



## Osteoarticular radiographic findings of the distal forelimbs in Tbourida Horses



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### ABSTRACT

Tbourida is a traditional Moroccan equestrian sport in which 15 horses gallop 200 m in a line while riders fire into the sky with muskets. The stop is the finale and representative demands of this equestrian event. Such particular sudden stop after a fast gallop requires a hyperextension of the metacarpophalangeal joint. Indeed, it is well known that Tbourida show predisposes horses to different injuries of the hard and soft tissues of the distal forelimbs. Yet, there is a paucity of research that examined such lesions. The aim of the present study was to investigate for the first time the type and the prevalence of osteoarticular findings in the distal forelimbs of Tbourida horses using radiographic images. The study was conducted on 127 Tbourida horses aged between 2.5 and 15 years old with 6-year-old horses being the most affected. Data analysis showed that 93,7% of horses exhibit degenerative joint lesions of the fetlock, 86,6% showed ossification of the ungual cartilage, 78,7% had enthesophytes associated with the deep digital flexor tendons, 81,1% had enthesophytes associated with the suspensory ligament branches, and 19,6% showed a particular exostosis on the first phalanx. This large number of lesions reflects how this sport is difficult for horses and also argues that animals are suffering from a lack of welfare and care in their husbandry management.

### 1. Introduction

The Tbourida exhibition is a common sport occurring within the four North African countries: Morocco, Algeria, Tunisia and Libya. In Morocco, Tbourida shows are among the most popular sport and involve at least 10000 horses. Each year, more than 22 regional and inter-regional qualifications are organized and lead to a prestigious national cup. Unlike most other equestrian sports, Tbourida is requiring sudden stops and starts. This sport involves 15 horses to gallop 200 m while the riders are unloading and reloading their muskets in different positions, throwing them in the air, and catching them before firing into the sky [1] (Fig. 1). The stop is the finale, and representative of the physical demands of the Tbourida event. It is described as a sudden stop after a fast gallop, during which the horse engages his hind limbs under the body, thus requiring a hyperextension of the metacarpophalangeal joint. We

assumed that this specific and hard biomechanical pattern may damage on soft tissues and could result long-lasting injuries on bones and joints.

In addition, the Tbourida horses in Morocco are known to be reared with traditional practices. The objective of such farm management is to obtain fatty horses. This is traditionally considered as beauty sign and an eligibility condition for competition. To obtain fatty animals, horses are stabled and shackled during the year with little period of training. In addition, food is provided with an excess of energy by giving high quantity of concentrate. All this traditional and animal welfare problems could lead to the development of chronic osteoarticular lesions. For example, it is well known for all veterinarians that the dietary energy imbalance, Tbourida horses usually exhibit repeated serious episodes of laminitis [2].

There is a significant amount of literature on radiographic findings (RFs) of the distal limb of the different horse breeds and equine sports [3, 4]. However, nowadays, there is a lack of research that investigated

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**Fig. 1.** Photo showing the exhibition of Tbourida horses: 15 riders galloping for a distance of 200 m, unloading and reloading their muskets in different positions, throwing them in the air, and catching them before firing into the sky (written informed consent for publication of this image was obtained from Dr Ahmed Tibary, Comparative Theriogenology, Department of Veterinary Clinical Sciences, College of Veterinary Medicine, Washington State University, Pullman. The copyright of this image was also transferred).

the nature of lesions and pathologies in Tbourida Horses. In the present study, we investigated for the first time the type and the prevalence of osteoarticular RFs in the distal forelimbs of Tbourida horses.

## 2. Material and methods

The study was in agreement with the international ethical recommendations; it was conducted by using non-invasive imaging approaches.

### 2.1. Animals

The study involved a total of 127 male horses, aged between 2.5 and 15 years old with 122 Arab-Barb breed, 4 Barb breed and only 1 Anglo-Arab breed. The horses were randomly selected from 10 breeding farms and all were used exclusively for Tbourida shows in Morocco. The sample was divided into three age groups: the first age group from 2.5 to 5 years old with 52 horses, the second from 6 to 10 years old with 62 horses, and the third from 11 to 15 years old and contained 13 horses.

### 2.2. Radiographic examination

The handling of horses was not difficult. If needed, horses were sedated with xylazine (Bayer Health Care, Puteaux, France), 0.44–1.1 mg/kg IV, or acepromazine (Vetoquinol, Lure, France), 0.03–0.05 mg/kg IV. All radiographic examinations were performed in the field, at the breeding farms with a portable high frequency X-ray machine (Medison Acoma Co., Ltd., Tokyo, Japan). The study was realized during a period of 10 months and through successive visits to farms. The radiographic constants used were 60 kV, 15 mA with an exposure time of between 0.25 and 0.3 s. The distance between the cassette and the X-ray generator was 70 cm. A PROSCAN CR system (Protec GmbH Co. KG, Dorfriesen, Germany) for image development was used. To minimize the X ray effect on the operators, and to visualize the different joints of the distal forelimb (the metacarpophalangeal and interphalangeal joints), proximal, intermediate, and distal phalanx, navicular bone, and the proximal sesamoid bone (PSB), only 2 survey radiographic views were taken (lateromedial and dorsopalmar). Complementary projections were made if any particular physical finding was detected, or if a lesion was suspected on any basic projection. Radiographic interpretation was performed by a panel of three experienced equine veterinarian Professors working at the Equine University Hospital of Hassan II Institute of Agronomy and Veterinary (RA, MP, HA)<sup>1</sup>. They interpreted together the X

rays results to ensure the homogeneity of the data. All RFs were categorized by the location and type of change and then graded according to a standardized protocol depending on their severity and clinical relevance [5]. Indeed, a complete clinical examination of the horses with lameness evaluation were performed (data not shown) in order to evaluate the general health and to categorize the RFs. Therefore, images that are considered with possible clinical consequences were assigned as abnormal radiographic findings (ARFs), those that have little clinical significances and didn't affect neither the appearance nor the locomotion were called suspect radiographic findings (SRFs) [5].

### 2.3. Statistical analysis

A chi-squared test was used to statistically analyze variations in the prevalence of different RFs according to the age category. This allowed testing the significance of correlation between each lesion and age categories. The level of significance was set at  $P < 0.05$ . The breed was not taken into consideration because most horses (96%) were Arab-barb.

## 3. Results

The Analysis of all X-rays images performed in the present study has revealed 18 types of RFs. This included 17 ARFs and 1 SRF. The overall prevalence of the RFs in the total population and in the different age groups is presented in Table 1 below. A total of 940 lesions were detected in the radiographic screening with the fetlock region being the most affected (47%) followed by the coffin joint (42%) and then the pastern region (11%). Most of Tbourida horses (80,31%) showed multiple osteoarticular RFs in the same forelimb.

### 3.1. Abnormal radiographic findings

The ARFs were classified according to their important prevalence on Major and Minor ARFs, where frequencies of Major ARFs are ranged between 19,6% and 93,7% while Minor ARFs were less than 14,9%.

#### 3.1.1. Major ARF

**3.1.1.1. Degenerative joint lesion of the fetlock (DJLF).** The DJLF was the most frequent identified ARF with a prevalence of 93.7% (119 horses from the total of 127, see Table 1). It was more significantly ( $P < 0.05$ ) observed in the second and the third age category than the first one. Two stages of DJLF were observed: Stage I observed in 53% of affected Tbourida horses and corresponded to soft tissue reaction and bone

<sup>1</sup> (RA, RahmaAzrib; MP, Mohammed Piro; HA, Hassan Alyakine).

**Table 1**

Over all prevalence of the RFs given as the number and percentage in total population and according to the age groups.

| Lesions                | Prevalence of RFs in total population | Prevalence of RFs according to the age group. Number of subjects/percentage |                |                 | P-value       |
|------------------------|---------------------------------------|---|----------------|-----------------|---------------|
|                        |                                       | 2,5 to 5 years old  | 6–10 years old | 11–15 years old |               |
| DJLF                   | 119/93,7%                             | 44/85%  | 62/100%        | 13/100%         | <b>0,0021</b> |
| FSLE                   | 103/81,1%                             | 36/69,2%  | 55/88,7%       | 12/92,3%        | <b>0,0167</b> |
| DDFTE                  | 100/78,7%                             | 36/69,2%  | 53/85,4%       | 11/84,6%        | 0,0925        |
| ISLD                   | 77/60,6%                              | 29/55,7%  | 37/59,6%       | 11/84,6%        | 0,1595        |
| N S                    | 65/51,1%                              | 22/42,3%  | 34/54,8%       | 9/69,2%         | 0,1600        |
| PDA                    | 60/47,2%                              | 26/50,0%  | 29/46,7%       | 5/38,4%         | 0,7534        |
| Third phalanx osteitis | 58/45,6%                              | 25/48,07%   | 25/40,3%       | 8/61,5%         | 0,3404        |
| Sesamoiditis           | 56/44,09%                             | 23/44,2%  | 29/46,7%       | 4/30,7%         | 0,5720        |
| Laminitis              | 50/39,3%                              | 20/38,4%  | 24/38,7%       | 6/46,1%         | 0,8694        |
| EDSL                   | 42/33,07%                             | 13/25,0%  | 29/46,7%       | 0/0,0%          | <b>0,0014</b> |
| SDFTE                  | 29/22,8%                              | 14/26,9%  | 13/20,9%       | 2/15,3%         | 0,5989        |
| OBE                    | 25/19,6%                              | 5/9,6%  | 15/24,1%       | 5/38,4%         | <b>0,0297</b> |
| DLJA                   | 19/14,9%                              | 11/21,1%  | 8/12,9%        | 0/0,0%          | 0,1313        |
| Fetlock OCD            | 12/9,4%                               | 3/5,7%  | 7/11,2%        | 2/15,3%         | 0,4484        |
| Ligament calcification | 11/8,6%                               | 2/3,8%  | 6/9,6%         | 3/23,07%        | 0,0813        |
| PSB fracture           | 3/2,3%                                | 1/1,9%  | 2/3,2%         | 0/0,0%          | 0,7564        |
| NUEPTP                 | 1/0,78%                               | 1/1,9%  | 0/0,0%         | 0/0,0%          | 0,4834        |
| UCO                    | 110/86,6%                             | 46/88%  | 53/85%         | 11/84,6%        | 0,8754        |

Bold value indicates that there is a significance correlation between the corresponding radiographic findings and the age group. DJLF: Degenerative joint lesion of the fetlock; FSLE: Fetlock suspensory ligament enthesopathy; DDFTE: Deep digital flexor tendon enthesopathy; ISLD: Intersesamoidean suspensory ligament desmitis; NS: Navicular syndrome; PDA: Pastern degenerative arthropathy; EDSL: Entesopathy of the distal sesamoidean ligament; SDFTE: Superficial digital flexor tendon enthesopathy; OBE: Over growth bone exostosis; DLJA: Distal interphalangeal joint arthropathy; OCD: Osteochondrosis dissecans; PSB: Proximal sesamoid bone; NUEPTP: Non union of the extensor process of the third phalanx; UCO: Ungual cartilage ossification.

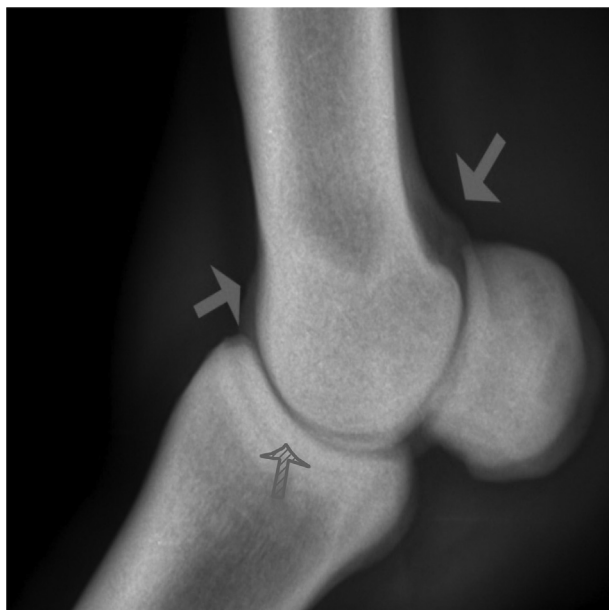
remodeling of the dorsal and palmar sites of the distal part of the third metacarpal bone and stage II was diagnosed in 47% of Tbourida horses and corresponded to subchondral bone sclerosis, joint space narrowing and presence of osteophytes (Figs. 2 and 3).

**3.1.1.2. Fetlock suspensory ligament enthesopathy (FSLE).** Results showed that the FSLE is the second important ARF found in the studied population just after the DJLF. This lesion was observed in 81,1% (103 horses, see Table 1) with significantly high prevalence ( $P < 0.05$ ) in the second and third age categories. Since the study focused on the distal forelimbs, only FSLE at the level of the metacarpophalangeal joint was diagnosed. This lesion was almost exclusively bilateral. It involved mostly the medial branch of the suspensory ligament and consisted of bone remodeling of

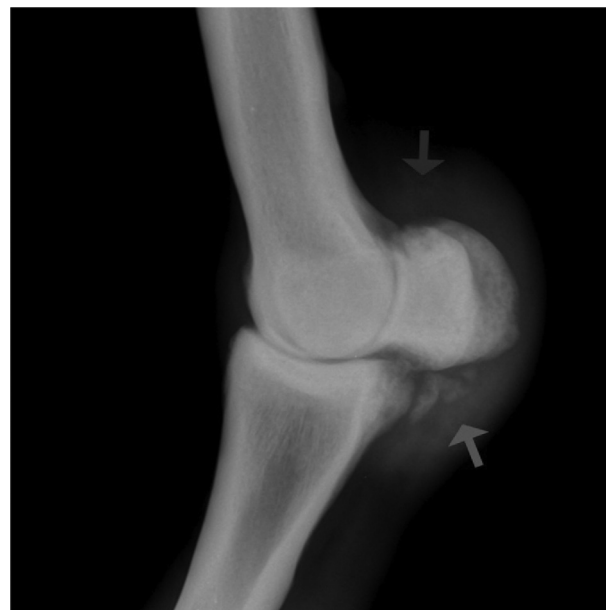
the proximal sesamoid bone (PSB) (Fig. 3).

**3.1.1.3. Deep digital flexor tendon enthesopathy (DDFTE).** All DDFTE lesions were bilateral and observed in 78,7% (100 horses, see Table 1) within the total population. The RFs of this lesion revealed bone remodeling of the distal phalanx at the attachment site of the deep digital flexor tendon (DDFT). Some times, the mineralization of the DDFT and podotrochlear bursa was also observed (Fig. 4).

**3.1.1.4. Intersesamoidean ligament desmitis (ISLD).** ISLD was detected in 60,6% (77 horses, see Table 1) of studied population. In major cases, this ARF revealed bone reaction of the PSB at the attachment site of the intersesamoidean ligament (Fig. 5). More than 81% of affected horses



**Fig. 2.** Lateromedial radiograph of the fetlock demonstrating degenerative joint disease stage 2 with reaction of soft tissue, bone remodeling at the third metacarpal bone, and joint space narrowing (arrows).



**Fig. 3.** Lateromedial radiograph of the fetlock demonstrating ossification of the distal sesamoidean ligament and sesamoiditis (arrows), with degenerative joint disease of the fetlock joint and enthesopathy of the suspensory ligament.



**Fig. 4.** Lateromedial radiograph of the distal phalanx demonstrating an increase of radiopacity on the third phalanx, at the insertion site of the deep digital flexor tendon (arrow).



**Fig. 5.** Dorsopalmar radiograph of the fetlock demonstrating an inter-sesamoidean ligament desmitis (arrow).

showed simultaneously the FSLE described above.

**3.1.1.5. Navicular syndrome (NS).** Within the total population, 51,1% (65 horses, see [Table 1](#)) showed NS in both forelimbs. On radiographic screening, horses with such lesion had different features of the navicular bone like palmar cortex erosion, medullary radiopacity and sclerosis ([Fig. 6](#)). Modification in the shape and the size of synovial invagination were also observed.

**3.1.1.6. Pastern degenerative arthropathy (PDA).** The PDA was revealed in 47,2% (60 horses, see [Table 1](#)) of the total studied population. Radiographic images revealed that all PDA-affected horses had simultaneously a DJLF. PDA corresponded to a lesion with narrowing space of



**Fig. 6.** Dorso-Proximal Palmaro-Distal oblique view of the distal forelimb showing signs of navicular syndrome (black arrows).

the proximal interphalangeal joint, subchondral bone reaction and osteophytes.

**3.1.1.7. Third phalanx osteitis.** Palmar and solar border irregularities with numerous vascular channels reflecting an osteitis of the third phalanx were identifiable on dorsopalmar and lateromedial radiography. Thus, horses affected by this lesion (45,6% of the total population) were bilaterally injured (see [Table 1](#)).

**3.1.1.8. Sesamoiditis.** Sesamoiditis was revealed in 44,09% (56 animals, see [Table 1](#)) of the studied Tbourida horses population. More than half of the affected horses (51,78%) belonged to the second age group (6–10 years). The lesion was bilateral in 98,2% (55 horses) of the affected horses and showed radiographically bone rarefaction of the PSB due to chronic demineralization.

**3.1.1.9. Laminitis.** Less than half of population (39,3%) was affected by bilateral chronic laminitis. The main radiographic features that were detected in Tbourida horses were the loose of parallelism between the hoof wall and the dorsal aspect of the distal phalanx. This was observed specially in the second age category (48% of total population, see [Table 1](#)). Dorsal hoof wall thickness, palmar rotation and distal displacement of the third phalanx were also diagnosed ([Fig. 7](#)).

**3.1.1.10. Enthesopathy of the distal sesamoidean ligament.** The bone remodeling of the palmar and proximal part of the first phalanx (P1) reflecting an enthesopathy of the distal sesamoidean ligament (EDSL) was diagnosed in 33.07% (42 horses, see [Table 1](#)) of studied population with significantly ( $P < 0.05$ ) high prevalence in the second age group (29 horses). 11/42 of these horses presented also on radiographic imaging an increase in radiopacity in both forelimbs of the distal sesamoidean ligament revealing its calcification.

**3.1.1.11. Superficial digital flexor tendon enthesopathy (SDFTE).** The SDFTE was revealed in 22,8% (29 Tbourida horses, see [Table 1](#)). Such lesion was characterized on radiographic screening by an important mineralization on the dorsal aspect of the middle phalanx and bone reaction at the attachment site of the superficial digital flexor tendon (SDFT).

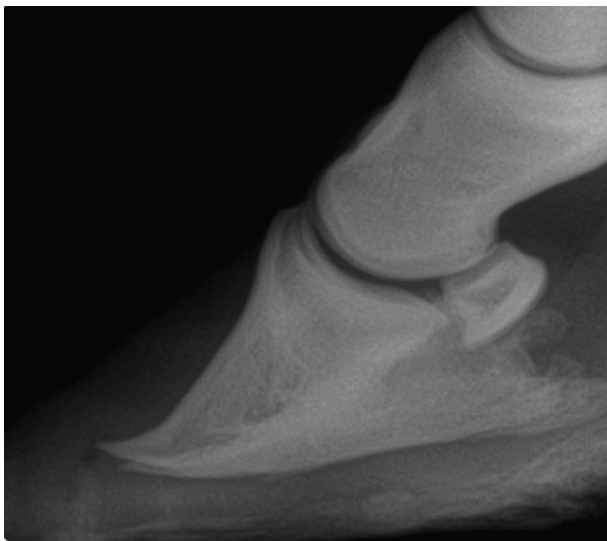


Fig. 7. Lateromedial radiograph of the distal forelimb showing with the loose of parallelism between the hoof wall and the dorsal aspect of the distal phalanx (Laminitis).

**3.1.1.12. Overgrowth bone exostosis of the first phalanx.** An overgrowth bone exostosis (OBE) of the P1 has been diagnosed on the dorsal and proximal part of the P1 in Tbourida horses. This lesion was observed with a high prevalence (19,6%: 25 horses, see Table 1). This ARF was seen as a particular and irregular overgrowth bony mass with a size and shape different from one animal to another (Fig. 8). However, in horses that showed bilateral injuries (20 horses), the shape was the same in both forelimbs. This bony exostosis involved almost all the dorsal and proximal parts of the P1 with a diameter that seems to be much larger on the lateral side. This lesion was significantly ( $P < 0.05$ ) more frequently observed in the second and third age group.

### 3.1.2. Minor ARF

The radiographic screening revealed other important ARFs with less frequency than what was described above. This included:



Fig. 8. Lateromedial radiograph of the fetlock demonstrating an exostosis on the dorsal and proximal part of the first phalanx in a 7-year-old Tbourida horse (arrow).

**The distal interphalangeal joint arthropathy (DIJA):** was observed only in the two first age groups with a prevalence of 14,9% (19 horses of total population, see Table 1). Radiographically, this lesion showed osteophytes on the extensor process of the third phalanx revealed on lateromedial view (Fig. 9).

**Fetlock osteochondrosis dissecans (OCD):** was another minor ARF that was diagnosed in 9,4% (12 horses, see Table 1). The horses affected by this ARF showed also the presence of the DJLF described above. In all cases (except in one horse) the lesion was bilateral (Fig. 10).

**The fracture of the proximal sesamoid bone:** was revealed in 2.3 % (3 horses, see Table 1) of the total studied population. Two horses aged of 7 and 8 years old presented a simple fracture without any clinical signs of lameness and 3 years old horse diagnosed with an apical fracture of the proximal sesamoid bone with disruption of the fetlock suspensory ligament. The horse showed on clinical exam a non weight-bearing lameness.

**Non-union of extensor process:** A four years old Tbourida horse showed bilateral non-union of extensor process of the third phalanx (Fig. 11), it is a rare case of osteochondrosis of the third phalanx in young horses. Clinically, the horse had poor limb conformation with toed out and heels down.

### 3.2. Suspected radiographic findings

Only one SRF was revealed in the presented study, which corresponded to an unguis ossification. Radiographically, all the ossified cartilages were smooth from the proximal to the distal part. No modification of external appearance and no lameness were seen in the clinical examination. The unguis ossification was bilateral (Fig. 12) and observed in more than 86,6% of Tbourida horses.

## 4. Discussion

The present study is the first to examine radiographically the distal forelimbs in Tbourida horses and to dress a list of significant osteo-articular findings that seems clinically serious. Some of these pathologies are depending of the age of animals.

### 4.1. Fetlock and pastern degenerative joint disease

Degenerative joint disease of the fetlock and pastern in Tbourida



Fig. 9. Lateromedial radiograph of the distal forelimb demonstrating osteophytes at the distal interphalangeal joint (arrow).



**Fig. 10.** Lateromedial radiograph of the fetlock demonstrating a fragment of osteochondrosis dissecans on the distal aspect of the sagittal ridge of the third metacarpal bone (arrow).



**Fig. 11.** Lateromedial radiograph of the distal forelimb demonstrating the non-union of the extensor process of the distal phalanx in a 4-year-old Tbourida horse with its fracture (arrow head).

horse were diagnosed in 93.7% and 47.2% respectively. These pathologies known also as osteoarthritis (OA) are ARFs, which adversely impact the economy of the equine industry and the health of the equine athlete. OA is one of the most common causes of lameness in horses. This lameness lead to a poor performance in sport horses and consequently to an early retirement of equine athletes [6, 7]. Many causes are reported to be behind the appearance of such disease like cartilage damage due to trauma, impact injuries, abnormal joint loading, excessive wear or as part of an ageing process [8, 9, 10].

Tbourida horses with these ARFs showed poor limb conformation. This finding seems to corroborate with another study that demonstrated that abnormal limb conformation led to improper load distribution on



**Fig. 12.** Dorsopalmar radiograph of the distal forelimb demonstrating bilateral ossification of the unguis cartilage in a 4-year-old Tbourida horse (arrows).

the articular surfaces, therefore increasing susceptibility to arthritic change [11]. The forces applied to the metacarpophalangeal joint in Tbourida horses when animals are moving at speed is probably involved in the development of osteoarthritic lesions. When galloping at high speed, the fetlock joint of Tbourida horses may be put under further stress by the obesity of the animal, which predisposes the joints to degenerative disease due to increased stress. This might also be explained by the application of hobbles around the pastern joint when the horse is stabled. Additionally, the biomechanical effect of the ground surface leads to musculoskeletal injuries in horses. It is now admitted that a comfortable track reduces by 50% the amplitude of the shock at hoof impact and reduce the vibrations that are generated producing an important level of deceleration at the braking phase of the hoof [12]. Tbourida shows usually take place on a hard surface ground. The shock waves generated at the hoof are intense and certainly affect the osteoarticular and the soft tissue of the distal forelimbs.

#### 4.2. FSLE, ISLD, sesamoiditis, EDSL, SDFTE and fracture of PSB

The mechanics and the anatomy of the PSB and the branches of the suspensory ligaments are intimately related. Thus, the development of a sesamoiditis may be a risk factor for the development of clinical signs of suspensory ligament branch injury (SLBI) [13, 14, 15].

The number and nature of vascular channels present on the abaxial surface of the PSB are characterizing the sesamoiditis in horses [16, 17, 18]. The significant sesamoiditis on radiography examination implies a 5 times greater risk of developing clinical SLBI with the beginning of training. In yearlings, the presence of sesamoiditis may be an indicator of future SLBI [19].

In our study, sesamoiditis was diagnosed in 44,09% of the sample. It was observed that the Tbourida horses were frequently rested for long periods of time before being abruptly returned to short periods of intense exercise. The lack of consistent and regular training throughout the year of Tbourida horses resulted in muscle weakness. Thus, the ligaments loosed significant quantities of water and glycosaminoglycans and synthesized less collagen [20] and reduced strength of bone-ligament bone complexes [21, 22]. Therefore, Tbourida horses are predisposed to develop FSLE, ISLD, EDSL, SDFTE and their calcification in some cases. The nature of Tbourida exhibition on a hard surface ground demanding a hyperextension of the fetlock joint during the sudden stop could

exacerbate the prevalence of these injuries.

Concerning the PSB fracture, it was demonstrated in thoroughbred horse that limiting exercise intensity and continuous time spent in racing-speed activity during a racing career is likely to decrease the incidence of PSB fracture in horses [23]. This could explain the low prevalence (2,3%) of PSB fracture in Tbourida horses.

#### 4.3. Deep flexor tendon enthesopathy, navicular syndrome, osteitis third phalanx and laminitis

Four different lesion types in the distal portion of the deep digital flexor tendon (DDFT) are recognized: core lesions, dorsal abrasions, sagittal plane and oblique splits and insertional lesions (including enthesopathy) [24, 25, 26, 27]. The most common site of DDFT lesion is at the level of navicular bone and proximal aspect of the navicular bursa, followed by its insertion on the distal phalanx and least commonly at the level of the proximal interphalangeal joint and proximal phalanx [28, 29].

Osseous changes that constitute enthesopathy include focal cortical bone loss, osseous cyst-like lesions, new bone production and sclerosis [30]. Radiographically, Foot examinations are almost always normal in horses with tendinopathy of the DDFT. Rarely, focal osteolysis and surrounding sclerosis may be seen in the facies flexoria of the distal phalanx on a lateromedial projection of the foot in chronic, severe cases of enthesopathy. The presence of dystrophic calcification in the distal portion of the DDFT is rare. The confirmation diagnosis requires the use of magnetic resonance imaging [30].

In the present study, the deep flexor tendon enthesopathy was an ARF detected in 78,7%. In Tbourida horses, Poor foot conformation, and the change of horse's gait particularly toward the finish line, have been shown to cause significant extension of the distal interphalangeal joint. This increases the traction of the deep flexor tendon and the inferior check ligament. The measurement of stresses on tendons in horses standing and walking was conducted in a study and concluded that the forces applied to the deep digital flexor tendon decrease when the angle of the wall of the foot increases [31]. Additionally, the exhibition of Tbourida horses in a hard surface ground predispose them to develop osteitis of the third phalanx and increase the degree of rotation of the third phalanx palmary or its distally rotation within the hoof in complicated cases of laminitis. During the sudden stop of Tbourida show, the deep digital flexor tendon slide on the palmar surface of the navicular bone. The friction of the DDFT could be behind the radiographic changes on navicular bone.

#### 4.4. Overgrowth bone exostosis of the first phalanx

A particular radiographic finding showing a bony overgrowth that looked like an exostosis on the dorsal and proximal part of the P1 was observed in 19,6% of the examined horses. In a recent study, we have diagnosed this lesion as an osteochondroma of the P1 [32]. Indeed, using different approaches (Computed tomography, Magnetic resonance imaging, histology analysis) on six ex vivo forelimbs of Tbourida horses that presented a particular OBE on the dorsal and proximal part of the P1 diagnosed previously by X-ray, computed tomography (CT) showed bone remodeling on the dorsal and proximal surface of the P1, with the presence of several bone fragments at this level. CT transverse reconstruction also revealed cortical and medullary continuity of the OBE, with underlying bone. Magnetic resonance imaging showed an increase in signal intensity on T1 and T2 -weighted gradient fast echo of the OBE. Histological examination of the OBE revealed a cap of hyaline cartilage, including large foci of endochondral ossification with a base of cancellous bone surrounding marrow spaces, which confirmed the diagnosis of osteochondroma lesion. Such osteochondroma lesions are rare in horses [32].

We think that the typical position of the Tbourida horse (exhibiting a hyperextended fetlock joint) especially at the sudden break, demanding

repetitive sliding of the common and lateral digital extensor tendons on the P1 and a hard surface ground during the show may be responsible for a high frequency of osteochondroma lesion in these horses.

#### 4.5. Distal interphalangeal joint arthropathy (DIJA)

The DIJA observed in the present study is an ARF that was diagnosed in 15% of the Tbourida horses. This is caused by normal forces on abnormal joint or abnormal forces on a healthy joint with the latter being most common due to poor conformation and improper trimming of Tbourida horses. Other factors may be involved, including biomechanical factors [33]. Predisposing factors including age, sex, breed, weight, and diet may also contribute to this disease [34, 35, 36]. The DIJA of the distal interphalangeal joint (DIPJ) is commonly associated with navicular disease and degenerative joint disease of the proximal interphalangeal and fetlock joint [37]. Clinically, horses with osteoarthritis of the DIPJ showed some palpable swelling of the distal dorsal part of the pastern, a tendency for hair along the dorsal aspect of the coronary band to stand erect. This probably reflects the relatively advanced stage of osteoarthritis in the horses [38, 39].

#### 4.6. Fetlock osteochondrosis dissecans

Osteochondral fragmentation (OF) of the fetlock known also as fetlock osteochondrosis dissecans (OCD) is a common lesion in the metacarpophalangeal/metatarsophalangeal (MCP/MTP) joints and is well recognized in sport horses like race horses [40, 41, 42, 43, 44] and in nonracing breeds [45].

Using the radiographic or the arthroscopic examination, OF can show many features. Thus, OF can be acute and sharply margined, or rounded in more chronic presentations. They may also be single or multiple, with various sizes and degrees of displacement [42, 46]. OCD is usually identified on standard radiographic projections of affected MCP/MTP joints [40], and is commonly diagnosed dorso-medially in affected forelimbs [42, 43, 46]. In a study conducted to identify the OF in European Warmblood breeds, it was concluded that there is no statistical difference between fore and hind limbs [45]. In the present study, OCD was diagnosed in 9,4% of the Tbourida horses. This ARF could be related as reported by Jeffcott L.B [47], Carlson et al [48] and Douglas J [49] to several risk factors: genetic predisposition, endocrine dysfunction, dietary imbalance, biomechanical stress, and repetitive trauma.

In another study already performed on Tbourida horses in Morocco, it was concluded that the absence of any vitamin or mineral supplement (VMS) in the diet of the Tbourida horses resulted in deficiencies or nutritional imbalances. This dietary imbalance could render the fetlock joint particularly vulnerable to the development of osteochondrosis dissecans.

#### 4.7. The non-union of extensor process of the distal phalanx

This rare condition of osteochondrosis was diagnosed in only one Tbourida horse. It occurs when the extensor process arises from a secondary center of ossification and fails to fuse [50]. This ARF should not be confused with a fracture of the extensor process of the distal phalanx because neither fracture line nor hard callus was detected on radiographic screening.

#### 4.8. Ungual cartilage ossification

The ossification of the unguinal cartilages in the forelimb is a common finding in many horse breeds like Finn horses, draft breeds, and Brazilian Jumper horses [51, 52, 53]. At the beginning, the nature of cartilages is hyaline, then progress with age to fibrocartilage and/or ossify [54]. Ossification of the cartilages follows different patterns [55] with the most common being ossification extending proximally from the palmar process followed by ossification via a separate center of ossification [53].

The aetiology of the ungual cartilage ossification is still unknown but could be associated with poor limb conformation, poor farriery or concussion [56]. The clinical significance of ungual cartilage ossification is often unknown [57] and may be considered an incidental finding during radiographic examination. However, a fracture of an ossified ungual cartilage can be behind a significant source of horse lameness [58]. This ossification affects both immature and adult horses [59] and is related more to the forces generated at the distal phalanx than the age of the animal.

According to the present study, ossification of the ungual cartilage represented a SRF and was diagnosed in 86,6% of the Tbourida horses. The prevalence of this lesion conducted in other studies was 79% in Finnhorses [55] and in 80% in Draught horses [53]. However, there was a significant effect of breed on maximum ossification grade of the ungual cartilage with in large native ponies (Dales, Highland, Fell and Connemara) and cob types, compared with other breeds (Irish draught, Crossbred, Thoroughbred, Thoroughbred Cross, Warmblood, Pony) [60].

Multiple times during the Tbourida show, the horses change suddenly their gait. They move from walking to trotting then to galloping at high speed to finally stopping suddenly at the finish line. The maximum vertical force applied on the sole of the hoof of a horse weighing 550 kg increases from 3600 N at walk to 6800 N at trot [61]. We believe that this increasing force with poor limb conformation and trauma generated by the use of hobbles when Tbourida horses are stabled may be responsible for this high frequency of ungual cartilage ossification.

## 5. Conclusion

The radiographic examination of the distal forelimbs highlighted a number of RFs in the Tbourida horses that could adversely affect their performance during the show. Not all osteoarticular injuries diagnosed by radiographic examination were associated with signs of lameness. The majority of the studied horses had poor limb conformation that predisposed them to certain lesions. Nowadays, no studies of the distal forelimbs in Tbourida horses have been performed and the little available data suggest that this sport is difficult for horses and that animals are suffering from a lack of welfare and care in their husbandry management. The involvement of factors such nutritional imbalances, trauma, poor training are largely incriminated. This particular sport seems to produce particular lesions. As an example, the OBE on the dorsal and proximal part of the P1 that we diagnosed later as an osteochondroma lesion seems to be uncommon and typical for Tbourida horses. This highlights the importance of further researches that should focus on the involvement of each factor (inadequate training, feeding or shackles) in the development of such RFS. In addition, awareness actions that veterinarians have to undertake to improve the welfare of Tbourida horses are important to reduce the prevalence of such lesions.

## Declarations

### Author contribution statement

Mohammed Seghrouchni: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Hind EL Kasraoui: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data.

Mohamed Piro, Hassan Alyakine, hassan Bouayad, Jamal Chakir, Noursaid Tligui: Conceived and designed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data.

Khalid El Allali, Rahma Azrib: Conceived and designed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

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## Competing interest statement

The authors declare no conflict of interest.

## Additional information

No additional information is available for this paper.

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