.9			
Slab fracture of tarsal bones	14 horses	Present	12	85.7	2	14.3	2.2	0.5–10.0	0.27
	1.4%	Absent	894	92.9	68	7.1			

N/A=Not applicable, All P values are for Fisher's exact test. a) Prevalence (%) was significantly (P<0.05) difference.

RESULTS

The number of samples

For the analysis of each type of joint, horses were chosen only if their radiographic views of that joint were complete and adequate for diagnosis. We excluded 230 horses from evaluation due to inadequate positioning of carpal radiographs—usually because the dorso-medial 25–35° to palmarolateral oblique view was too dorsopalmar—leaving 852 horses with adequate bilateral images for evaluation. We excluded 106 horses from evaluation due to inadequate positioning of tarsal radiographs—usually because the dorsal 45° medial-plantar lateral oblique view was too dorsoplantar–leaving 976 horses with adequate bilateral images fot evaluation. We excluded 27 horses from evaluation due to inadequate positioning of MCP radiographs–usually because the lateromedial view was an inaccurate lateromedial orientation–leaving 1,055 horses with adequate bilateral images for evaluation. We excluded 51 horses from evaluation due to inadequate positioning of MTP radiographs–usually because the lateromedial view was an inaccurate lateromedial orientation—leaving 1,031 horses with adequate bilateral images for evaluation.

Prevalence rates of radiographic abnormalities

The prevalence of radiographic abnormalities in the horse was summarized in Tables 1–6.

Six categories of radiographic abnormalities were apparent in the carpal joints (Table 1), and the circular lucency of the ulnar

Table 3. Prevalence of radiographic abnormalities in fore fetlocks of starters and failure to start a race; 1,055 horses

Radiographic abnormalities	Over all incidence	Category	Starters		Failure to start a race		Odds ratio	95% confidence interval	P value
			Numbers	Prevalence	Numbers	Prevalence			
Proximal dorsal fragments at P1	34 horses	Present	30	88.2	4	11.8	1.7	0.6–4.9	0.31
	3.2%	Absent	946	92.7	75	7.3			
Proximal palmar fragments at P1	6 horses	Present	5	83.3	1	16.7			
	0.6%	Absent	971	92.6	78	7.4			
SCLs at distal MC3	3 horses	Present	2	66.7	1	33.3			
	0.3%	Absent	973	92.7	77	7.3			
SCLs at proximal P1	2 horses	Present	1	50.0	1	50.0			
	0.2%	Absent	975	92.6	78	7.4			
Notch at the proximal aspect of MC3 sagittal ridge	256 horses	Present	243	94.9	13	5.1	0.6	0.3–1.1	0.10
	24.3%	Absent	733	91.7	66	8.3			
Fragments at the dorsal aspect of distal MC3	10 horses	Present	8	80.0	2	20.0	3.1	0.7–15.1	0.17
	9.5%	Absent	968	92.6	77	7.4			
Irregular lucency of a sagittal ridge at the distal aspect of the distal MC3	7 horses	Present	6	85.7	1	14.3			
	0.7%	Absent	970	92.6	78	7.4			
Palmar supracondylar lysis of MC3	6 horses	Present	5	83.3	1	16.7			
	0.6%	Absent	971	92.6	78	7.4			
Enthesophytes in palmar surface of P1	15 horses	Present	14	93.3	1	6.7	0.9	0.1–6.8	1.00
	1.4%	Absent	962	92.5	78	7.5			

N/A=Not applicable, P1=the first phalanx, MC3=the third metacarpal bone. All *P* values are for Fisher's exact test.

carpal bone was the most frequently found radiographic abnormality (12.8%, 109/852 horses). Eight categories of tarsal joint abnormalities were found (Table 2), and the presence of osteophytes in a distal intertarsal joint was the most common abnormality (30.2%, 295/976 horses). Sixteen categories of MCP joint abnormalities and 14 categories of MTP joint abnormalities were found (Tables 3–6). A notch on the proximal aspect of an MC3 sagittal ridge was the most common radiographic abnormality found in MCP joints (24.3%, 256/1,055 horses). Proximal palmar fragmentation of the P1 occurred more commonly in MTP joints (4.9%, 51/1,031 horses).

Radiographic abnormalities related to the failure to start a race

Of all the yearlings, 1,000 (92.4%) horses were assigned to the starter group, whereas 82 horses (7.6%) were in the "failure to start" group. Five radiographic abnormalities were significantly related to the failure to start a race at 2–3 years of age, while 26 categories of radiographic abnormalities were not related. Twelve categories of radiographic abnormalities were excluded from the statistical analyses because they were found in less than 10 horses.

Circular lucency at an ulnar carpal bone was significantly (*P*=0.007) correlated to the failure to start racing compared with those horses without circular lucency at that location (Table 1). Wedged or collapsed tarsal bones (*P*=0.040, Table 2), with irregular lucency of a sagittal ridge at the distal aspect of the distal MT3 (*P*=0.004, Table 5), or with proximal dorsal fragmentation of a hind P1 (*P*=0.030, Table 6) were also associated with failure to start racing. The vascular irregularities of fore proximal sesamoid bones were associated with the failure to start racing. The horses with a group 1-vascular irregularity were significantly less likely to start racing than those with a group 2 vascular irregularity (*P*=0.010, Table 4).

Follow up survey

There were two horses with wedged or collapsed tarsal bones, four horses with irregular lucency of a sagittal ridge at the proximal sagittal ridge of a distal MT3, three horses with proximal dorsal fragmentation of a hind P1, one horse with wedged tarsal bones and proximal dorsal fragmentation of a hind P1, and two horses with a sagittal ridge at the proximal sagittal ridge of a distal MT3 and proximal dorsal fragmentation of a hind P1. The actual reasons that the horses had not entered a race were pelvic fractures (2 horses), a fractured distal phalanx (1 horse), cervical stenotic myelopathy and a fractured proximal sesamoid bone (1 horse), superficial digital flexor tendonitis (2 horse), laryngeal hemiplegia (1 horse), economic problems (2 horses) or unknown cases.

DISCUSSION

In this study, 43 categories of radiographic abnormalities were found on examination of 1,082 horses at yearling sale. The horses with radiographic abnormalities such as wedged or collapsed tarsal bones, irregular lucency of a sagittal ridge at the distal aspect of the distal MT3 and proximal dorsal fragmentation of a hind P1 were significantly less likely to start racing at 2–3 years of age than the horses without these radiographic abnormalities. The horses with group 1, no regular or irregular vascular channels of

Table 4. Prevalence of radiographic abnormalities in fore proximal sesamoids of starters and failure to start a race; 1,055 horses

Radiographic abnormalities	Over all incidence	Category	Starters		Failure to start a race		Odds ratio	95% confidence interval	P value
			Numbers	Prevalence	Numbers	Prevalence			
Elongation of sesamoid bones	22 horses	Present	20	90.9	2	9.1	1.2	0.3–5.4	0.68
	2.1%	Absent	956	92.5	77	7.5			
Abnormal shape of sesamoid bones	87 horses	Present	80	92.0	7	8.0	1.1	0.5–2.4	0.83
	8.2%	Absent	896	92.6	72	7.4			
Fracture of sesamoid bones	4 horses	Present	4	100.0	0	0.0			
	0.4%	Absent	972	92.5	79	7.5			
Osteophytes in sesamoid bones	3 horses	Present	2	66.7	1	33.3			
	0.3%	Absent	974	92.6	78	7.4			
Enthesophytes in sesamoid bones	66 horses	Present	62	93.9	4	6.1	0.8	0.3–2.2	0.81
	6.3%	Absent	914	92.4	75	7.6			
Irregular vascular channels in sesamoid bones	162 horses	Present	150	92.6	12	7.4	1.0	0.5–1.9	1.00
	15.4%	Absent	826	92.5	67	7.5			
The vascular groups of sesamoid bones	32 horses 3.0%	group 1	25	78.1	7	21.9	0.3	0.1–0.7	0.01
	663 horses 62.3%	group 2	613	92.5	50	7.5			
	198 horses 18.8%	group 3	188	94.9	10	5.1	0.7	0.3–1.3	0.26
	110 horses 10.4%	group 4	102	92.7	8	7.3	0.1	0.4–2.1	1.00
	29 horses 2.7%	group 5	26	89.7	3	10.3	1.4	0.4–4.8	0.48
	28 horses 2.7%	group 6	22	95.7	1	4.3	0.6	0.1–4.2	1.00

All P values except for the vascular grade of sesamoid are for Fisher's exact test. P value of the vascular grade of sesamed is for χ^2 test.

Table 5. Prevalence of radiographic abnormalities in hind fetlock of starters and failure to start a race; 1,031 horses

Radiographic abnormalities	Over all incidence	Category	Starters		Failure to start a race		Odds ratio	95% confidence interval	P value
			Numbers	Prevalence	Numbers	Prevalence			
Proximal dorsal fragments at P1	33 horses	Present	27	81.8	6	18.2	2.9	1.2–7.3	0.03*
	3.2%	Absent	927	92.9	71	7.1			
Proximal palmar fragments at P1	51 horses	Present	47	92.2	4	7.8	1.1	0.4–3.0	0.79
	4.9%	Absent	907	92.6	73	7.4			
SCLs at the distal MT3 or proximal P1	0 horses	Present	0	0.0	0	0.0			
	0.0%	Absent	954	92.5	77	7.5			
Notch at the proximal aspect of MT3 sagittal ridge	165 horses	Present	152	92.1	13	7.9	1.1	0.6–2.0	0.87
	16.0%	Absent	802	92.6	64	7.4			
Fragments at the dorsal aspect of distal MT3	9 horses	Present	8	88.9	1	11.1			
	0.9%	Absent	946	95.6	76	7.4			
Irregular lucency of a sagittal ridge at the distal aspect of the distal MT3	32 horses	Present	16	72.7	6	27.3	5.0	1.9–13.1	0.004[a]
	3.1%	Absent	938	93.0	71	7.0			
Palmar supracondylar lysis of MT3	0 horses	Present	0	0.0	0	0.0			
	0.0%	Absent	954	92.5	77	7.5			
Enthesophytes in palmar surface of P1	17 horses	Present	15	88.2	2	11.8	1.7	0.4–7.4	0.37
	1.6%	Absent	939	92.6	75	7.4			

P1=the first phalanx, MT3=the third metatarsal bone. All P values are for Fisher's exact test. a) Prevalence (%) was significantly ($P<0.05$) difference.

the sesamoid bone, in the fore fetlocks were significantly less likely to start racing than the horses with group 2, one or two linear vascular channels. However, these radiographic abnormalities might not necessarily cause the failure to successfully start racing.

In this study, 11 horses (1.1%) had wedged or collapsed tarsal bones, and this finding was comparable to the prevalence of 1.2% (13/1,101 horses) reported in a study conducted in the U.S.A. [9]. It has been previously speculated [1] that a wedge-shaped

Table 6. Prevalence of radiographic abnormalitis in hind proximal sesamoid bones of starters and failure to start a race; 1,031 horses

Radiographic abnormalities	Over all incidence	Category	Starters		Failure to start a race		Odds ratio	95% confidence interval	P value
			Numbers	Prevalence	Numbers	Prevalence			
Elongation of sesamoid bones	8 horses 0.8%	Present	7	87.5	1	12.5			
		Absent	947	92.6	76	7.4			
Abnormal shape of sesamoid bones	64 horses 6.2%	Present	59	92.2	5	7.8	1.1	0.4–2.7	0.81
		Absent	895	92.6	72	7.5			
Fracture of sesamoid bones	14 horses 1.4%	Present	12	85.7	2	14.3	2.1	0.5–9.5	0.28
		Absent	942	92.6	75	7.4			
Osteophytes in sesamoid bones	13 horses 1.3%	Present	11	84.6	2	15.4	2.3	0.5–10.5	0.25
		Absent	943	92.6	75	7.5			
Enthesophytes in sesamoid bones	79 horses 7.7%	Present	74	93.7	5	6.3	0.8	0.3–2.1	0.83
		Absent	880	92.4	72	7.6			
Irregular vascular channels in sesamoid bones	182 horses 17.7%	Present	165	90.7	17	9.3	1.4	0.8–2.4	0.28
		Absent	789	92.9	60	7.1			
The vascular groups of sesamoid bones	90 horses 8.7%	Group 1	83	92.2	7	7.8	0.9	0.4–1.9	0.66
	596 horses 57.8%	Group 2	556	93.3	40	6.7			
	163 horses 15.8%	Group 3	150	92.0	13	8.0	1.2	0.6–2.3	0.60
	136 horses 13.2%	Group 4	124	91.2	12	8.8	1.3	0.7–2.6	0.36
	18 horses 1.7%	Group 5	15	83.3	3	16.7	2.8	0.8–10.0	0.12
	28 horses 2.7%	Group 6	26	92.9	2	7.1	1.1	0.2–4.7	0.71

All *P* values except for the vascular grade of sesamoid are for Fisher's exact test. *P* value of the vascular grade of sesamed is for χ^2 test.

fracture of the third tarsal bone could be related to incomplete ossification of the small tarsal bones. Overloading on an immature tarsal bone may result in valgus deformities and/or pathological fractures associated with the collapse of the third tarsal bone and/or the central tarsal bone [3]. Hence, wedging or collapse of the tarsal bones might become a serious factor delaying the start of racing careers. In our follow-up survey, however three of eleven horses could not start a race because of superficial digital flexor tendonitis, a pelvic fracture or unknown causes. The other eight of eleven horses with this radiographic abnormalities could start racing.

Irregular lucency of a sagittal ridge at the distal aspect of the distal MT3 was observed in 22 horses (2.1%) in this study. In two previous studies, this abnormality was seen in 1.7% (19/1,102 horses) and 7.5% (159/2,401 horses) of Thoroughbred yearlings [8, 9]. In another study, Standardbred racehorses with sagittal ridge lesions performed worse than those without lesions [7]. Also, yearlings with a defect greater than 10 mm in length in the sagittal ridge of an MT3 took longer to enter their first race, were less likely to start, and started in fewer races at 2–3 years of age than unaffected horses [8]. Our finding supported these previous studies. Generally, the prognosis is good for lucency at the dorsal aspect of an MC3/MT3 that is treated conservatively; this problem was resolved clinically in 80% (12/15) of horses, and for eight of these horses, radiographs showed that lesions had improved [12]. Although the etiology has not been satisfactorily explained in this study, lucency at the proximal sagittal ridge of a distal MT3 may be associated with delays in the age at which young horses start racing.

The prevalence (3.2%, 33 horses) of proximal dorsal fragmentation of hind P1s in this study was similar to those in previous reports (3.3% [9], 2.2% [8], and 2.0% [4]). In our study, horses exhibiting this abnormality were significantly less likely to start racing at 2–3 years of age than horses without this abnormality—similar to the Kane's study [10]. The return-to-use rate for arthroscopic surgery of a P1 associated with osteochondral fractures among 270 racehorses was 72% [11]. A follow-up study on 461 P1 fragmentation surgeries also indicated that 89% of the Thoroughbred horses were active above their presurgical grades [5]. It is recognized that small and non-displaced fractures can successfully heal with 120 days of complete rest [2]. It is needed to clear which treatment for P1 fragmentation of yearlings is the best to prevent poor performance in the future.

Kane *et al.* [10] reported that horses with moderate or extreme palmar supracondylar lysis of the third metacarpus were less likely to start racing at two or three years of age than horses without this radiographic abnormality. They found 24 horses (2.1%) with this radiographic abnormality and 14 of these horses started racing [9, 10]. In the present study, the prevalence rate of palmar supracondylar lysis of MC3 was 0.6% (6 horses). In the other studies of yearlings, Jackson *et al.* [8] reported the prevalence rate of this radiographic abnormality was 0.1% and Cohen *et al.* [4] reported that there were no cases of this radiographic abnormality. We were not able to ascertain the relationship between the failure to start racing and this radiographic abnormality because the number

of horses with this radiographic abnormality was small. It was not clear why the prevalence rate of this radiographic abnormality was different among studies.

In the present study, the prevalence rate of enthesophytes in sesamoid bones in the fore limbs was 6.3% (66 horses), and is higher than that in Kane's study (1.3%, 14/1,102 horses) [9]. The prevalence rate of modelling of the fore proximal sesamoid bones in Jackson's study [8] defined as proliferative change in the articular surface of the sesamoid bones, so included both osteophytes and enthesophytes was 3.8%, and this was lower than the prevalence rate of enthesophytes in sesamoid bones in the present study. Kane *et al*. [10] reported that horses with enthesophytes in proximal sesamoid bones were less likely to start racing than horses without this abnormality. Similarly, Jackson *et al*. [8] reported that modeling of the borders of the proximal sesamoid bones of the forelimbs was associated with a reduced chance of starting a race as a 2- or 3- year-old. However, enthesophytes in sesamoid bone was not associated with the failure to start a race at 2–3 years of age in the present study. The reason for this difference is unclear but may be related to the diagnoses of enthesophytes in the sesamoid bone. However, we defined this radiographic abnormality according to Kane's report [9]; we might include more mild cases, for example the slight irregularity changes of proximal sesamoid bones. Therefore, the prevalence rate of this abnormality in the present study was higher than those in the other two studies.

There were 16 cases with dorsal medial intercarpal joint disease, and the prevalence rate of this abnormality was 1.9% in the present study. This prevalence rate was lower than that in Kane's study (2.7%, 30/1,130 horses) [9]. Jackson *et al*. [8] reported enthesophytes at the carpal bones and the prevalence rate of this abnormality was 2.6%. Kane *et al*. [10] reported that dorsal medial intercarpal joint disease was associated with a decreased chance of starting a racing career. In contrast, the present study found that this radiographic abnormality was not significantly associated with the failure to start racing. Jackson's study [8] reported that change in radial and third carpal bones showed no significant association with beginning to race. The result of Jackson' study [8] was similar to the result of the present study. These discrepancies may be related to the presence of fragments involving the radial carpal bone or third carpal bone. The number of horses with these fragments in Kane's study [10] may be higher than those in Jackson's study [8] and in the present study. Horses with fragments involving the radial carpal bone or third carpal bone may be less likely to start racing than those without the fragments.

In this study, 12 horses with wedged or collapsed tarsal bones, irregular lucency of a sagittal ridge at the distal aspect of the distal MT3 and proximal dorsal fragmentation of a hind P1 reported these as reasons for "failure to start a race". However, the actual reasons associated with failure to start racing were different from these radiographic abnormalities. There may be no relationship or latent factors linked to radiographic abnormalities at yearling sales and the actual reason to fail to start racing at 2–3 years of age. There are three limitations to the present study. The first is the lack of clinical signs in the joints that show radiographic abnormalities. The second is the bias in the selection of the horses included in this study; it is likely that the horses with clinical symptoms associated with more severe radiographic abnormalities would not have been listed at the sales. The third is that some radiographic abnormalities did not find enough cases to establish a clear relationship between these radiographic abnormalities and starting a race or not. In future, to determine the relation between rare radiographic abnormalities and the racing careers of 2–3-year olds, larger surveys are needed.

We conclude that abnormalities found in the radiographs at yearling sales can be associated with failure to start racing at 2–3 years of age; however, not all of these radiographic abnormalities were the major reasons for horses to fail to start racing at 2–3 years of age.

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