Dorsoproximal proximal phalanx osteochondral fragmentation in 117 Warmblood horses

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Summary
The objective of the present study was to determine clinical and arthroscopic characteristics associated with dorsoproximal proximal phalanx (P1) fragments in Warmblood horses, as well as to examine their histopathological appearance. One hundred sixty-eight fragments were removed from 150 fetlocks of 117 Warmblood horses. Details of signalment and results of clinical examination were collected prior to surgery. After arthroscopic fragment removal and joint evaluation for synovial and/or cartilage abnormalities, the fragments were measured and evaluated histopathologically. The vast majority of the fragments (97.2%) were found medially, without predilection for front or hind limbs. In 10% of the joints, more than one fragment was present. The mean size of the fragments was 6.8 ± 2.6 mm. Only eight horses presented fetlock-related lameness. Horses of seven years of age and older (OR = 13.32, p = 0.033) and the presence of more than one fragment (OR = 11.12, p = 0.014) were significantly associated with lameness. Arthroscopic evaluation revealed one or more abnormalities in 50.7% of the joints. On histopathology, osteochondral fragments presented as a bony center covered with smooth hyaline cartilage on one side and some fibrous tissue on the other side. No clear histopathological signs were indicating precisely their origin. In Warmblood horses with dorsoproximal P1 fragments, the age (seven years and older) and the presence of more than one fragment in a fetlock significantly increased the risk of lameness. The osteochondral dorsoproximal P1 fragments could be defined as a developmental orthopedic disease.

Keywords
Warmblood horse, fetlock, osteochondral fragment, proximal phalanx, histopathology

Introduction
Diseases of the locomotory system are the most important causes of early retirement of horses (1). Prepurchase examinations are frequently performed in order to identify abnormalities or potential problems that would make the horse unsuitable for the intended use (2). Although the predictive value of certain radiographic findings is somewhat controversial, radiography has become an integral part of pre-purchase examinations. In addition to taking into account the animal’s specific performance characteristics, the presence or absence of radiographic abnormalities has become an important economic factor in the horse business (2, 3).

Proximodorsal proximal phalanx (P1) fragments are frequently detected during radiographic examination of the metacarpal and metatarsophalangeal joints (4–8). There are conflicting opinions on the nature of these fragments (9). In racehorses, they are considered to be traumatic in origin and cause lameness (10–16). Krook and Maylin (17) proposed that these fractures in Thoroughbred racehorses are manifestations of osteochondrosis (OC), but this is not generally accepted (13, 15). On a radiographic survey of yearling Standardbred horses, proximodorsal P1 fragments were diagnosed in 36 of 753 horses (4.8%) and were considered to be manifestations of developmental orthopedic disease (4). Similar fragments may be found in Warmblood horses and some of these fragments could be OC-related (13, 15). In immature horses they have been described as OC, but it is rare to find histologic evidence to support these claims (18).

When the fragments cause clinical signs, the treatment of choice is surgical removal via arthroscopy (11–16). However, there is some ambiguity concerning the clinical significance of such fragments in the metacarpal- or metatarsophalangeal joint (19, 20).

The aims of the present study were i) to determine the clinical and arthroscopic characteristics associated with the presence of dorsoproximal P1 fragments of the fetlock in Warmblood horses, and ii) to examine the histopathological aspect of these fragments in an attempt to determine their origin.

Materials and methods

Clinical and arthroscopic study
Warmblood horses presented for arthroscopic removal of one or more dorsoproximal P1 fragments in one or more fetlocks at the Large Animal Teaching Hospital of the Ghent University, Veterinary clinic ‘De Bosdreef’ and ‘Tierklinik Telgte’ between January 2004 and October 2006, were included in this study. The fragments were detected during pre-purchase radiographic examination and lameness investigation. Cases showing osteochondral fragmentation at a location other than the dorsal margin of P1 in an affected fetlock joint were excluded.

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The signalment of each horse was recorded and all of the horses underwent a complete clinical examination prior to surgery. The fetlock joints were categorized as presenting 'no', 'moderate' or 'severe' distraction after inspection and palpation of the dorsal and palmar/plantar pouch. Moderate distention was defined as the presence of synovial effusion, but without causing extreme tension on the joint capsule. The severely distended joints showed typical convex palmar/plantar pouches laterally and medially. The horses were trotted (hard and soft ground) and underwent flexion tests of the fetlocks. When lameness was present, intra-synovial anaesthesia of the metacarpal- or metatarsophalangeal joint was performed and the lameness was re-evaluated.

Radiographic examination always included a lateromedial view for location of the fragment(s) at the dorsoproximal aspect of P1 (Fig. 1). A more specific location was determined using oblique radiographs, and/or by performing ultrasonography of the dorsal aspect of the fetlock joint.

Arthroscopic removal of the fragments was performed using a standard dorsal approach and the site for the instrument portal was determined by needle placement in order to ensure optimal access to the fragment (21). During arthroscopy, the dorsal aspect of the fetlock joint was evaluated for the presence of abnormalities, such as mild synovitis (local or generalised moderate increase in number of normal synovial villi), severe synovitis (local or generalised important increase in number or the presence of severely thickened synovial villi), wear lines, superficial cartilage fribillation, cartilage erosions (local partial thickness cartilage loss) or severe cartilage damage (full thickness cartilage loss, exposure and/or damage of subchondral bone) on the dorsal aspect of the condyle. After removal, the size of the fragments on their long axis was recorded.

**Histopathological study**

The fragments that were retrieved during the last six months of the study period were fixed in 4% buffered formaldehyde solution, dehydrated and embedded in methyl methacrylate (Technovit 9100®). Four µm transverse sections were cut and haematoxylin-eosin, toluidin blue, von Kossa and sirius red stains were applied. In order to make a comparison with the histological features of OC, histological sections were included that had been obtained from 10 typical Osteochondrosis Dissecans (OCD) fragments of the intermediate ridge of the tibia (5) and the lateral femoral ridge (5). All of the fragments were histologically analysed using conventional light-microscopy.

### Results

**Clinical and arthroscopic findings**

One hundred sixty-eight fragments were removed from the dorsoproximal P1 of 150 fetlocks of 117 Warmblood horses: 40 mares, 38 stallions and 39 geldings with a mean age of 4.1 ± 2.7 years old (1 to 16 years old) (Table 1). In 88 horses, one joint was affected, while 25 horses had two joints and four horses had three joints with P1 fragments. There were 67 front limbs (44.7%) and 83 hind limbs (55.3%) involved. During inspection and palpation of the affected fet-
Dorsoproximal P1 osteochondral fragmentation

Locks, 126 joints were not distended, 14 joints presented moderate and 10 joints showed severe distension. Eight out of 117 horses were lame on the affected limb and showed a positive flexion test. Of these, six joints showed severe effusion, one moderate and one showed no distension. Intrasynovial anaesthesia of the involved fetlock was positive in all eight cases.

All fragments were removed during arthroscopy after determination of their exact location. A single fragment was found in 135 joints (90.0%), two fragments in 12 joints (8.0%) and three fragments in three joints (2.0%). In total, 160 (95.2%) fragments were found medially and eight (4.8%) laterally. The mean size on their long axis was $6.8 \pm 2.6$ mm (two to 14 mm) and 157 (93.5%) fragments were attached with fibrous tissue to the underlying bone. Three (1.8%) were fixed firmly (bone to bone contact), and eight (4.7%) fragments were floating free within the joint.

The arthroscopic joint evaluation revealed one or more abnormalities in 76 joints (50.7%): mild synovitis was present in 38 fetlocks, severe synovitis in 14, wear lines at the dorsal surface of the condyle in 15, superficial cartilage fibrillation in seven joints, cartilage erosions just reaching to the subchondral bone in 39 joints, and two joints presented severe cartilage and subchondral bone damage. In the remaining 74 joints (49.3%), visible abnormalities were not detected.

**Histopathological findings**

Fourty-five dorsoproximal P1 fragments were examined histologically. All of the fragments were rounded and showed a similar morphology: each fragment consisted of a bony centre covered with smooth hyaline cartilage on one side and some fibrous tissue on the opposite side (Fig. 2). The central osseous part had a compact and lamellar structure, and no areas of retained cartilage were evident within the subchondral bone of the fragments. There was a well defined osteochondral junction which did not show any growth activity between the osseous centre and its overlying cartilage cap. In all of the fragments, the extracellular matrix of this cartilage cap was hyaline in nature and had a smooth uniform aspect without any signs of degeneration. The chondrocytes did not show clustering, hypertrophy, calcifications or necrosis. In a fragment removed from a one-year old horse, alignment of the chondrocytes perpendicular to the joint surface was visible (Fig. 3). This architecture is very similar to young articular cartilage.

The fibrous tissue at the side where cartilage was not present showed the presence of small blood vessels.

The typical OCD fragments consisted of a central bony structure covered on the one side with a cartilage cap and on the other side with fibrous tissue. The central bone structure in all of the analysed fragments contained cores of retained cartilage. The transition between bone and hyaline cartilage was not well defined. The hyaline cartilage cap showed a smooth aspect, consisting of a hyaline extracellular matrix. A thin layer of fibrous tissue was present at the side formerly attached to the underlying bone.

The factors significantly associated with fragment characteristics, clinical symptoms and arthroscopic findings are recorded in Table 2.

Statistical analyses revealed a significant association between the sex of the horses and the number of fragments in a joint, with geldings being more likely to have more than one fragment (OR = 6.92; p = 0.016). Other significant correlations between the data of the horses (age, sex and breed) and the fragment characteristics (localization, size, number of fragments, fragment attachment) were not detected.

Univariable analysis revealed that the age of the horses (p = 0.033), the number of fragments (p = 0.019) and whether they were free floating or attached (p = 0.024) were significantly associated with clinical symptoms. However, in the multivariable analysis, only the number of fragments and the age proved significant.
analysis only the age of the horses and the number of fragments were significantly associated with the clinical findings. Independent from one another, older horses (seven years old and above) (OR = 13.32; p = 0.033) and the presence of more than one fragment in a fetlock joint (OR = 11.12; p = 0.016) were more likely to be associated with lameness. No other independent variables were significantly associated with the clinical findings.

The presence of arthroscopic abnormalities was significantly associated with the age of the horses. Horses of seven years and above were more likely to present one or more arthroscopic abnormalities (severe synovitis, wear lines, superficial cartilage fibrillation, cartilage erosions or severe cartilage damage) (OR = 11.81; p < 0.001). The arthroscopic findings were neither significantly associated with the clinical signs, nor with the other independent variables.

### Discussion

The present study describes the clinical and arthroscopic findings of 117 Warmblood horses presented with a combined total of 168 dorsoproximal P1 fragments in 150 fetlocks. The majority of these Warmblood horses were rather young (84.6% of the horses were younger than seven years old); had only one fetlock joint affected, and there was no statistical significant difference between front and hind limb involvement. As described for Thoroughbreds (11, 12, 14), the vast majority of the fragments (95.2%) originated from the medial part of the dorsoproximal rim of P1. Most of the fetlocks (90.0%) contained a single fragment which was attached with fibrous tissue to the underlying bone (93.5%) and their mean largest diameter was 6.8 mm ranging from two to 14 mm. Geldings were more likely to have more than one fragment in the affected fetlock, but due to the lack of any logical explanation this is considered to be more of a coincidental finding.

In the radiographs, these fragments appeared to be rounded with smooth borders and showed neither signs of a fresh or old fracture line, nor local bony reaction around the fragment or at the dorsoproximal border of P1. This suggests that these fragments were probably present for a longer period of time as described for Thoroughbreds (6, 8) and Standardbreds (4, 5, 7). A radiographic survey of 3749 young Warmblood horses revealed that 777 (20.7%) had a fragment in one or more fetlock joint (3), however, no information was given on the type and location of the fragments. Oblique radiographs and ultrasonographic examination were useful in order to determine the exact location and only horses with fragments that originated from the dorsoproximal border of P1 were retained for this study.

At the time of fragment removal, arthroscopic evaluation of the synovium and the cartilage of the dorsal aspect of the fetlock joints revealed joint abnormalities in 50.7% of the fetlocks examined and horses of seven years of age and above were significantly more likely to present severe synovitis and cartilage abnormalities. Stock et al. (3) stated that the presence of intra-articular fragments involves the risk of irreversible cartilage damage and predisposes the individual to developing degenerative joint disease. The results of the present study do not allow us to establish a direct causal relationship between the presence of the dorsoproximal fragments and the observed arthroscopic abnormalities. Unfortunately, objective studies on the presence of osteo-

### Table 2

Risk factors for fragment characteristics, arthroscopic findings and clinical signs in 150 joints of 117 Warmblood horses: parameters in the final multivariable logistic regression models, coefficients with standard errors, p-values and odds ratios with 95% confidence intervals (CI).

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Coefficients ± standard error</th>
<th>P-value</th>
<th>Odds ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-2.820 ± 0.864</td>
<td>0.001</td>
<td>-</td>
</tr>
<tr>
<td>Sex</td>
<td>-1.935 ± 0.802</td>
<td>0.016</td>
<td>6.92 (1.44-33.35)</td>
</tr>
<tr>
<td>Mare</td>
<td>-0.049 ± 1.023</td>
<td>0.962</td>
<td>0.95 (0.13-7.07)</td>
</tr>
<tr>
<td>Stallion</td>
<td>0.000 ± 0.000</td>
<td>0.000</td>
<td>-</td>
</tr>
</tbody>
</table>

Final model for clinical symptoms (lameness or not)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Coefficients ± standard error</th>
<th>P-value</th>
<th>Odds ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-2.699 ± 1.101</td>
<td>0.014</td>
<td>-</td>
</tr>
<tr>
<td>Age</td>
<td>-1.807 ± 0.525</td>
<td>0.025</td>
<td>-</td>
</tr>
<tr>
<td>7 years and above</td>
<td>0.997 ± 0.275</td>
<td>0.333</td>
<td>0.99 (0.84-1.15)</td>
</tr>
<tr>
<td>5 and 6 years</td>
<td>0.052 ± 0.275</td>
<td>0.998</td>
<td>1.00 (0.04-24.55)</td>
</tr>
<tr>
<td>3 and 4 years</td>
<td>-0.307 ± 1.361</td>
<td>0.822</td>
<td>0.74 (0.05-10.60)</td>
</tr>
<tr>
<td>1 and 2 years</td>
<td>0.000 ± 1.631</td>
<td>0.000</td>
<td>-</td>
</tr>
<tr>
<td>Number of fragments</td>
<td>-0.307 ± 1.361</td>
<td>0.000</td>
<td>-</td>
</tr>
<tr>
<td>&gt; 1</td>
<td>0.409 ± 0.000</td>
<td>0.016</td>
<td>11.12 (1.55-79.59)</td>
</tr>
<tr>
<td>1</td>
<td>0.000 ± 0.000</td>
<td>0.000</td>
<td>-</td>
</tr>
</tbody>
</table>

Final model for arthroscopic findings

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Coefficients ± standard error</th>
<th>P-value</th>
<th>Odds ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-0.486 ± 0.444</td>
<td>0.274</td>
<td>-</td>
</tr>
<tr>
<td>Age</td>
<td>-0.033 ± 0.003</td>
<td>0.997</td>
<td>-</td>
</tr>
<tr>
<td>7 years and above</td>
<td>0.033 ± 0.003</td>
<td>&lt; 0.001</td>
<td>11.81 (3.22-43.31)</td>
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<tr>
<td>5 and 6 years</td>
<td>0.033 ± 0.003</td>
<td>0.138</td>
<td>2.43 (0.75-7.89)</td>
</tr>
<tr>
<td>3 and 4 years</td>
<td>0.033 ± 0.003</td>
<td>0.117</td>
<td>2.04 (0.84-4.98)</td>
</tr>
<tr>
<td>1 and 2 years</td>
<td>0.033 ± 0.003</td>
<td>0.000</td>
<td>-</td>
</tr>
</tbody>
</table>

*Arthroscopic findings were classified as no abnormalities and only mild synovitis compared to severe synovitis, wear lines, superficial cartilage fibrillation, cartilage erosions or severe cartilage damage.
chondral fragments being a significant risk factor for faster development of degenerative joint disease have not been performed.

In the present study, a significant association was not found between the observed arthroscopic abnormalities and the clinical signs of lameness. All of the lame horses were admitted with arthroscopic abnormalities, but not every joint with arthroscopic abnormalities resulted in lameness at the time of evaluation. The clinical value of these observed lesions can be questioned. In racing Thoroughbreds, the prognosis (return to racing and return to racing at the same or higher level of performance) after arthroscopic removal of proximodorsal P1 chip fragments is better if other lesions (wear lines at the dorsal surface of the condyle, cartilage erosions, chronic proliferative synovitis and/or osteochondritis-dissecans) are not present within the joint (12). Warmblood horses possibly do not present clinical signs because they are not trained before the age of three and are not challenged at high speed, even when the same gross degenerative changes as racehorses are present. As a result of this, the detection of more subtle lamenesses or performance limitations can be more difficult in Warmblood horses compared to racehorses. Up to now, a follow-up study has not been carried out in Warmblood horses in order to evaluate whether the presence of arthroscopic abnormalities in the fetlock has an influence on future performance of the horses.

In the vast majority of horses (93.2%), clinical signs such as joint effusion, positive flexion test or lameness were not associated with the presence of the fragment(s), since most of these horses were young and the fragments were detected during prepurchase radiographic examination. The arthroscopic removal was performed as a ‘prophylactic’ measure before starting training activities and for selling purposes. Only eight horses were admitted with a lameness, but the presence of fetlock-related lameness was significantly associated with the age (seven years old and above) of the horses and the number (more than one) of fragments.

Some ambiguity exists concerning the clinical significance of these fragments and their prophylactic removal in horses that are not lame. The question arises whether leaving these fragments in place in non-lame horses would influence the competitive career of these horses. The results of the present study do not provide an answer to the question whether these fragments are causing further joint pathology, nor do they provide indispensible evidence that Warmblood horses benefit from such ‘prophylactic’ intervention. However, if they cause synovial and cartilage changes, once degenerative arthritis ensues, the removal of the fragment(s) does not reverse the changes that are present (14). Clinical evaluation of the horses revealed two independent significant risk factors for lameness: horses of aged seven years and above, and the presence of more than one fragment. Considering these arguments, the early removal of fragments at the time of detection might be prudent as goes the saying, ‘prevention is better than cure’.

The histopathology of the dorsoproximal P1 fragments revealed a bony structure covered with a hyaline cartilage on one side and some fibrous tissue on the other side. However, there were not any clear histopathological signs indicating the precise origin of these osteochondral fragments. The central, trabecular bone structure did not show any foci of retained cartilage typical of a failure in endochondral ossification associated with the development of osteochondrosis (22–25). Even the presence of a secondary centre of ossification could not be demonstrated (24). The examination of a fragment that was removed from a one-year-old horse showed alignment of the chondrocytes perpendicular to the joint surface (Fig. 3). This architecture is very similar to young articular cartilage. Apart from this, histopathological examination does not help to reveal the origin; therefore it is necessary to evaluate all aspects of these fragments in an attempt to define the origin.

The dorsoproximal P1 fragments in Warmblood horses can hardly be defined as ‘chip fractures’, as described in Thoroughbreds (10–16), for several reasons. Firstly, their smooth rounded radiographic appearance, the lack of a fresh or old fracture line or local bony reactions around the fragment or at their origin, all point to a longer history of presence. Secondly, the absence of clinical symptoms in a large group of the evaluated horses is not indicative of traumatic fragmentation. In case of a fracture, one would expect at least some synovial effusion at the time of development. Thirdly, the recurrence of fragmentation, which is in agreement with a fracture origin as seen in Thoroughbreds (14), has not been described or observed by the authors in Warmblood horses. Histopathology did not reveal any signs of a fracture, but on the other hand, it also does not exclude the possibility of fragmentation in a very early postnatal period.

Although histopathological examination did not reveal any typical characteristics of OCD (i.e. retention of cartilage cores in the central bone [22–25]), the radiographic and clinical appearance still point towards this.

Combining all of these arguments, it is possible that these fragments have incompletely detached in the early postnatal period, stayed connected to the ‘parent’ bone and developed accordingly. Due to the fact that there are difficulties in defining equine osteochondrosis and that confusion exists in choosing words (22), it is difficult to give a correct name to the present condition. Osteochondrosis is considered to be a manifestation of defective endochondral ossification (26), hence it may be most correct to define them as developmental orthopaedic disease, where a fragment of normal cartilage and/or bone quality detaches in an early postnatal period.

In Warmblood horses with dorsoproximal P1 fragments, the age (seven years and above) as well as having more than one fragment in a fetlock joint, significantly increased the risk of developing lameness. The osteochondral dorsoproximal P1 fragments could be defined as a developmental orthopaedic disease.

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