Impact of Dimethyl Sulfoxide (DMSO) Combined with Corticosteroid on Repair of Fractures of the Proximal Phalanx in 14 Horses

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ABSTRACT
This study evaluates the impact of fetlock intra-articular and digital flexor tendon sheaths intra-synovial injections of dimethyl sulfoxide (DMSO) combined with corticosteroid as conservative treatment of mid-sagittal fractures of the proximal phalanx (P1) in horses. Fourteen horses with radiographically confirmed mid-sagittal fractures of P1 were recruited for this study. These horses were treated with fetlock intra-articular and digital flexor tendon sheaths intra-synovial injections of 5 mL of 20% dimethyl sulfoxide combined with 100 mg hydrocortisone sodium succinate. fiberglass cast was applied from the carpal joint and down to the hoof. Intravenous phenylbutazone was injected at a dose of 4.4 mg kg\(^{-1}\) for one week. The animal was kept for box confinement for 3-8 weeks. Lameness re-examination and follow up radiographs were performed for each horse after 1, 2 and 3 months of treatment. All data were expressed as mean and standard deviation. Horses with short and long incomplete mid-sagittal fractures showed clinical improvement in lameness after 10±1.5 and 18±3 days of treatment and returned to work after 33±2.5 and 55±5.5 days of treatment. Out of four horses with complete mid-sagittal fracture, three animals showed clinical improvement in lameness and recovery after 35±4.7 and 85±4.5 days of treatment. In conclusions, conservative treatment including; fetlock intra-articular and digital flexor tendon sheaths injection of DMSO combined with corticosteroid, fiberglass cast and box confinement can reduce the healing time and minimize the degenerative joint changes and healing callus in both incomplete and complete mid-sagittal fractures of the proximal phalanx in horses.

Key words: DMSO, horses, hydrocortisone, proximal phalanx, mid-sagittal fracture

INTRODUCTION
Fractures of the proximal phalanx (P1) are frequently common bone injury of thoroughbred and standard bred horses. Sagittal fracture is the most common fracture of the proximal phalanx. Mid-sagittal fractures were classified into short (less than 30 mm), long (greater than 30 mm) and proximal incomplete and complete fractures (Stashak, 2002; Bertone, 2004).

Longitudinal compression and a synchronous lateral to medial rotation or twisting of the P1 in relation to the third metacarpal/metatarsal bones were the central etiological factors (Ellis et al., 1987). The increase in P1 principal compressive and shear bone strains associated with restricted foot slip indicate that alterations in foot:ground interaction may play a role in fracture occurrence in horses (Singer et al., 2015).
The most common clinical signs of proximal phalangeal fractures were lameness, fetlock joint effusion, pain with flexion and rotation of the phalanges and hematoma on the proximal dorsal cortex of the proximal phalanx (Stashak, 2002).

Besides the clinical findings, several diagnostic imaging techniques have been applied for diagnosis of P1 fractures including; radiography, ultrasonography, computed tomography, arthroscopy and high-field or low-field magnetic resonance (Elce and Richardson, 2002; Dyson et al., 2011; Brunisholz et al., 2015).

Various modalities have been used for treatment of P1 fractures in horses depending upon the type of fracture. In addition, each of these modalities has several advantages and disadvantages. The P1 fractures have been repaired either by conservative treatment (Smith and Wright, 2014) or surgical interventions including; neutralized bone plates (Tetens et al., 1997), lag screws (Dechant et al., 1998), arthroscopy (Elce and Richardson, 2002), transfixation casting (Lescun et al., 2007), a tapered-sleeve transcortical pin external skeletal fixation device (Nunamaker and Nash, 2008). The main disadvantages of the surgical repair of P1 fractures are the expense, potential risks and complications associated with general anesthesia and surgery. Adverse outcome to return the horse to athletic function after treatment of non-comminuted P1 fractures with conservative and surgical repair with lag screw fixation has been reported (Tetens et al., 1997; Stashak, 2002).

Dimethyl sulfoxide (DMSO) has a potent anti-inflammatory, anti-arthritic, anti-platelet aggregation, analgesic, anti-bacterial, antifungal properties as well as the ability to serve as a free radical scavenger of free oxygen and hydroxyl radicals (Brayton, 1986). DMSO has been used alone or mixed with corticosteroids in horses to reduce soft tissue swelling and inflammation after acute trauma. In addition, DMSO promotes the absorption of corticosteroids and the effect of corticosteroid was increased 10 fold when DMSO was used as a carrier (Koller, 1976).

Due to the expense, potential risks and complications of general anesthesia and surgery, the purpose of this study was to report the outcome of fetlock intra-articular and digital flexor tendon sheaths intra-synovial injections of DMSO combined with corticosteroid as conservative treatment of mid-sagittal fractures of the proximal phalanx in horses.

**MATERIALS AND METHODS**

This study was conducted on 14 draught horses admitted to the surgery clinic at Faculty of Veterinary Medicine, Cairo University, Egypt.

All horses suffered from forelimb lameness, fetlock joint effusion and hematoma on the proximal dorsal cortex of the proximal phalanx. Full case history was obtained and thorough clinical examination was carried out for all horses. The examined horses were subjected to fetlock joint flexion test. Fracture of proximal phalanx was suspected in all horses.

Plain radiographic examination was carried out in all examined horses with an X-ray machine (Fischer, Stuttgart, Germany). The radiographic setting factors were 55-60 kVp, 10 mA and 90 cm focal spot film distance (FFD). Dorsopalmar and lateromedial views were taken in all cases. Dorsolateral palmodial, dorsomedial palmodio lateral oblique views were taken when necessary. Fractures were diagnosed and identified as previously described (Markel and Richardson, 1985).

Conservative treatment of P1 fractures included fetlock intra-articular and intra-synovial of deep digital flexor tendon sheaths injections of 5 mL of 20% Dimethyl sulfoxide (DMSO®, Diamond Lab., USA) combined with 100 mg hydrocortisone sodium succinate (Solu-Cortef®, EPICO, Egypt). Fiberglass cast (Fiberglass cast®, Afri Medical Co., Egypt) was applied from the carpal joint and

down to the hoof. Intravenous non steroidal anti-inflammatory, Phenylbutazone (Phenyloject®, ADWIA, Egypt) was injected at a dose of 4.4 mg kg$^{-1}$ for one week. The animal was kept for box confinement for 3-8 weeks. Lameness re-examination and follow up radiographs were performed for each horse after 1, 2 and 3 months of treatment.

Statistical analysis: All data were expressed as mean and standard deviation using SPSS-version 20 (IBM Corporation, 2009, New York, USA).

RESULTS

Clinical and radiographic examinations revealed mid-sagittal fracture at the proximal phalanx in all horses. The mean age and weight of affected horses were 5.2 years and 520 kg. The affected animals were 10 horses and 4 mares. All horses had a history of a single forelimb lameness for a period of 2-28 days prior to the examination (mean 14.5±0.5). Lameness appeared 24-48 h after heavy exercise or fast work.

The clinical signs included forelimb lameness, little weight bearing on the affected limb, fetlock joint effusion, hematoma and pain at the dorsal surface of the proximal phalanx. The clinical examination revealed lameness before and after flexion test of the fetlock joint.

Proximal phalanx fracture was recorded in either left (8 cases) or right forelimb (6 cases). Short incomplete mid-sagittal proximal phalanx fractures, long incomplete mid-sagittal proximal phalanx fracture and complete mid-sagittal proximal phalanx fractures were observed in 5, 5 and 4 horses, respectively. A distinct fracture pattern with one (11 cases) or two subchondral fracture lines (3 cases) running parallel in close proximity to each other was identified.

The impact of conservative treatment of short and long incomplete and complete mid-sagittal fractures of proximal phalanx was favorable in 13 horses. Moreover, all recovered horses resumed full service and returned to the intended use in short duration with minimal arthritic changes. The lameness improved at walking and appeared during trot after 10±1.5 days in horses with short incomplete mid-sagittal fractures (Fig.1a). These affected horses were recovered and returned to exercise and work after 33±2.5 days of treatment (Fig.1b).

Horses with incomplete long mid-sagittal fractures showed clinical improvement in lameness after 18±3 days of treatment and complete recovery after 55±5.5 days of treatment.

Complete mid-sagittal fractures of proximal phalanx extending through lateral cortex (2 cases) and proximal interphalangeal joint (2 cases) were diagnosed in four horses (Fig. 2a). All horses had synovial distensions of the palmar pouches of fetlock joint and synovial digital flexor tendon sheaths with non weight bearing.

Three horses showed clinical improvement in lameness 35±4.7 days after treatment and recovery after 85±4.5 days after treatment (Fig. 2b).

One mare with old complete mid-sagittal fracture of proximal phalanx extending through proximal inter-phalangeal joint (Fig. 3a) showed persistence lameness with no clinical and radiographic improvement after 12 weeks of treatment. Radiography displayed secondary degenerative joint disease of the fetlock joint and osteophytes formation at the dorsal aspects of the metacarpal bone and proximal phalanx (Fig. 3b). Other complications including; weight bearing laminitis and digital flexor tendinitis were also developed in the contra-lateral limb. The owner was advised to destroy this mare.

DISCUSSION

Fractures of the proximal phalanx are one of the most common fractures of Thoroughbred horses in training and limited details on the effective treatment have been published (Smith and
The P1 is prone to mid-sagittal fracture and less commonly frontal plane longitudinal fractures due to heavy exercise (Bertone, 2004; O’Hare et al., 2013).

The mean age and weight of the affected animals were 5.2 years and 525 kg. These findings differ from other study which recorded the mean age of 9.5 years and mean body weight of 574 kg (Brunisholz et al., 2015). This difference could be attributed to the breed of examined horses with P1 fractures.

As other orthopedic affections in horses (Mostafa et al., 2014a, b; Senna et al., 2015), diagnostic imaging tools including; radiography, Computed Tomography (CT), ultrasonography, arthroscopy, high-field and low-field magnetic resonance have been used for diagnosis of P1 fractures in horses (Dyson et al., 2011; Brunisholz et al., 2015). Horses included in this study on the basis of both clinical and radiographic diagnosis of incomplete (short and long) or complete sagittal fracture of proximal phalanx (P1). In this respect computed tomography is superior to radiography in both identifying the fracture and determining fracture size and location (Brunisholz et al., 2015). Moreover, high-field or low-field Magnetic Resonance (MR) imaging confirms the presence of a fissure fracture or subchondral and trabecular bone trauma of the P1 (Dyson et al., 2011; Pownder et al., 2015).

All of the examined horses had single P1 fracture of the forelimb. In contrast, Brunisholz et al. (2015) reported fourteen forelimbs and 10 hind limbs with P1 fractures. This difference could be
attributed to the total number of the examined horses. Moreover, all examined horses had mid-sagittal P1 fracture. On CT, 92% of P1 fractures were located in the mid-sagittal plane (Brunisholz et al., 2015). The recorded clinical signs and radiographic findings in this study were previously reported (Tetens et al., 1997).

Contrary to our findings, horses treated conservatively by cast and stall rest required approximately 3-4 months of treatment to become free from pain and lameness, in addition they developed exostosis at the fracture site and secondary joint disease that might cause lameness when returned to work (Ellis et al., 1987; Tetens et al., 1997; Kuemmerle et al., 2008). Meanwhile, P1 fractures treated surgically with lag screw fixation, reduced this protracted healing time by half and resulted in less callus and degenerative joint changes (Holcombe et al., 1995). Lescun et al. (2007) added that the outcome of surgical repair is better than conservative treatment of P1 fractures especially comminuted one.

Compared to the previous studies, the present results indicate that addition of DMSO combined with corticosteroid to the usual conservative treatment showed dramatic improvement in lameness and pain in horses suffered from short and long incomplete mid-sagittal fractures and complete mid-sagittal fracture of proximal phalanx after 10±1.5, 18±3 and 35±4.7 days of treatment. The positive impact of using DMSO with Hydrocortisone in this study support previous suggestions for
treatment of extensive tissue trauma, osteoarthritis and periosteal reaction involving the carpal and fetlock joints and the metacarpal bones with DMSO (Robert, 1982). Moreover, the use of intra-articular corticosteroids in joint diseases enhances glycosaminoglycan (GAG) content and GAG synthetic rate in the articular cartilage, as well as has potent anti-inflammatory and chondroprotective effects (Mcllwraith, 2002).

Complete mid-sagittal proximal phalanx fractures opening through the lateral cortex were associated with synovial effusions in the fetlock joint and digital flexor tendon synovial sheath. Fetlock intra-articular and intra-synovial digital flexor tendon sheaths injections of DMSO and corticosteroid associated with application of fiberglass cast at the lower limb and box confinement showed favorable results after 35±4.7 days of treatment and improved well after 85±4.5 days of treatment. However, surgical lag screw fixation or neutralized plate associated with fiberglass cast was recommended in similar cases before (Ellis et al., 1987; Tetens et al., 1997).

In this study, one mare had an old complete mid-sagittal fracture extending through the proximal inter-phalangeal and fetlock joint that showed no significant improvement, persistence lameness and degenerative joint changes. This could be attributed to the chronicity of the case,
therefore early treatment is recommended for good repair of the complete fracture of P1. Similar findings have been described during healing of comminuted fracture (Ellis et al., 1987) and during short incomplete mid-sagittal fracture (Markel and Richardson, 1985). This poor prognosis for horses with complete P1 fractures was attributed to the disruption of the articular surface and development of cartilage erosion and osteophytes (Holcombe et al., 1995). The articular cartilage is a highly differentiated structure and has a limited respiratory potential due to the lake of organization, lymphatic vessels and innervation (Abu-Seida, 2015).

CONCLUSIONS

In conclusions the addition of fetlock intra-articular and intra-synovial of deep digital flexor tendon sheaths injection of DMSO combined with corticosteroid to the usual conservative treatment including fiberglass cast and box confinement can exert favorable effects, reduce the healing time and minimize degenerative joint changes and healing callus in horses suffered from incomplete and complete mid-sagittal fractures of the proximal phalanx.

REFERENCES


