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Subchondral cyst of distal phalanx in young and mature horses: a new surgical option

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Abstract:

Background: No agreement to the optimal medical or surgical treatment of subchondral cystic lesions (SCLs) has been achieved yet. Conservative treatment outcome of subchondral cystic lesions of the distal phalanx may be scarce, and different surgical approaches might be limited due to the lesion localization. **Objectives**: To describe a surgical technique to treat subchondral cystic lesions of the distal phalanx with an absorbable device, regardless to SCLs localization, that eliminates lameness and stimulates bone healing in both young and mature horses. **Study design:** Clinical case series. **Materials and methods**: 5 young horses and 5 mature horses were lame due to subchondral cystic lesion of the distal phalanx. Only rest and medical treatment were previously attempted. An absorbable screw has been inserted in all horses. Follow up was obtained by official electronic database. **Results**: All horses returned to athletic activity after surgical treatment. In two cases, surgical complication was recorded. **Main limitations:** The low number of patients, the need of dedicated instruments and familiarity with the use of absorbable device to perform surgical procedure. **Conclusions**: The insertion of an absorbable device can be considered a valid surgical option to treat subchondral cystic lesions of the distal phalanx.

Subchondral cyst of distal phalanx in young and mature horses: a new surgical option

New surgical option for the treatment of distal phalanx cysts

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Summary

Background: No agreement to the optimal medical or surgical treatment of subchondral cystic lesions (SCLs) has been achieved yet. Conservative treatment outcome of subchondral cystic lesions of the distal phalanx may be scarce, and different surgical approaches might be limited due to the lesion localization.

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Results: All horses returned to athletic activity after surgical treatment. In two cases, surgical complication was recorded.

Main limitations: The low number of patients, the need of dedicated instruments and familiarity with the use of absorbable device to perform surgical procedure.

Conclusions: The insertion of an absorbable device can be considered a valid surgical option to treat subchondral cystic lesions of the distal phalanx.

Keywords: horse, cyst, absorbable device, surgical treatment, distal phalanx.

Introduction:

Subchondral bone cysts (also called subchondral cystic or osseous cyst-like lesions) are the most common type of cystic-like lesion identified in horses causing lameness with variable prognosis. Subchondral cystic lesions (SCLs) are typically found in the medial femoral condyle (45.8%) and in the proximal phalanx (26.5%), and less commonly in the distal phalanx (Fürst and Jackson 2018). However, SCLs have been described in the metacarpus, middle phalanx, radius, humerus, scapula, sesamoids, vertebra, femoral head, mandibula, carpal and tarsal bones (Von Rechenberg *et al.* 1998; McIllwraith 2016; Fürst and Jackson 2018). SCLs of the distal phalanx are considered uncommon, and despite several pathogenic mechanisms have been proposed, their pathogenesis remains not completely understood. Disturb of osteochondral ossification, joint inflammation, focal sepsis and/or ischemic chondronecrosis have been involved in young horses (Jeffcott 1991; Olstad *et al.* 2015), while in mature horses chronic and repetitive stress or micro-trauma of the articular cartilage and/or the subchondral bone may cause SCL (Jeffcott 1991; Olstad *et al.* 2015). Morphology of SCLs has been described as radiolucent areas of the bone, surrounded by a zone of sclerotic bone (Figure 1A) (Von Rechenberg *et al.* 1998). When SCLs are located adjacent to the articular surface, with or without a communication to the joint, usually cause lameness (Dyson 2003). Conversely, when they are not located in the subchondral area might be asymptomatic, but the reason is unclear (Sherlock and Mair 2011; Fürst and Jackson 2018). Nevertheless, SCLs are deemed responsible for poor performance and financial loss and can lead to disputes between vendor, buyer and veterinarian (Whitman *et al.* 2006; Pérez-Nogués *et al.* 2021; Pérez-Nogués *et al.* 2023). Radiography is often useful in the diagnosis of SCL, however magnetic resonance imaging (MRI) or computed tomography (CT) are in some cases necessary to confirm their location (Schön *et al.* 2017). In the literature a few therapeutic options for SCLs of the distal phalanx were described, compared to other SCLs localization, and to date no consensus to the optimal medical or surgical treatment has been achieved. The aim of this study, is to describe a surgical technique to treat SCLs of the distal phalanx with an absorbable device, regardless of lesion localization, that eliminates lameness, stimulates bone healing and consequently improve radiographic images in both young and mature horses.

Material and methods:

The subjects belonged to clients of four different equine hospitals located in Italy, France and Germany. All horses presented a history of lameness referable to cystic lesion of the distal phalanx. The horses, admitted to the surgical procedure not undergo any prior surgical treatment. They received medical treatments and stall rest, with no improvement of lameness. Breed, sex, age, degree of lameness (AAEP grading scale), affected limb, diameter of the lesion, complications after surgery, and racing/sport results before and after surgery were recorded. Out of n. 20 cases operated between 2019 and 2022, n.10 horses met the inclusion criteria; n.2 thoroughbreds, n.3

standardbreds, n.5 warmbloods. Patients who had an outcome by means of an official data base were included in the study; pleasure horses or not belonging to professional categories were excluded to avoid subjective assessments.

Clinical diagnosis: The suppression of lameness through local perineural analgesia of the palmar digital nerve or the abaxial sesamoid nerve, using 2 ml of carbocaine for each nerve, was performed to localize the area of lameness.

Diagnostic imaging: standard radiographic views were performed using lateromedial, standing dorsopalmar, 65°dorsoproximal-palmardistal, 65° dorsoproximolateral-palmar oblique, and 65° dorsoproximomedial-palmar oblique projections. When the local digital analgesia suppressed completely the lameness and no radiographic abnormalities were visible, MRI (Hallmarq, Veterinary Imaging Ltd, Guildford, Surrey, UK) and CT (Samsung, CT BodyTom32-slice CT scanner) exams were performed. MRI was able to identify and localize SCLs as well as assess further concomitant soft tissue injuries, while CT was capable to evaluate the spatial configuration and completeness of the SCL architecture, the presence of its communication with the joint and secondary degenerative joint disease (Sherlock and Mair 2011). In all horses a radiographic examination of the contralateral limb was performed, to rule out bilateral SCLs. The dimensions of the SCL were determined as described by Wallis and colleagues (2008), and the width and the height of the radiographic lucency were recorded on a 65° dorsoproximal-palmardistal projection of the distal phalanx. Surgical options were considered for SCL of at least 7 mm diameter. The use of an absorbable device has been suggested (Ravanetti *et al.* 2022), the financial implications and all surgical risks, including general anaesthesia, were discussed and finally a signed informed client consent form was obtained.

Absorbable device: An interference screw was selected for all lesions. The implant

(Osteotrans-OT, Takiron Osaka, Japan; M.I.T distributors, Piacenza, Italy) is a forged composite of unsintered nano-hydroxyapatite (μ-HA) and poly L-lactic acid (PLLA). The μ-HA and carbonate ion act as a filler while the polymeric substance (PLLA) serves as a matrix (Shikinami and Okuno 1999). The insertion of the absorbable device requires the use of dedicated instruments (MIT Italia), (Figure 1B) while to perform the bone tunnel cannulated drill bit was used.

Surgical technique: The day before surgery, the foot was prepared by abrasive removal of the superficial hoof wall and scrubbed, subsequently a sterile patch soaked of chlorhexidine was applied. In order to isolate from the manure, the foot was further protected by a plastic bag. Two radiographic generators were positioned and fixed to prevent variations in technique, positioning and movements around surgical field (Figure 1C). In case of SCL not visible radiographically, an intraoperative CT scanner was used to localize the lesion (Figure 1D,E).

The surgery was performed in general anaesthesia with the horse placed in lateral recumbency, and the access was based on SCL anatomical location (dorsal, medial, lateral). The foot package was removed and the limb was prepared for aseptic surgery by routine clipping, scrubbing and drapping. The lesion was identified by dorsopalmar and lateromedial radiographic views, and a wire was fixed to guide drill trajectory (Figure 2A,B). Then a 12 mm diameter drill bit was used to remove the corium and prepare the portal access. A copious flush was performed to remove the corium waste. A 5.5 mm drill bit and sleeve were inserted through the hole and the lesion was reached under radiographic or CT guidance. To prepare the correct diameter of the bone tunnel, a 7 mm and then an 8 mm drill bit were used (Figure 2C), then debridement and flushing were performed to remove the fibro myxoid cyst. Subsequently, a 9 mm diameter tap was used to prepare the bone tunnel (Figure 2D), and a 9 mm interference screw was inserted (Figure 2E,F).The adequate position of the interference screw was in the centre of the lesion, and below the bone edge to prevent contact with the lamellar corium (Figure 3A-C). The hoof hole was then closed using sterile bone cement (Graftys bone substitute - Graftys, Aix en Provence Cedex 3, France) (Figure 3D) and an adhesive patch was applied as protection. The bone cement binds the hoof and does not induce reaction of the lamellar corium.

Operative and post operative care: All horses were pre-medicated with procaine penicillin 22,000 UI/kg IM and flunixin meglumine 1.1 mg/kg IV. Anti-inflammatory therapy was continued after surgery for three days. The adhesive patch was changed every three days and was maintained until a hoof growth of at least 2 cm was visible. Fever, lameness, and/or distal inter-phalangeal joint swelling were recorded in the first two weeks after surgery. Stall rest was recommended for three weeks followed by progressively increase walking exercise for six weeks. After this period, horses received a turnout period of paddock of 8 weeks before resuming training. Radiographic control was performed one week, and then three and six months after surgery.

Follow-up evaluation: Time from surgery to follow-up ranged from 8 months to 4 years. Follow-up information for young racehorses included number of starts post-surgery. Performance data were recorded using electronic database (france-galop.com; letrot.com; ippicabiz.it; equibase.com) (Table 1). For warmbloods, performances information were obtained using FEI database and FFE Compet (Table 2). In addition, telephone discussion on clinical outcome was made with owners or trainers.

Results

Patients: Five young racehorses (age 12-24 months), 2 Thoroughbreds and 3

Standardbreds, 3 females and 2 males, and 5 warmbloods (age 5-14 years old), 3 females and 2 males, underwent surgery.

Lameness evaluation: In all horse lameness was due to SCL of the distal phalanx in the front leg. In young horses the onset of lameness was acute after few weeks of breaking and training. In the mature horses was intermittent, with an increase of lameness after a jump session of training.

Radiographic, MRI, CT evaluation: In 8 horses the SCL was evaluable on radiographs and the lesion was very near to the sagittal plane with a visible joint cloaca. In two horses MRI exam have been performed. A SCL in the medial aspect of glenoid cavity, opened in the joint space was diagnosed in case n. 4. The lesion was associated with bone sclerosis of glenoid cavity and bone oedema of the distal phalanx (Figure 4A,B). In case n. 7, an active and evolutionary subchondral cystic lesion in the lateral aspect of glenoid cavity of the distal phalanx, associated with significant bone oedema in the surrounding area, was observed (Figure 4C,D). SCLs visible on radiographs ranged in diameter between 8 and 11 mm, while the diameter of SCLs observed on MRI were 8 mm in the young horse and 10 mm in the mature horse. No horses showed bilateral lesions. In cases n. 4 and n. 7 the surgery was performed under CT guidance.

Post-surgery clinical and images evaluation: In two cases, n. 5 and n. 6, an image compatible with gas production in the space between the lamellar corium and hoof wall was visible on radiographs performed one-week post-surgery. The bone cement was removed to facilitate drainage, penicillin (22,000 UI/kg IM once daily) and gentamicin (6.6 mg/kg IV once daily) were administered for the subsequent 5 days. Radiographic examination was performed 7 days later, and no further intervention was required. In all patients the lesion was still visible in the lateromedial and dorsopalmar views performed three months after surgery. In the radiographic control performed six months after surgery the lesion was not visible in the lateromedial view, while in dorsopalmar view the cavity showed a greater bone density and a reduction in diameter (Figure 5A-D).

In case n. 4 a CT was performed six months after surgery, and a slight increase of subchondral bone density, with no signs of joint disorders, was observed. The device was less discernible in shape, due to the beginning of resorption process (Figure 6A,B). In case n. 7 MRI was performed two and six months after surgery. MRI showed improvement of subchondral bone density, moderate bone sclerosis and disappearance of the bone oedema; further improvement was observed six months after surgery (Figure 6C,D).

Follow up evaluation of young horses: None of the five subjects had run before surgery. Three horses had run between 10 to 18 times after surgery. One is actually in training, and one horse was retired 10 months after surgery for suspensory ligament lesion of the hind leg (Table 1).

Follow up evaluation of mature horses: Four horses regularly resumed previous show-jumping activity. One horse was euthanized due to fracture of the tibia 6 months after surgery (Table 2).

Discussion

Several surgical and conservative treaments, with variable outcome, have been proposed for SCL. This study described for the first time, the insertion of an interference absorbable screw to treat SCL in the distal phalanx. Inorganic (metals, ceramics, and glasses) and polymeric (synthetic and natural) materials are commonly used in human orthopedic surgery, while in equine surgery the use of absorbable devices has been increased in recent years (Ravanetti *et al.* 2020; Lechartier 2022; Ortved 2022; Ravanetti *et al.* 2022) , mainly in SCLs surgical treatment. It has been shown that bio-ceramic device can undergo interfacial interactions with surrounding tissues; the blood vessels, for example, can penetrate bio-ceramic device while homogeneously degrades and the new bone begin to replace it (Hench 1988). In the biomedical field, the goal is to develop and characterize artificial materials or "spare parts" to improve and repair physiologic function (Steiner and Rendano 1982). Since SCLs are uncommon in the distal phalanx, only a few scientific literature have been published, and mostly in young horses (Wagner *et al.* 1982; Story and Bramlage 2004; Peter *et al.* 2018); moreover, there are no studies comparing different treatments. Conservative treatment includes controlled exercise, systemic use of bifosphonate, non steroidal anti-inflammatory drugs and the use of intrarticular medications like corticosteroids, platelet rich plasma and stem cells (Sherlock and Mair 2011). Conservative treatment has a low success rate of approximately 30% (Verschooten and De Moor 1982; McIlwraith *et al.* 2006). Among surgical treatments, arthroscopic approach with debridement of the lesion reported 90% of success rate mainly in young thoroughbreds (Story and Bramlage 2004); however, the technique can be performed when SCLs are located in the dorsal aspect of the joint. Similarly, an arthroscopic guided intralesional steroid administration can assure a clinical improvement in a short period (Redding 2007) but no reduction in cyst size. For SCL not accessible arthroscopically an extra articular approach through the hoof to facilitate debridement (Wagner *et al.* 1982), and associated to subsequent bone grafting, has been recommended (Smith *et al.* 2005). Both these studies were performed on a few cases with return to athletic performance, however extensive management and morbidity were reported. The prognosis for the return to previous athletic activity in horses with SCL depend on age, lesion location in weighbering area, breed and athletic use. Mainly, the causes of lameness are joint communication, intracystic pressure, and pathological bone architecture of the area affected (Del Chicca *et al.* 2008). The torsional/compression force, due to biomechanical effect of the common digital extensor tendon and deep digital flexor tendon, should also be considered. It has been documented that SCL predisposes to decreased bone density and strength, subsequently leading to cavitation of the bone, eventually predisposing to fracture (Ahn and Park 1994). However, in the occurrence of concomitant fracture and SCL, the latter appears first (Del Chicca *et al.* 2008). The surgical technique applied in the present study included the use of wide diameter absorbable implant made of μ-HA/PLLA that assures elasticity, similar to cortical bone, and maintains high strength during the period of time necessary of bone healing, possibly preventing the development of pathological fractures during the resorption process (Shikinami and Okuno 1999). In addition, the extra-articular access minimized the risk of iatrogenic damage of the articular cartilage and adjacent soft tissue. As further benefit, the device does not cause artefacts during CT or MRI exams, facilitating its correct insertion during surgery if CT is required as a guide. In the author's opinion the insertion of a wide device, through a 9 mm hole, may further stimulate osseus restorative healing. The MRI performed two months after surgery, showed the disappearance of bone oedema surrounding SCL, confirming this hypothesis. It has been commonly recognised that outcome is better in young horses, that are able to race at least once compared to maternal siblings (Peter *et al.* 2018). Mature horses are considered patients at risk, probably due to a less efficient bone metabolism, and often associated osteoarthritis; the combination of these conditions, might cause a low succes rate (Sherlock and Mair 2011). A recent study showed that radiographic improvement did not correlate with soundness, and the reduction in cyst size or an increase in radiopacity could be influenced by radiographic image quality (Tompe and

Sargar 2022). In the present study, the insertion of an absorbable device allowed radiographic reduction of lesion size, soundness and return to athletic activity in a period comparable for both young and mature horses. No recurrence of lameness due to SCL and/or post operative morbidity, like joint infection, osteomyelitis or device rejection, were recorded.

Study limitations: The main limitation relates to the low number of patients. MRI and CT were performed in only two horses, with useful and detailed information about bone healing. It might be interesting extending the use of these image techniques in a greater number of patients after surgery to increase knowledge about modifications that occur during healing. Another possible limit of this surgical procedure is the need of dedicated instruments and familiarity with the use of absorbable device.

Conclusion

This surgical option can be applied for the treatment of SCLs in the distal phalanx, regardless of the lesion location. Given the promising results, the use of absorbable device can be considered an option for veterinarians, owners and trainers, that offers good athletic prognosis in young as well as mature horses.

Declarations:

Authorship P. Ravanetti conceived and executed the study, executed surgeries, drafted and revised the manuscript. E. Zucca drafted and revised the manuscript. All authors approved the final version of the manuscript and agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Authors' declarations of interests The authors have no financial interests or other conflicts related to this report to declare.

Funding This study was unfunded.

Ethical animal research The study was conducted using client-owned horses according to the highest standard (best practice) of veterinary care.

Owner informed consent Explicit owner informed consent for participation in this study was obtained.

Horses were selected from farms and stables in the clientele of the subsequent Equine Hospitals:

Equitecnica Equine Hospital, Noceto (Parma) Italy

Clinique Veterinaire MBvet, Ecouché, France

Clinique du cheval, Grenade, France

Pferdepraxis Kühnle, Ilshofen, Germany

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Figure legends:

Figure 1: A) 65° dorsoproximal-palmardistal radiographic view of the distal phalanx showed a SCL (white arrow) and surrounding bone sclerosis (red arrow). B) interference screws, dedicated screwdriver and tap. C) two radiographic generators are positioned to perform distal-palmar and lateromedial view. D) the surgical theatre with CT scanner. E) drapped distal phalanx during surgical session inside CT scanner.

Figure 2: A) 65° dorsoproximal-palmardistal radiographic view. The wire determines drill trajectory. B) view of the horse foot positioned, with wire in the hoof to obtain, the radiographic image (A). C) latero-medial radiographic view, the 8.0 mm drill bit enlarged the bone tunnel. D) latero-medial radiographic view, the tap prepares the bone tunnel. E) the interference screw was inserted. F) 65°dorsoproximal-palmardistal

radiographic view, the screw was inserted in the lesion.

Figure 3: A,B) CT images of transverse and sagittal plane confirmed that the interference screw was placed in correct position. C) reconstructed 3D CT image, the interference screw was inserted (red arrow). D) the hoof hole was closed with bone cement.

Figure 4: A) case n.7 and C) case n. 4, standing dorsopalmar radiographic view of the distal phalanx. No lesions were evident. B,D) transverse magnetic resonance (MRI) T1 gradient echo. The SCLs were evident in the medial (B) and lateral (D) area of the distal phalanx (yellow arrow).

Figure 5: A) 65° dorsoproximal-palmardistal radiographic view of SCL in sagittal position. B) reduction in size of SCL. six months after surgery cC latero-medial radiographic view showed SCLs (red arrow). D) the lesion was no longer visible six months after surgery.

Figure 6: A,B) dorsal and transverse CT planes showed a moderate improvement of bone mineralization and the loose of interference screw primary shape (yellow arrow) six months after surgery. No signs of joint inflammation were evident. C,D) sagittal and transverse MRI images T1 gradient echo obtained six months after surgery. C) disappearance of bone oedema around the SCL (yellow arrow), D) reduction of joint cloaca (yellow arrow).

Table headings:

Table 1

Abbreviations: F, female; M, male; Stb, Standarbred; Tb, Thoroughbred

Table 2

Abbreviations: F, female; M, male; SF, Selle francaise; SI, Sella Italiano

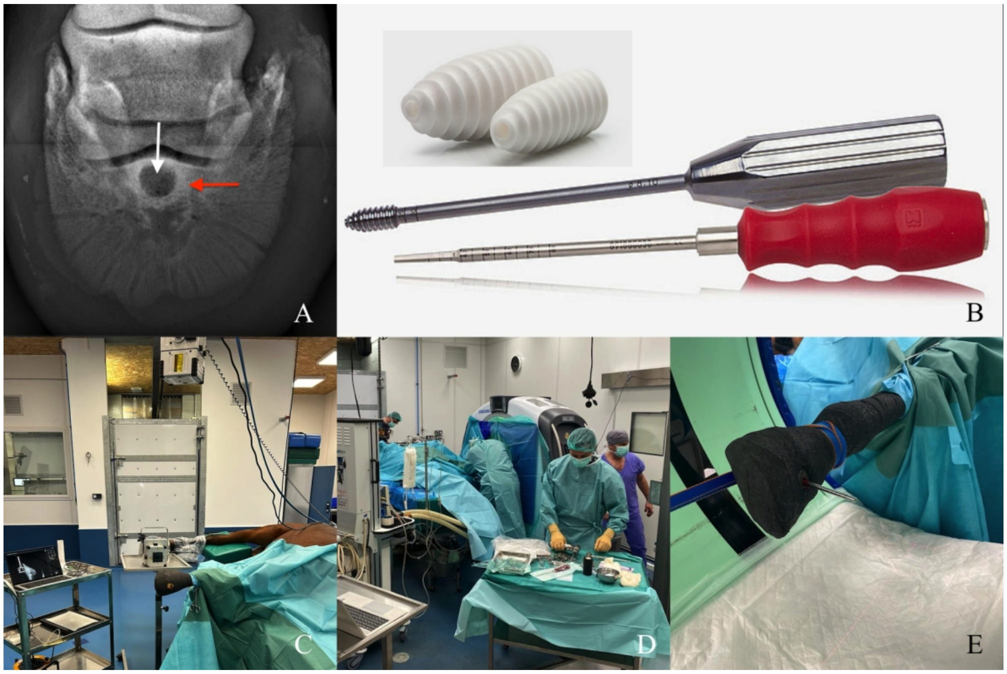

Figure 1: A) 65° dorsoproximal-palmardistal radiographic view of the distal phalanx showed a SCL (white arrow) and surrounding bone sclerosis (red arrow). B) interference screws, dedicated screwdriver and tap. C) two radiographic generators are positioned to perform distal-palmar and lateromedial view. D) the surgical theatre with CT scanner. E) drapped distal phalanx during surgical session inside CT scanner.

317x211mm (144 x 144 DPI)

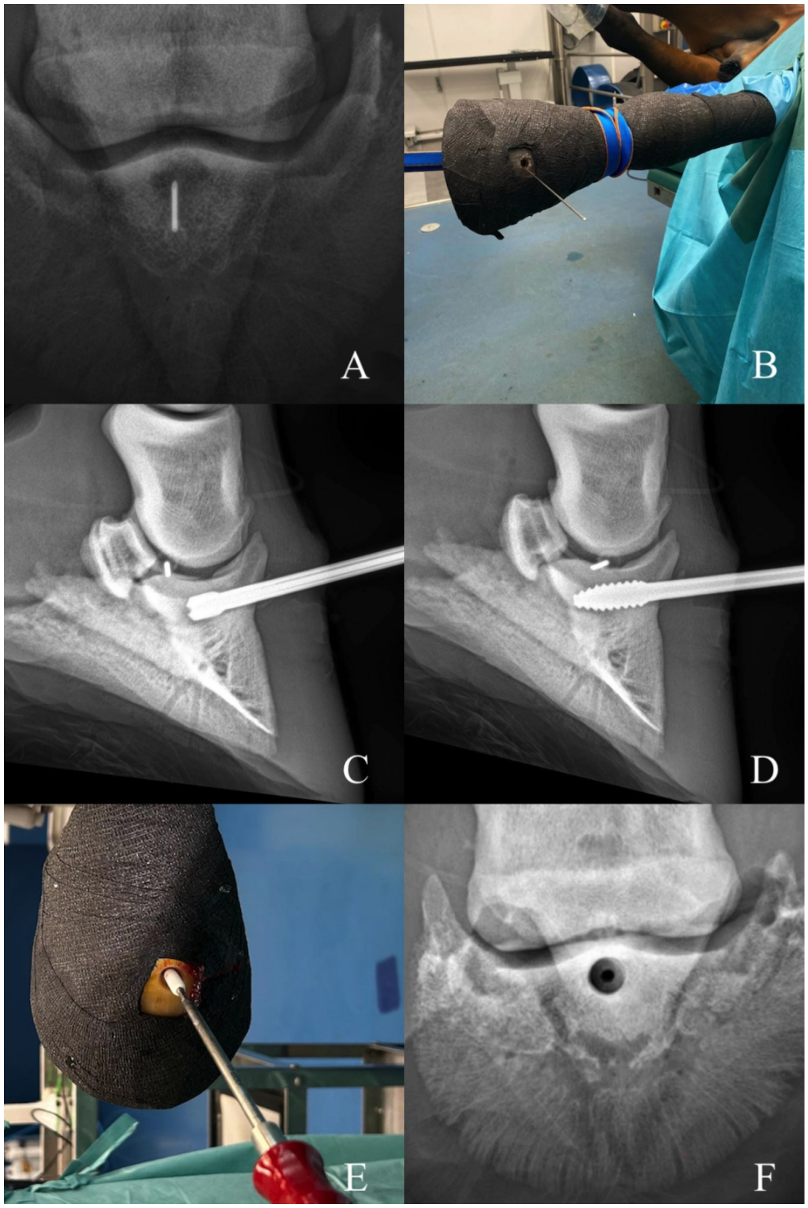

Figure 2: A) 65° dorsoproximal-palmardistal radiographic view. The wire determines drill trajectory. B) view of the horse foot positioned, with wire in the hoof to obtain, the radiographic image (A). C) latero-medial radiographic view, the 8.0 mm drill bit enlarged the bone tunnel. D) latero-medial radiographic view, the tap prepares the bone tunnel. E) the interference screw was inserted. F) 65°dorsoproximal-palmardistal radiographic view, the screw was inserted in the lesion.

211x317mm (144 x 144 DPI)

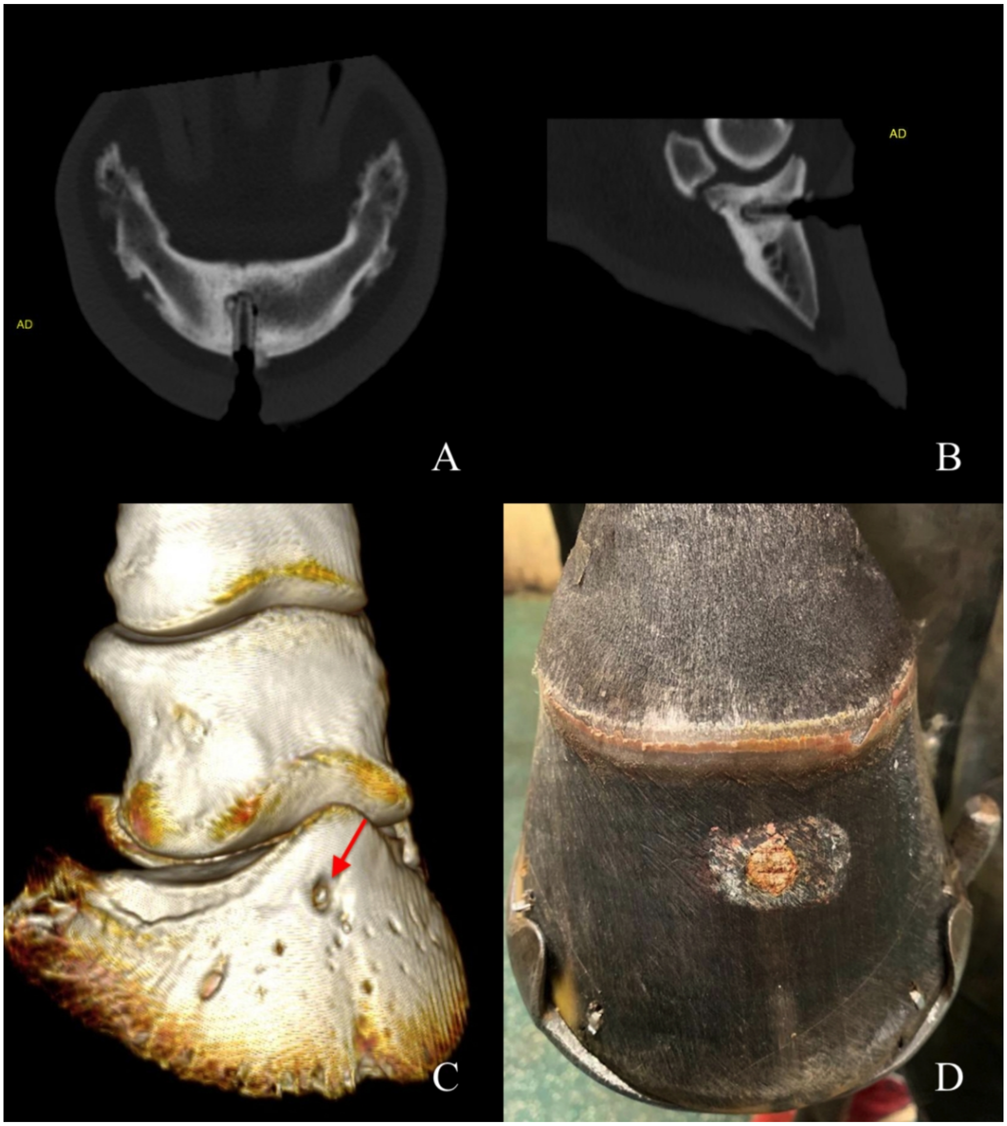

Figure 3: A,B) CT images of transverse and sagittal plane confirmed that the interference screw was placed in correct position. C) reconstructed 3D CT image, the interference screw was inserted (red arrow). D) the hoof hole was closed with bone cement.

211x236mm (144 x 144 DPI)

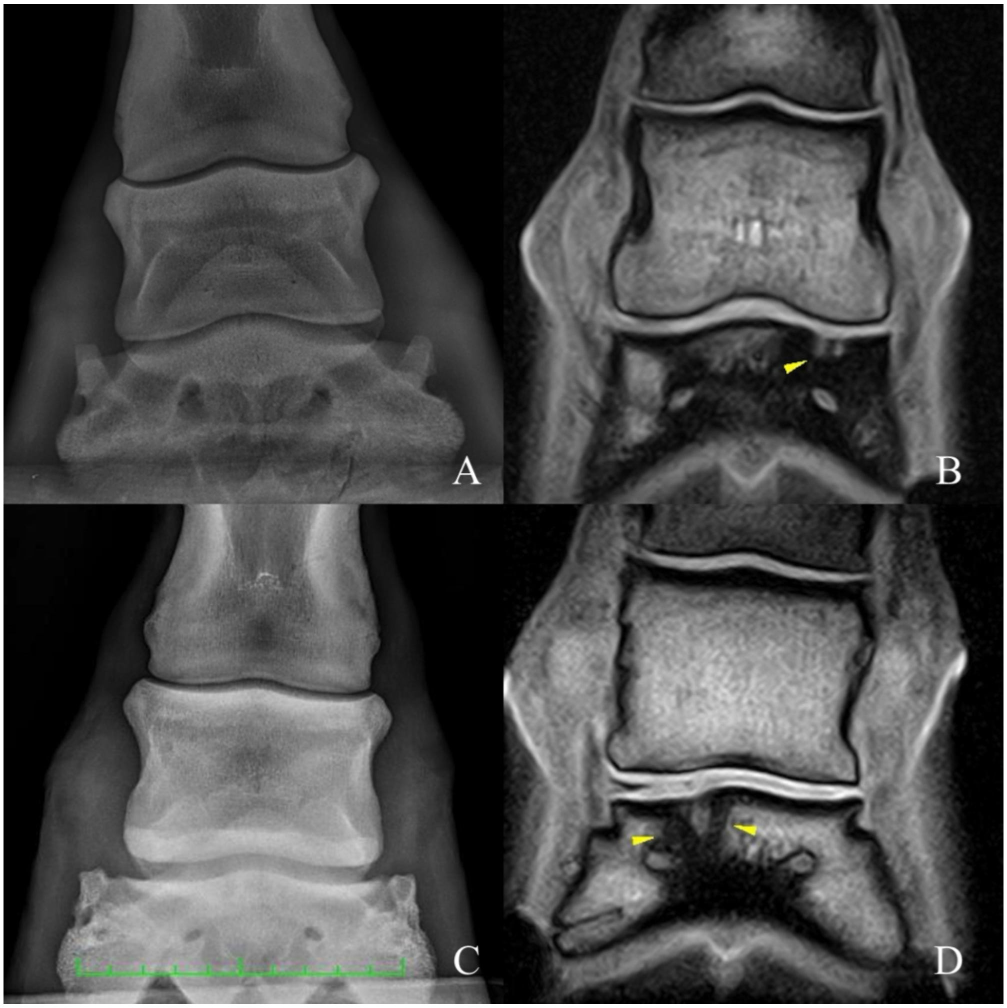

Figure 4: A) case n.7 and C) case n. 4, standing dorsopalmar radiographic view of the distal phalanx. No lesions were evident. B,D) transverse magnetic resonance (MRI) T1 gradient echo. The SCLs were evident in the medial (B) and lateral (D) area of the distal phalanx (yellow arrow).

211x211mm (144 x 144 DPI)

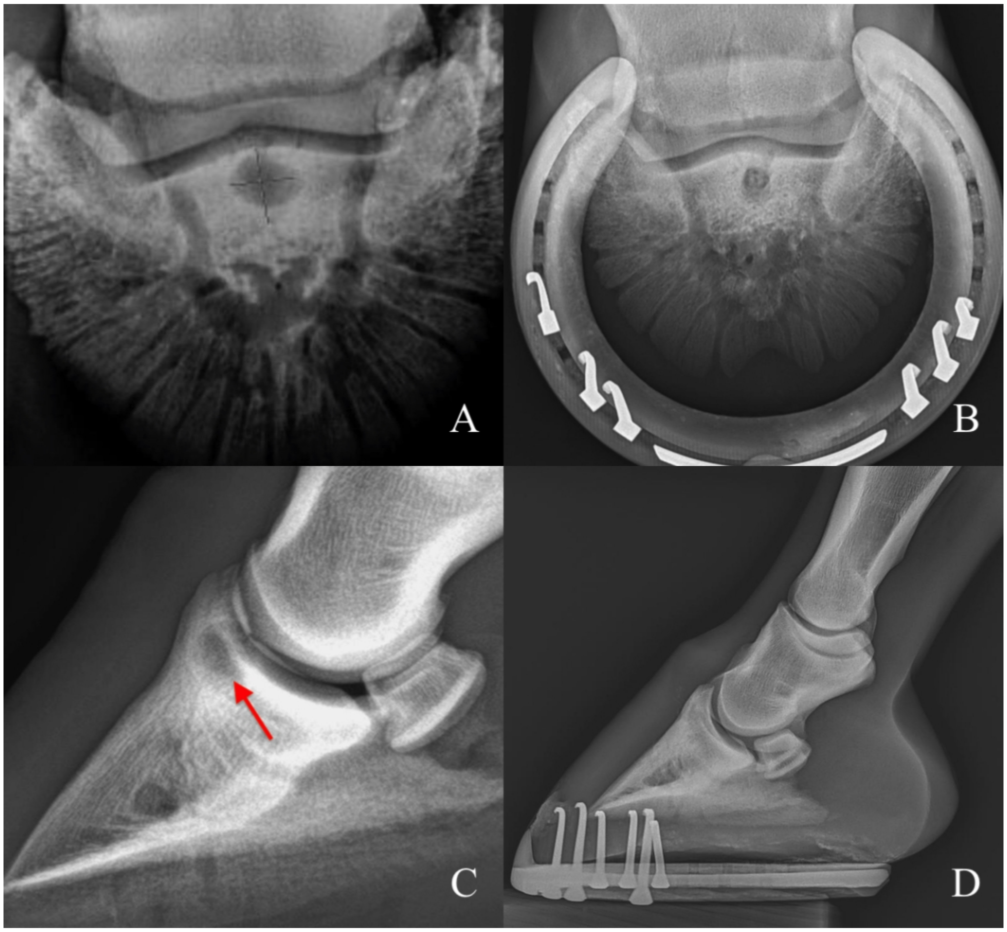

Figure 5: A) 65° dorsoproximal-palmardistal radiographic view of SCL in sagittal position. B) reduction in size of SCL six months after surgery. C) latero-medial radiographic view showed SCLs (red arrow). D) the lesion was no longer visible six months after surgery.

211x195mm (144 x 144 DPI)

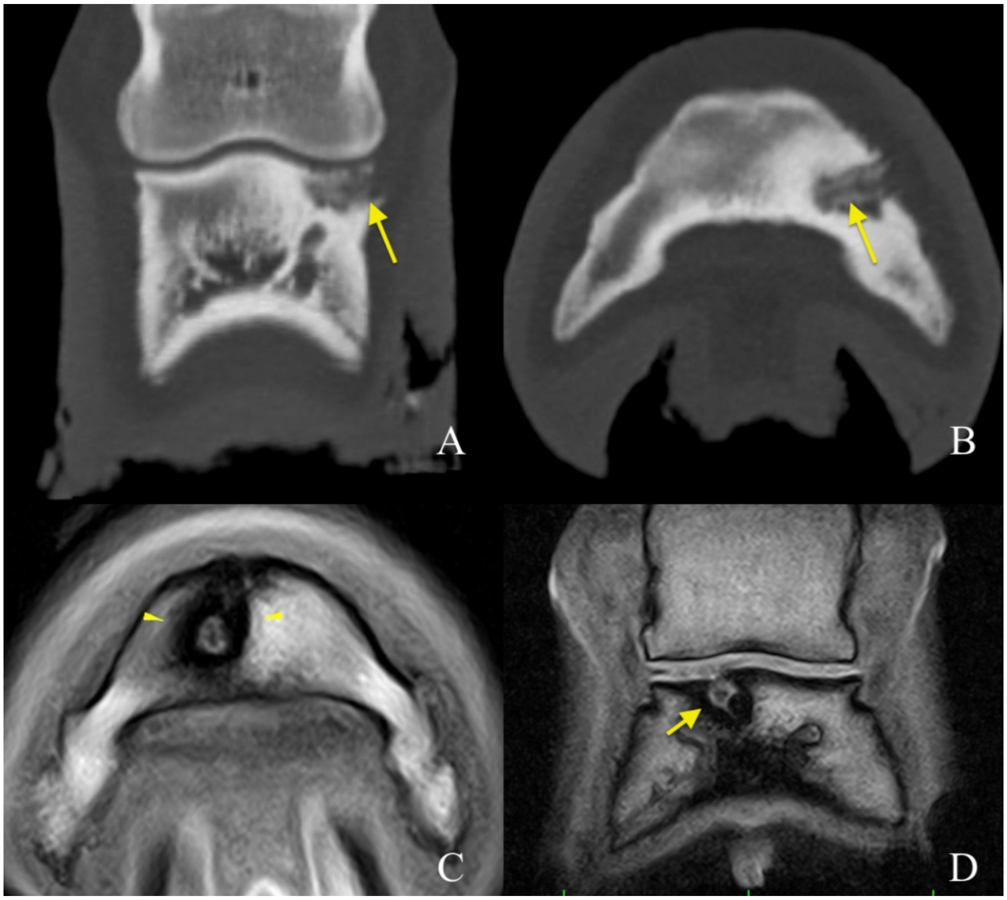

Figure 6: A,B) dorsal and transverse CT planes showed a moderate improvement of bone mineralization and the loose of interference screw primary shape (yellow arrow) six months after surgery. No signs of joint inflammation were evident. C,D) sagittal and transverse MRI images T1 gradient echo obtained six months after surgery. C) disappearance of bone oedema around the SCL (yellow arrow), D) reduction of joint cloaca (yellow arrow).

211x188mm (144 x 144 DPI)

Young racehorses	Sex	Breed	Age at surgery (months)	Lameness. (AAEP scale)	Diameter of lesion. (mm)	Performance before surgery	SCL location	Outcome
n.1	M	Tb	12	4	11	No	sagittal	18 races
n.2	M	Stb	24	3	11	No	sagittal	15 races
n.3	F	Stb	24	2	8	No	sagittal	in training
n.4	F	Tb	18	3	8	No	medial	reformed broodmare
n.5	F	Stb	14	3	10	No	sagittal	10 races

Mature warmbloods	Sex	Breed	Age at surgery (years)	Lameness. (AAEP scale)	Diameter of lesion. (mm)	Performance before surgery	SCL location	Outcome
n.6	M	Hannover	7	2	11	Yes	sagittal	1 show
n.7	M	SF	14	3	10	Yes	lateral	1 show
n.8	F	SF	5	2	9	No	sagittal	51 shows
n.9	F	SF	6	3	10	No	sagittal	Died for tibial fracture
n.10	F	SI	4	3	11	No	sagittal	5 shows