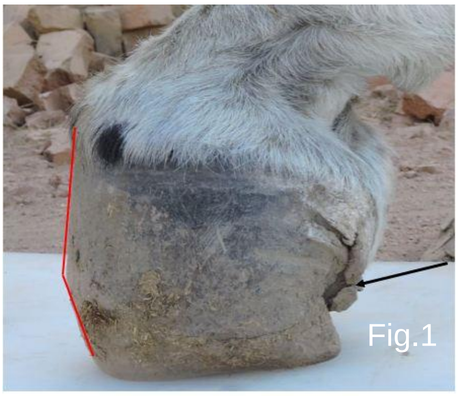
RESULTS

Club foot in donkeys were classified in the present study into three degrees according to toe angle (mean± SE), the first degree the toe angles less than (<90°) the mean was 77.6 ± 1.8°. The second degree the toe angles less or equal (≤ 130°) the mean was 106.3± 3.5° and the third degree more than (> 130°) the mean was 150.3± 7.00°. Bilateral hind club foot was diagnosed in 9 donkeys and unilateral in 8 hind limbs and 3 forelimbs.

The first degree of toe angle

The dorsal hoof wall appeared straight, convex or even segmented into two parts (Figure 1). The coronary band slope from dorsal hoof wall to heel appeared normal or migrated or concave in shape at the quarters or heel areas (Figure 1). The dorsal coronary band slightly bulged with marked wearing of the toe due to dragging. The loaded side of the hoof wall appeared rolled under and nearly straighter. The unloaded side appeared curved and flared side showed quarter cracks (Figure 2). Unsymmetrical ground surfaces. Atrophied frog migrated backward, out of bearing weight, contracted heels and the center groove of the frog is deep and extended to the coronary band hair line (Figure 3). Disparity in the two heels (Figure 4) and increased in lengths and heights with deep fissure at the base of the frog.



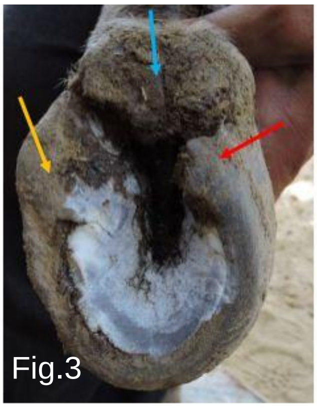


Figure 1. First degree club foot 14 years donkey showing dorsal hoof wall segmented into two parts, contracted heels and frog and the frog out of bearing weight (black arrow).
Figure 2. First degree club foot 9 years, the coronary band is not parallel to the ground surface (red arrow), the loaded side is straight (black arrow), the unloaded side is curved (yellow arrow).
Figure 3. First degree club foot 17 years, unsymmetrical ground surface, contracted, backward migrated and deep fissure at the base of frog (blue arrow), loaded heel is rolled under (yellow arrow) and the unloaded is fared (red arrow).
Figure 4. First degree club foot 14 years donkey, disparity heels with deep fissure at the base of the frog (yellow arrow).

The second degree of toe angle

The dorsal hoof wall was increased in lengths with wearing, damaged, cracks, hoof wall separation and quarter cracks. The overloaded toe appeared damaged (Figure 5). The dorsal coronary band is bulged, lost the slope, appeared parallel to the ground surface, concave in shape, with proximal migration at the medial and lateral quarters, with sever tension and pain on the common digital flexor tendon. The heels contracted and increased in heights and lengths. Fissures in the bulb of the heels with granulomatous inflammation involved the frog and skin of the pastern .Atrophied frog, the lateral and medial sulcui of the frog extended backward associated with deep fissure in the central sulcus of the frog extended to the hair line of the coronary band (Figure 6). The solar surface appeared deformed, square in shape and lost its normal shape. The frog deformed, lost the normal wedge shape with widening, deep lateral and medial sulcui and migrated backward (Figure 7).

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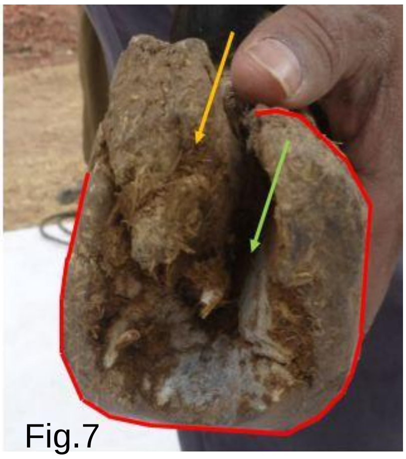
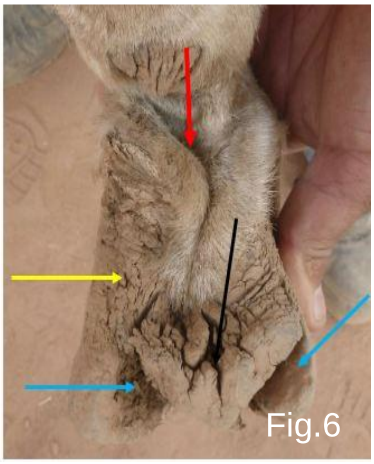
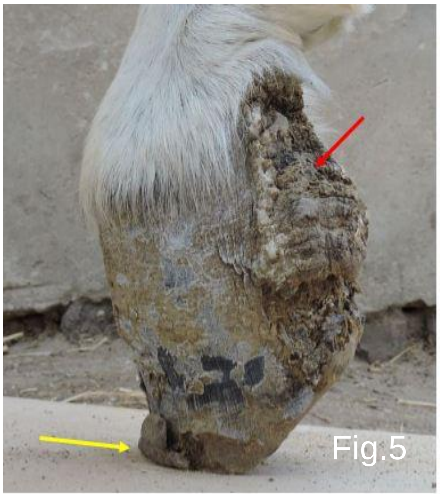
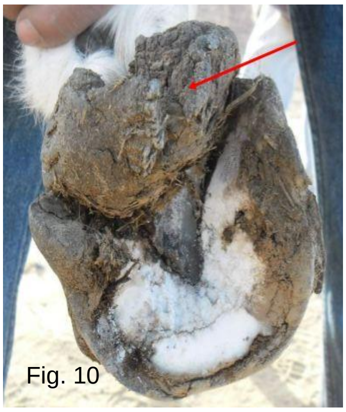
The third degree of toe angle

The entire ground surface of the foot is out of the weight bearing surface, landing and loading mainly on the dorsal wall surface or pastern during walking. The hoof wall showed wearing fragmented and separated. The coronary band appeared bulged, concave and contact with the ground surface during walking associated with proximal migration above the medial and lateral quarters and heels (Figure 8). There was marked increased of the heel height and lengths. The frog lost wedge shape and deformed. The central sulcus of the frog appeared as long narrow fissure and extended up to mid palmar/planter pastern above the base of the frog (Figure 9). The solar surface appeared square or irregular in shape. The horn materials of sole, frog and digital cushion were completely disappeared or destroyed and covered by hard keratin materials (Figure 10).









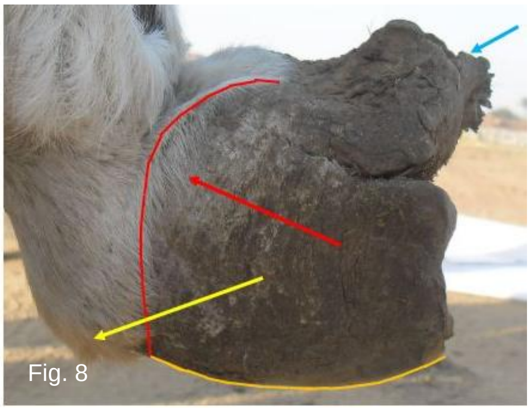


Figure 5. Second degree club foot 16 years, damaged and cracks of overloaded toe (yellow arrow), granulomatous inflammation at the base of frog, heels and the pastern (red arrow).
Figure 6. Second degree club foot 13 years, the digital cushion is atrophied (red arrow), contracted heels (yellow arrow), the lateral grooves is wider (blue arrow), the central sulcus extended to the hair line (black arrow).
Figure 7. Second degree club foot 13 years, the solar surface is deformed, square in shape (red line), the frog lost shape (yellow arrow) and widening deep lateral sulcui (green arrow).
Figure 8. Third degree club foot 19 years, the coronary band concave in shape (red line), dorsal coronary band contact with the ground (yellow arrow), frog migrated rear (blue arrow).
Figure 9. Third degree club foot 19 years, frog and digital cushion out of bearing surface. The central sulcus appeared long narrow and extended to mid planter pastern (red arrow).
Figure 10. Third degree club foot 19 years; solar surface became deformed, square and lost wedge shape (red arrow).

Radiographic evaluation of club foot

The 1st degree club foot showed osteophyte reactions at the proximo-dorsal aspect of the first phalanx. Osteolytic changes were appeared at navicular bone and third phalanx associated with palmar/planter soft tissues reactions (Figure 11). The 2nd degree club foot, radiographic changes displayed osteophyte reactions at dorso-distal aspect of the third metacarpal/metatarsal aspects and at the capsule of fetlock joint with narrowing the joint space. Palmar/ planter soft tissues thickening associated with osteophyte reaction of the navicular bone and at dorsal aspect of the second phalanx. The dorsal aspect of the third phalanx revealed osteolytic changes with decreased radio-opacity (Figure 12). The 3rd degree club foot revealed soft tissue reaction and thickening at the palmar / planter aspect of the distal limb with marked radio-opaque masses and calcification of palmar / planter structures. Osteohyte reaction was seen at the navicular bone, the dorsal aspect of 2nd phalanx and proximo-distal aspect of 3rd phalanx. The distal dorsal aspect of the 1st phalanx had osteophytic reactions with calcification of pastern joint. The 3rd phalanx showed osteolytic reaction at the dorsal, distal and at the tip of 3rd phalanx (Figure 13).

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Figure 11. (First degree): Lateromedial radiography revealed palmar radiodense mass (black star).

Figure 12. (Second degree): Lateromedial radiography revealed palmar radiodense mass (black star), osteophyte reaction at the dorsal wall of the Third phalanx (white arrow) with radiolucent zone within the disto dorsal aspect (the tip) of the Third phalanx (black arrow).

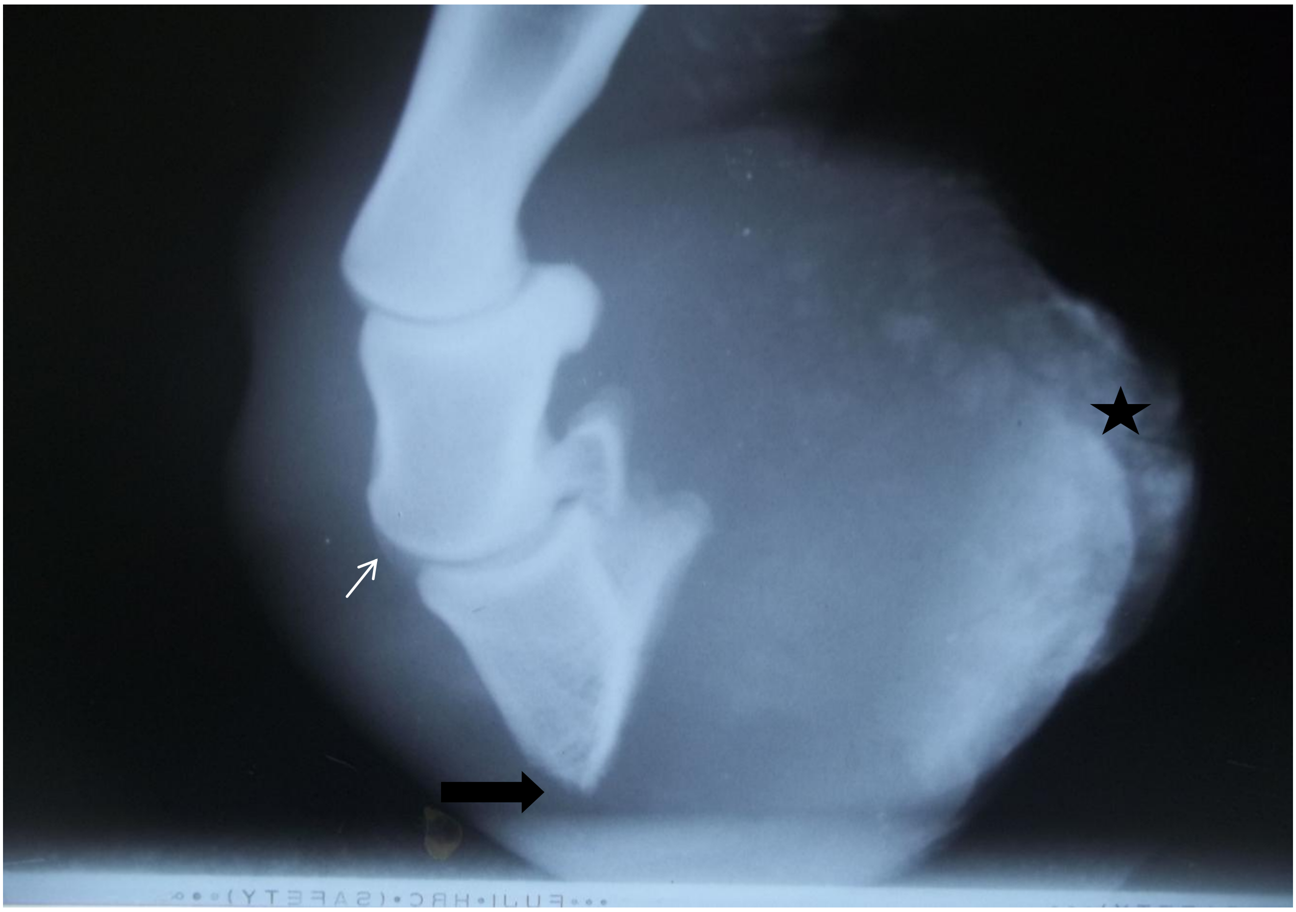

Figure 13. (Third degree): Lateromedial radiography revealed palmar radiodense mass (black star), osteophyte reaction at the distodorsal aspect of the Second phalanx (white arrow) with radiolucent osteolytic change at the disto dorsal aspect of the Third phalanx (bone loss at the tip of Third phalanx) (black arrow).

DISCUSSION

Club foot or Flexural deformity of the distal interphalangeal joint in horses can occur congenitally or acquired later in life due to overload, injury, environmental factors, or farriery practices (Hunt, 2011, Redden, 2014 and Curtis, 2017). Donkey club foot in the present study had three degrees according to measured toe angle. Increased heel heights and lengths, the loaded heels rolled under and the unloaded heels was flared, contracted heels, the digital cushion and frog atrophied and migrated back ward, the coronary band displaced, concave in shape or nearly parallel to the ground surface and dorsal coronary band bulged, hoof wall separations and toe and quarter cracks with wearing were the constant findings. In this respect, similar findings have reported in the horses (O'Grady and Dryden, 2012; O'Grady, 2014; Floyd and Mansmann, 2007; Redden, 2014) in horses. However, club foot in donkeys showed specific findings, the bulb of the heels and base of frog have deep fissures and the central sulcus appeared deep narrow and extended to the hair line. The digital cushion appeared contracted, atrophied associated with granulomatous inflammations. The horny materials of sole, frog and digital cushion were completely disappeared or destroyed and covered by hard keratin materials. These results were contradictory with the findings obtained in horses (O'Grady and Dryden, 2012) in the horses

Several classifications of clubfoot in horses have been reported (Redden, 2003; O'Grady, 2014) they classified club foot or flexural deformity into four grades depending on toe angle opposite to the healthy foot. In the present investigation donkey club foot was classified into three degrees based on the toe angles. The use toe angles for classification of club foot provide a reliable method in donkey due to 9 (41%) donkeys in the present study have bilateral, 8 donkeys unilateral and one had triple club foot deformities. Therefore, the use of opposite limb in the present study is unreliable.

Congenital and acquired club foot were reported and attributed to nutritional imbalance, trauma, improper trimming, persistent musculotendinous contractions of deep digital flexor muscle and pain (Redden, 2014). Club foot in this study could be attributed to stress and pain from hard work during pulling overloaded carts laden with bricks to and from the firing ovens of the brick kilns along the day. Therefore, overworking, stress and pain were considered the predisposing causes. However, acquired club foot in horses may be secondary to chronic lameness or injury (Hunt, 2011).

Club foot in donkeys displayed disparity, increased in heights and lengths associated with contracted heels. The dorsal hoof wall was landing and loading on the ground, wearing fragmented, toe and quarter cracks with hoof wall separations are common findings. Similar observations have been mentioned previously in horses (Floyd and Mansmann, 2007; O'Grady et al., 2007; Redden, 2014). They reported increased heel growth, raised heels, lead to distal interphalangeal joint flexion altered the distal phalanx alignment, prompts the toe first landing at the dorsum of the foot predisposed to excessive wear, toe and quarter cracks due to lack of adequate horn protection. Moreover, O' Grady et al. (2007) stated that club foot altered biomechanics of the foot result in an increased load being placed on the dorsal section of the foot during landing.

Previous studies proved changes hoof shape in club foot influenced by differing hoof growth rates at various sites around the hoof capsule lead to the hoof wall at the heels growing faster than the toe (Faramarzi et al., 2009), the viscoelastic composite of tubular and inter tubular horn (Dyson et al., 2011), plastic compression (Hood et al., 2001). In addition, the factors influencing changes in hoof capsule shape are thought to be associated with; hoof growth, wear at the bearing border, farriery, plastic deformation and normal weight-bearing and loading (Curtis, 2017). Therefore, the changes in the hoof capsule shapes in the present study could be attributed to multifarious agents mainly overloading, hoof compression, farriery, plastic deformation and hoof growth.

Collins et al. (2011) mentioned that donkey radiography is important for diagnosis of the internal relationships of the osseous structures of the foot and the distal phalanx and subjective assessment of the minor changes, as well as the relationship between the distal phalanx and the hoof capsule (Dyson et al., 2011). Several studies support that radiography foot conformation in horses had lapping and/or bone demineralization of the coffin bone due to the abnormal pressure distribution at the level of the apex of the third phalanx which compresses the blood supply that nourishes it (Redden, 2014; O'Grady and Dryden, 2012). The current findings observed osteophytic and osteolytic in the 3rd phalanx in club foot donkeys. Furthermore, previous guidance on foot conformation in the horses influences the forces acting on the structures in the foot, especially the deep digital flexor tendon, the navicular bone and the distal interphalangeal joint pathology (Wilson and Weller, 2011; Eliashar et al., 2004; Moleman et al., 2006; Holroyd et al., 2013). Similar findings have been seen in deep digital flexor tendon, navicular bones and osteoarthritis in fetlock joints in club foot donkeys supported the same reported in horses.

CONCLUSION

Club foot in donkeys displayed disparity, increased in heights and lengths associated with contracted heels. The central sulcus appeared deep narrow and extended to the hair line. The digital cushion appeared atrophied associated with granulomatous inflammations. The horn materials of sole; frog and digital cushion were destroyed and covered by hard keratin materials in the 3rd degree club foot. The use toe angle for classification of club foot provides a reliable method in donkey. Overworking, stress and pain were considered the predisposing causes in donkeys.

DECLARATIONS

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Competing interests

The authors have declared that no competing interest exists.

Authors' contribution

M.B. Mostafa was responsible for design, study execution, interpretation and preparation of the manuscript. A.I. Abdelgalil was responsible for data collection, radiographic interpretation and writing the manuscript. S. Farhat was responsible for execution**.**

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