Long-term outcome of arthrodesis of the proximal interphalangeal joint in two adult warmblood horses using a locking compression plate and four lag screws

Langetermijnresultaat van artrodese van het proximale interfalangeale gewricht bij twee volwassen warmbloedpaarden gebruikmakend van een "locking" compressieplaat en vier trekschroeven

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ABSTRACT

Two adult warmblood horses with a history of chronic hind limb lameness originating from the proximal interphalangeal joint (PIPJ) were presented at the equine hospital De Bosdreef (Belgium) between 2016 and 2017. Based on the case history and orthopedic examination, chronic osteoarthrosis (OA) of the PIPJ was diagnosed in both horses. A modified surgical arthrodesis of the PIPJ was performed using a central dorsal three-hole proximal interphalangeal locking compression plate (PIP plate) and four 5.5 mm transarticular cortical screws placed in a lag fashion (TCS-LF). The procedure resulted in an early bone bridging of the PIPJ and a return of the horses to the intended use within ten months after the surgery.

SAMENVATTING

Twee volwassen warmbloedpaarden met een voorgeschiedenis van chronisch manken aan het achterbeen uitgaande van het proximale interfalangeale gewricht (kroongewricht) werden aangeboden op de dierenkliniek De Bosdreef (België) tussen 2016 en 2017. Op basis van de anamnese en het orthopedisch onderzoek werd chronische osteoartrose (OA) van het kroongewricht gediagnosticeerd bij beide paarden. Een gemodificeerde chirurgische artrodese van het kroongericht werd uitgevoerd gebruik makend van een centrale, dorsale driegaten proximale interfalangeale "locking"-compressieplaat (PIP plaat) en vier 5,5 mm transarticulaire, corticale trekschroeven. Dit resulteerde in een snelle botfusie van het kroongewricht en een terugkeer naar het oorspronkelijk werk binnen de tien maanden na operatie.

INTRODUCTION

The proximal interphalangeal joint (PIPJ) of the horse is a diarthrodial, high-load, low-motion joint (Watkins, 1996; Zubrod and Schneider, 2005; Lischer and Auer, 2019). The articular border of the PIPJ is formed proximal by the convex surface of the condyles of the proximal phalanx (P1), and distally by the concave trochlea of the middle phalanx (P2) (Figure 1). At the dorsal border of the PIPJ, the joint capsule adheres firmly to the common/long digital extensor tendon. The two collateral ligaments of the PIPJ originate at the distolateral and distomedial aspects of the P1 and insert on the lateral and medial eminences of P2, respectively. The collateral sesamoidean ligaments (CSL) of the navicular bone originate at the dorsolateral and dorsomedial aspects of the distal P1, between the digital extensor tendon and the collateral ligaments of the PIPJ, and extend distally to their insertion on the proximolateral and proximomedial aspects of the navicular bone (Figure 2). At the palmar/plantar aspect, the PIPJ is supported by

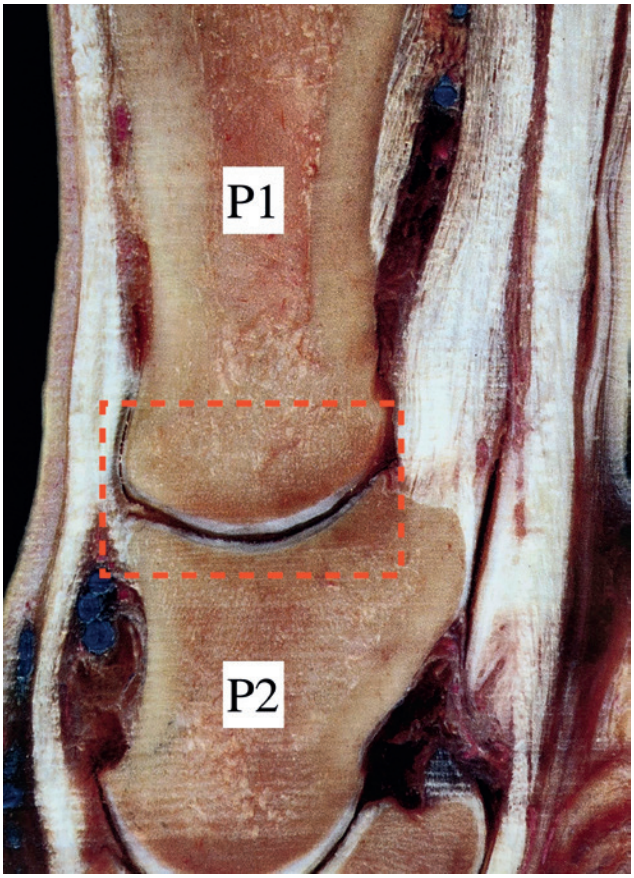

Figure 1. Proximal interphalangeal joint (PIPJ) (red dashed rectangle). The articular border of the PIPJ is formed proximally by the convex surface of the condyles of the proximal phalanx (P1), and distally by the concave trochlea of the middle phalanx (P2). Courtesy of Jean-Marie Denoix.

Figure 2. Tendons and ligaments at the dorsal and lateral aspect of the proximal interphalangeal joint (PIPJ): long/common digital extensor tendon (black arrow), lateral/ medial collateral sesamoidean ligaments (red arrow), lateral/ medial collateral ligaments of the PIPJ (yellow arrow). Courtesy of Jean-Marie Denoix.

the branches of the superficial digital flexor tendon (SDFT) (Figure 3), the straight distal sesamoidean ligament (Figure 4) and the axial and abaxial palmar/plantar ligaments of the pastern. These palmar/plantar ligaments and tendons all insert on the palmar/plantar eminence of P2, and together with the deep digital flexor tendon (DDFT), they form the palmar/plantar soft tissue "tension band" of the PIPJ (Watkins, 1996) (Figures 3 and 4).

The most common pathologies affecting the PIPJ include severe osteochondrosis (Watkins, 1996; Lischer and Auer, 2019), joint instability secondary to disruption of the ligamentous or tendinous support (McCormick and Watkins, 2017), fractures of the proximal and/or middle phalanx (Crabill et al., 1995; Watkins, 1996), septic arthritis (Groom et al., 2000), bone cysts and chronic degenerative joint disease (Zubrod and Schneider, 2005; Jones et al., 2009; Lischer and Auer, 2012; Lischer and Auer, 2019).

Thinning of the articular cartilage and bone-on-bone contact with or without new bone formation leads to pain and malfunction of the affected joint and consequently, to a loss of use of the horse (Zubrod and Schneider, 2005). In cases where the underlying pathology leads to irreversible injury to the articular cartilage unresponsive to medical treatment, fusion of the subchondral bone plates is the ultimate pain relief procedure (Lischer and Auer, 2019).

There are three options of joint fusion: ankylosis, facilitated ankylosis and arthrodesis.

Joint ankylosis is the result of a naturally occurring, spontaneous fusion of the bone plates in a diseased articulation (Lischer and Auer, 2019). In adult horses, the ankylosis of a joint is usually the result of a chronic degenerative disease. Fusion of the bone plates in such cases is typically slow, lasting months to years, and resulting in a long-term loss of performance.

The presence of chondrocytes on the articular surface acts as a barrier for neovascularization and ossification, and delays bridging between the two bone plates (Lischer and Auer, 2019). Facilitated ankylosis is defined as an iatrogenic stimulation of chondronecrosis in diseased joints, without surgical fixation of the adjacent bones (Zubrod and Schneider, 2005; Zubrod et al., 2005; Wolker et al., 2011; Caston et al., 2013). The purpose of facilitated ankylosis is to accelerate the bone bridging, and to shorten the duration of lameness and loss of performance.

Several methods are described to facilitate ankylosis. These techniques include either repeated intra-articular injections of monoiodoacetate (Penraat et al., 2000; Zubrod et al., 2005) or ethyl alcohol (Zubrod et al., 2005; Wolker et al., 2011; Caston et al., 2013), direct application of a laser (Neodymium- doped: Yttrium Aluminum Garnet) to the articular cartilage (Zubrod et al., 2005; Watts et al., 2010) and mechanical destruction of the cartilage by either drilling across the joint space (Zubrod and Schneider, 2005; Zubrod

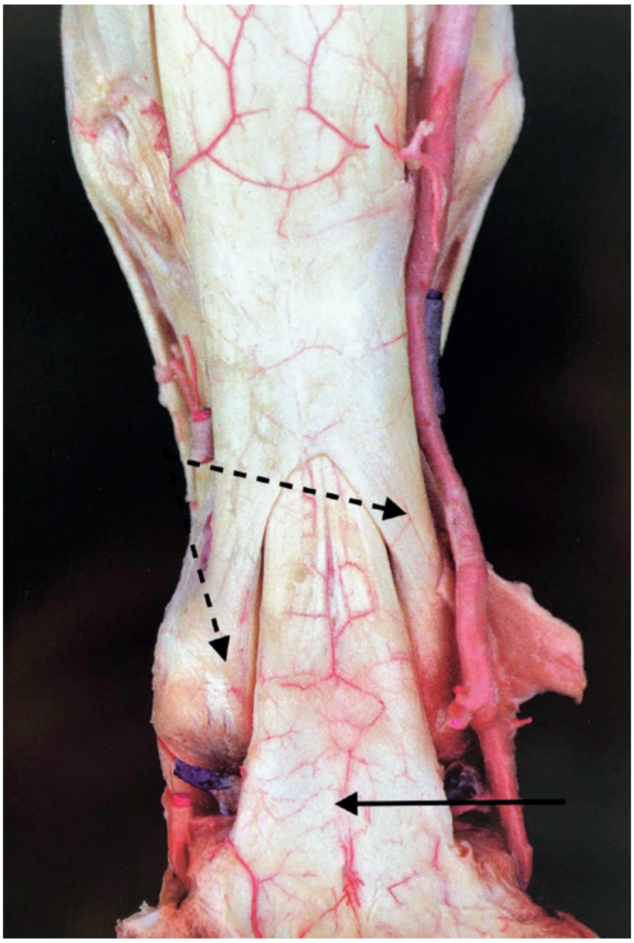

Figure 3. Tendons and ligaments at the palmar/plantar aspect of the proximal interphalangeal joint (PIPJ): medial and lateral branch of the superficial digital flexor tendon (black dashed arrows), deep digital flexor tendon (black full arrow). Courtesy of Jean-Marie Denoix.

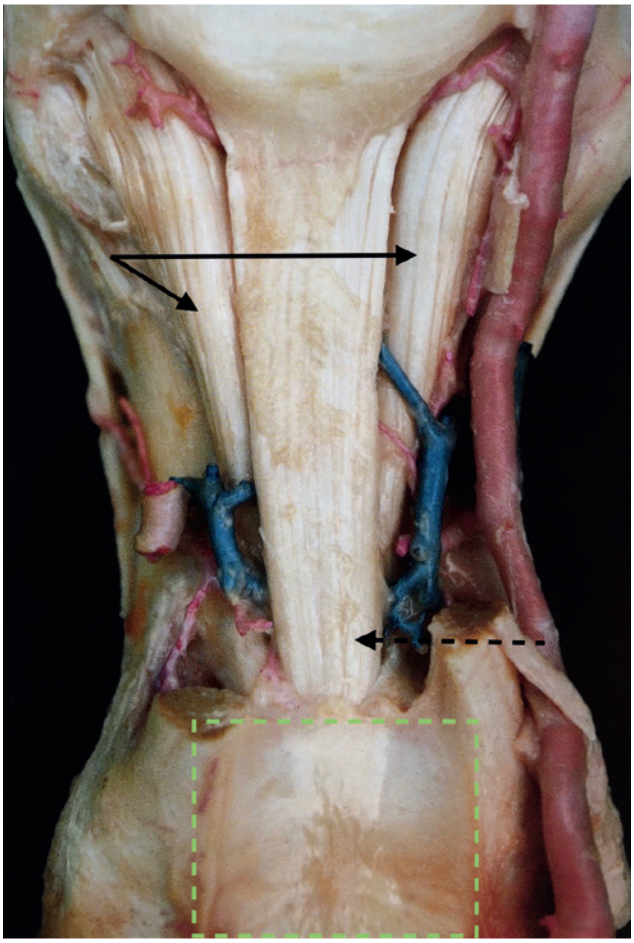

Figure 4. Tendons and ligaments at the palmar/plantar aspect of the proximal interphalangeal joint (PIPJ) after the removal of the flexor tendons: medial and lateral oblique sesamoidean ligaments (black full arrows), straight sesamoidean ligament (black dashed arrow). Attachment of the ligaments at the palmar/plantar eminence of P2 (green dashed rectangle). Courtesy of Jean-Marie Denoix.

et al., 2005) or by a hydrothermal intra-articular lavage (Lischer and Auer, 2019).

The main advantage of the facilitated ankylosis compared to the more advanced surgical arthrodesis techniques, is the relatively low cost of the procedure. However, continuous motion of the adjacent bone plates prolongs the bone bridging and delays the return of the horse to the intended use when compared to surgical arthrodesis techniques.

The principle of arthrodesis is the mechanical destruction of the articular cartilage and an additional joint stabilization using surgical implant. It is considered the fastest and the most efficient method of joint fusion (Lischer and Auer, 2019). Arthrodesis is performed when the articular cartilage is mechanically removed, the bone surfaces aligned into a normal weight-bearing position and the adjacent bones fixed with internal fixation implants (Watkins, 1996; Zubrod and Schneider, 2005; Lischer and Auer, 2019). The ideal arthrodesis procedure results in a perfect alignment, compression and stability of the fused bone plates (Lischer and Auer, 2019).

Arthrodesis of high-motion joints, such as the distal interphalangeal joint (DIPJ), metacarpophalangeal joint (MCPJ), carpal or shoulder joint, is performed as a salvage procedure for pain relief in pasture horses and/or horses used for breeding purposes (Watkins, 1996; Zubrod and Schneider, 2005; Lischer and Auer, 2019). Contrary to high-motion joints, arthrodesis of low-motion joints such as the PIPJ can result in a full return to athletic performance (Watkins, 1996; Zubrod and Schneider, 2005; Lischer and Auer, 2012).

Different arthrodesis techniques of the PIPJ have been reported: two diverging 4.5 or 5.5 mm transarticular cortical screws placed in lag fashion (TCS-LF) (Herthel et al., 2016), three parallel 4.5 or 5.5 mm TCS-LF (Read et al., 2005; Carmalt et al., 2010), a combination of dynamic compression plate (DCP) with two 5.5 mm TCS-LF (Sod et al., 2011), a combination of limited-contact dynamic compression plate (LC- DCP) with two 5.5 mm TCS-LF (Rocconi et al., 2015), a combination of locking compression plate (LCP) with two 5.5 mm TCS-LF (Sod et al., 2011; Sakai et al., 2018), double DCP or LCP plating (Cra-

Figure 5. Preoperative and follow-up radiographs of case 1. Preoperative (A and B), postoperative (C and D), four months (E and F) and ten months follow-up (G and H), lateromedial (A, C, E, G) and DPl (B, D, F, H) radiographic views of the proximal (P1) and middle (P2) phalanges of case 1. No radiographic signs of implant failure were detected at any time. A. and B. There is moderate smooth new bone formation at the dorsoproximal aspect of P2 (long arrow), and at the dorsolateral and dorsomedial articular margins of the proximal interphalangeal joint (PIPJ) (short arrows). The articular margin is mildly irregular, and there is generalized narrowing of the joint space. Ill-defined subchondral bone lysis is present within the distolateral P1 (arrowheads). C. and D. The locking plate is well positioned. There is excellent alignment of the P1 and P2. E. and F. The articular margins are poorly visualized. Irregular new bone formation is seen proximal and distal to the locking plate (long arrows). G. and H. Smooth new bone formation is bridging the joint space, and the articular margins are not visualized. The new bone formation proximal and distal to the plate is smoothly outlined (long arrows). There is mild hyperextension of the distal interphalangeal joint.

bill et al., 1995; McCormick and Watkins, 2017) and a combination of a three-hole proximal interphalangeal locking compression plate (PIP plate) with two 5.5 mm TCS-LF (Zoppa et al., 2011; Ahern et al., 2013).

The successful outcome of an arthrodesis procedure depends on the method used, the limb affected, the breed of the horse and the underlying pathology present (Schaer et al., 2001; Zubrod and Schneider, 2005; Knox and Watkins, 2006; Sod et al., 2011; Zoppa et al., 2011; Lischer and Auer, 2012; Ahern et al., 2013; Rocconi et al., 2015; Herthel et al., 2016; Sakai et al., 2018). Surgical arthrodesis of the PIPJ using a three-hole PIP plate and two 5.5 mm TCS-LF is currently considered the gold standard (Schaer et al., 2001; Zubrod and Schneider, 2005; Knox and Watkins, 2006; Sod et al., 2011; Zoppa et al., 2011; Lischer and Auer, 2012; Ahern et al., 2013; Rocconi et al., 2015; Herthel et al., 2016).

In the caseload of the present study consisting primarily of heavy warmblood horses (95%), a concern was raised, that the previously described arthrodesis techniques may not provide sufficient palmar/plantar compression of the PIPJ, resulting in a prolonged bone fusion and delayed return of the horse to the intended use (D.W. Richardson, personal communication, 2016). Therefore, a modified PIPJ arthrodesis technique using a PIP plate and four TCS-LF was performed in two patients to improve the stability of the implant construct and to increase the speed of bony fusion of the PIPJ.

The authors hypothesized that the placement of two additional TCS-LF would be technically feasible and should provide superior palmar/plantar compression to the PIPJ. The objective of this small case series is to describe the modified arthrodesis technique and to report its long-term outcome.

CASE REPORTS

Case selection

Medical records of horses undergoing PIPJ arthrodesis at the equine hospital De Bosdreef were reviewed. The selection criteria to perform a modified arthrodesis technique included breed (warmblood) and bodyweight (above 550 kg btw). Only cases with a minimum of ten months follow-up available after the surgery were included in this case series.

Two horses met the inclusion criteria. Both horses had a history of chronic hind limb lameness related to osteoarthrotic changes of the PIPJ, which were unresponsive to conservative treatment.

Case 1

Clinical examination

Case 1 was a five-year-old showjumping gelding [558kg bodyweight (btw)]. The horse was homebred, and no previous traumatic events had been noted by the owner.

During the initial orthopedic examination, no palpable abnormalities of the hind limbs were detected. On the straight line, the horse was sound at walk and showed mild [American Association of Equine Practitioners (AAEP) grade 1/5] left hind limb lameness at trot. The lameness increased with the affected limb on the inside of a circle on a hard surface (AAEP grade 2/5). Flexion of the distal limb was negative. A high digital plantar nerve block at the base of the sesamoid bones including dorsal branches at the level of the proximal P1 (2% mepivacaine hydrochloride, Scandicaine, Aspen, Ireland) resulted in a complete alleviation of the lameness after ten minutes.

Diagnostic imaging

The preoperative radiographic examination included lateromedial (LM), dorsoplantar (DPl) (Figures 5A and 5B), dorsolateral-plantaromedial oblique (DLPlMO) and dorsomedial-plantarolateral oblique (DMPlLO) projections of the PIPJ.

Moderate smooth new bone formation was present at the dorsoproximal aspect of P2 and at the dorsolateral and dorsomedial articular margins of the joint. The articular surface was mildly irregular, and there was generalized joint space narrowing. Ill-defined subchondral bone lysis was present within the distolateral P1. There was a mild soft tissue thickening surrounding the PIPJ as well as focal soft tissue swelling centered over the dorsal recess of the PIPJ. The radiographic findings were consistent with a chronic OA of the PIPJ. The origin of the degenerative changes was unclear.

Based on the case history, clinical and diagnostic imaging findings, a surgical arthrodesis of the PIPJ was advised.

Case 2

Clinical examination

Case 2 was a sixteen-year-old breeding mare (572kg btw). The horse presented with severe end-stage OA of the left hind PIPJ, most likely secondary to a previous fracture of the articular margin of the medial condyle of P1. A plantar digital neurectomy had already been performed at the level of the proximal sesamoid bones but the horse remained lame. No further details were available regarding the earlier surgical procedures, which had been done elsewhere.

During the initial examination at the hospital, the horse was lame at walk (AAEP grade 4/5), with a marked soft tissue swelling located at the dorsomedial aspect of the left hind PIPJ. Flexion of the distal limb was positive and resulted in a non-weight-bearing lameness (AAEP grade 5/5). A diagnostic nerve block was not performed.

Diagnostic imaging

The preoperative radiographic examination included LM, DPl (Figures 6A and 6B), DLPlMO and DMPlLO projections of the affected PIPJ.

A large amount of irregular new bone formation was present at the dorsal aspect of P2 and the dorsodistal 1/3 of P1. Additional irregular new bone formation was also present at the medial, and to a lesser extent, the lateral aspect of the PIPJ. DPl radiographs revealed a complete collapse of the medial joint space and marked narrowing laterally, as well as extensive ill-defined osteolysis of the medial subchondral bone and loss of the normal articular margins. There was moderate medial subluxation of P2 in relation to P1. These findings were consistent with the diagnosis of severe osteoarthrosis with collapsed joint space and subluxation of the left hind PIPJ.

SURGICAL TECHNIQUE

One day prior to the surgery, the affected limb was clipped and the hoof wall meticulously cleaned with a rasp. A distal limb bandage was placed over the hoof wall to avoid contamination of the surgical site. The horses were medicated with non-steroidal antiphlogistics (NSAID) [4 mg/kg phenylbutazone intravenously (IV) (Fenylbutazon 20%, VMD Livestock Pharma, Belgium)] and antibiotics [6.6 mg/kg gentamicin IV (Gentaveto-5, VMD Livestock Pharma, Belgium) and 22.000 IU/kg sodium benzyl-penicillin IV (Penicilline, Kela Pharma, Belgium)] and fasted for twelve hours preoperatively.

Prior to the induction of general anesthesia, both horses were premedicated with 20 µg/kg detomidine IV (Detogesic, Zoetis, New Jersey, USA) and 0.1 mg/kg morfine IV (Morphine Sulfate 10 mg/ml, Sterop, Belgium). General anesthesia was induced with 2.2 mg/kg ketamine IV (Ketamidor, Ecuphar, Belgium) and 0.06 mg/kg midazolam IV (Midazolam Mylan, Mylan, Belgium) and maintained with isoflurane (Iso-Flo, Zoetis, New Jersey, USA) in oxygen flow and a 40 µg/kg/hour continuous rate infusion of romifidine IV (Sedivet, Boehringer Ingelheim Vetmedica, Germany).

The horses were positioned in lateral recumbency with the affected limb up. A pneumatic tourniquet (set up on 350 mmHg) was placed above the hock to prevent excessive hemorrhage. A regional limb perfusion with 2 mg/kg ceftiofur IV (Excenel, Zoetis, New Jersey, USA) using the left saphenic vein was performed immediately prior to the surgical procedure.

An “inverted T” skin incision was made with the horizontal part of the T located approximately 2 cm above the coronary band, and extending abaxially to the palpable borders of P2. The vertical part of the T was made from the dorsoproximal third of the P1 and extended dorsodistally until the horizontal incision. Two triangular shaped skin flaps with attached subcutaneous tissues were sharply separated with a scalpel blade n° 24 from the underlying long digital extensor tendon (LDET) and retracted. An “inverted V” incision was then made through LDET, with the midpoint of the “V” starting just distal to the fusion of the dorsal/extensor branches of the suspensory ligament and LDET. The transected distal end of the tendon was retracted distally to facilitate the visualization of the PIPJ. The PIPJ was opened and luxation aided by sharp transection of both lateral and medial CSLs and collateral ligaments of PIPJ. Placement of the Hohmann retractors into the joint space facilitated a forceful distraction of the PIPJ. After complete luxation of the PIPJ, an oscillating saw was used to remove the cartilage from the articular surfaces of P1 and P2. Remaining cartilage was removed with a curette. The subchondral bone plates of P1 and P2 were fenestrated using a 3.2 mm drill bit (osteostixis). Extension of the digit realigned the articulation into a normal weight-bearing position. The new bone formation present at the dorsoproximal aspect of P2 in case 2 was partially removed by ostectomy to allow better positioning of the plate. The PIP plate was then contoured to approximate the dorsal surfaces of P1 and P2. A 5.0 mm self-tapping locking screw was placed into the distal stacked combi-hole of the PIP plate on P2 (Figure 7A). Care was taken that the locking screw was inserted just distal to the proximal subchondral bone plate of P2. The locking screw was not fully tightened. The PIPJ was again disarticulated and four glide holes for the 5.5 mm TCS-LF were drilled into the P1. The entrance points of the glide holes of the first and second TCS-LF were positioned approximately 2.5 cm dorsoproximal to the distal edge of P1, just medial and lateral to the PIP plate (Figure 7A). The exits of the glide holes were centered just palmar/plantar to a mid distance between the dorsal and plantar surfaces of the distal condyles of P1 (Figure 7B). The entrance points of the glide holes of the third and fourth TCS- LF screws were placed in a similar fashion, approximately 1cm distal and abaxial to the first two TCS- LF (Figure 7A). Once the four 5.5 mm glide holes were drilled, the joint was reduced into a normal weight-bearing position and the thread holes for TCS- LFs were drilled into the proximal P2 using 4.0 mm drill bit. After measuring, tapping and tightening the appropriate screw length, the joint was firmly compressed along its plantar surface. The PIP plate was then positioned in place and the preplaced locking screw in P2 fully tightened. Placement of a 5.5 mm cortical screw in load into the proximal combi hole on the PIP plate compressed the PIPJ dorsally. A second 5.0 mm locking screw was placed into the remaining middle combi hole of the PIP plate (Figure 7A). The positioning of all the implants was assessed using intrasurgical fluoroscopy.

The surgical wound was closed in three layers. The LDET tendon ends were apposed and sutured in a continuous pattern using absorbable monofilament suture material (polydioxanon, PDS USP1/Metric4,

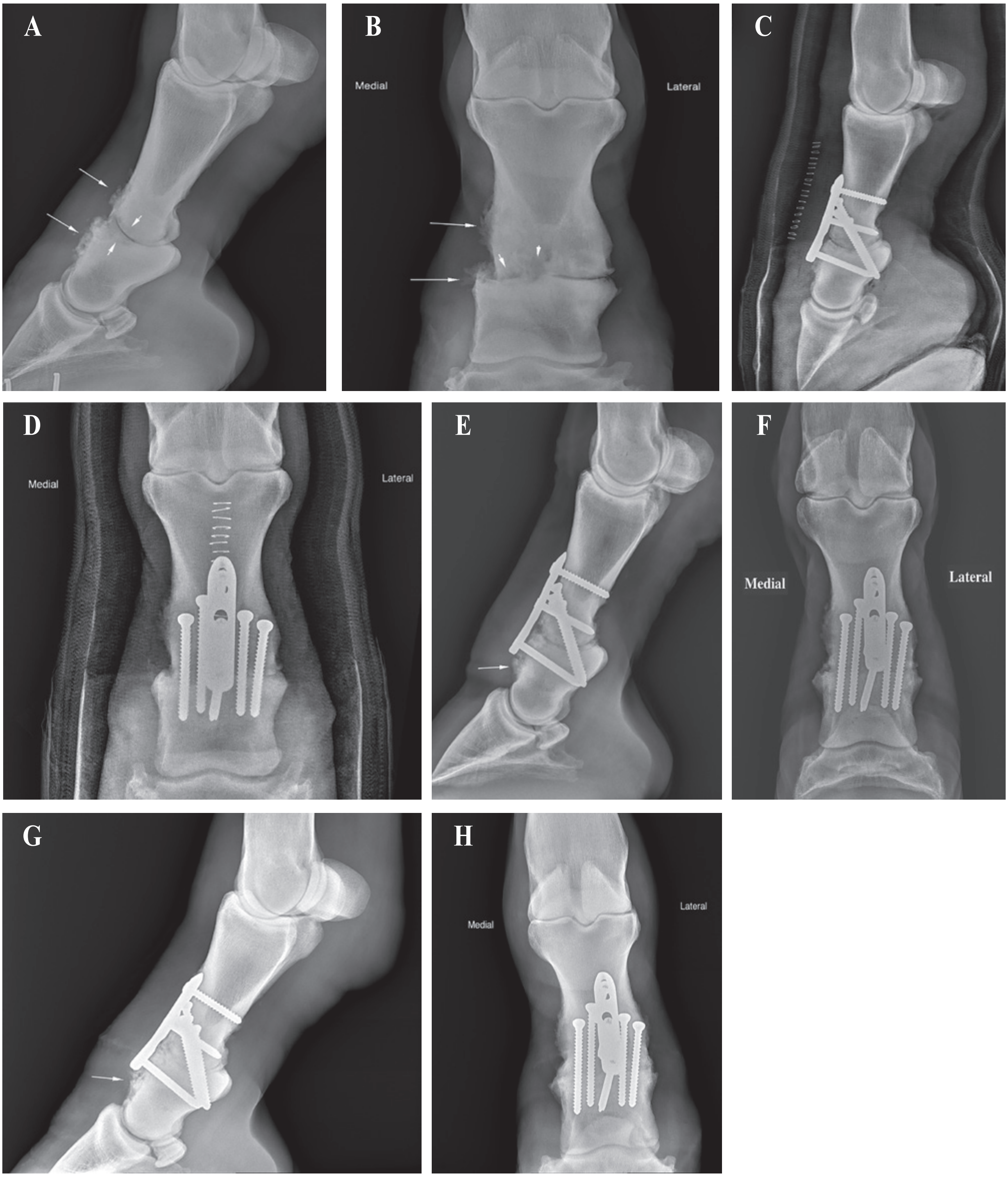

Figure 6. Preoperative and follow-up radiographs of case 2. Preoperative (A and B), postoperative (C and D), four months (E and F) and ten months follow-up (G and H), lateromedial (A, C, E, G) and DPl (B, D, F, H) radiographic views of the proximal (P1) and middle (P2) phalanges of case 2. There were no radiographic signs of implant failure at any time. A. and B. A large amount of irregular new bone formation is visible at the dorsal aspect of P2 and less pronounced of P1 (long arrows). Irregular new bone formation surrounding the proximal interphalangeal joint (PIPJ) is also present medially (long arrows). There is complete medial collapse and lateral narrowing of the PIPJ space, and P2 is displaced medially in relation to P1 (subluxation). Extensive osteolysis (arrowheads) is seen within the subchondral bone, most pronounced at the medial aspect. C. and D. The locking plate is successfully positioned at the dorsal aspect of the PIPJ. The new bone formation at the dorsal aspect of the joint has been partially removed during the surgery. There is good alignment between all phalangeal bones. The subluxation of the PIPJ has been reduced. E and F. The PIPJ joint space is still mildly visible on the LM view. New bone formation is present at the medial and lateral aspect of the joint, and distal to the plate (long arrow). G. and H. Smooth to mildly irregular new bone formation is bridging the joint space. New bone formation is extending distally from the plate until the distal interphalangeal joint (DIPJ).

Ethicon). The subcutaneous tissues were closed with a continuous suture pattern using absorbable polyfilament suture (polyglactin, Vicryl USP0/Metric3.5, Ethicon), and the skin was apposed with a combination of skin staples (Appose™ ULC Auto Suture, Covidien) and a simple interrupted suture pattern using absorbable monofilament suture (polydioxanon, PDS USP 2-0/Metric3, Ethicon).

A half-limb fiberglass cast (5in/12.7cm Scotchcast™ Poly Premium, 3M Health Care) enclosing the foot was placed postoperatively for a duration of six weeks. Recovery from general anesthesia was uneventful and assisted with a head and tail rope through locking belaying device (Del Barrio MC et al., 2018; Wilderjans, 2008).

POSTOPERATIVE MANAGEMENT

Postoperatively, the horses received antibiotics [6.6 mg/kg gentamicine IV (Gentaveto-5, VMD Livestock Pharma, Belgium) and 22.000 IU/kg sodium benzyl-penicillin IV (Penicilline, Kela Pharma, Belgium)] for ten days. Non-steroidal antiphlogistics (NSAID) were administered intravenously once a day for seven days (4.4 mg/kg phenylbutazone (Fenylbutazone 20%, VMD Livestock Pharma, Belgium), followed up by per oral (PO) administration (2.2 mg/kg phenylbutazone, Butagran Equi, Dopharma, the Netherlands) once a day for another fourteen days. A regional limb perfusion with ceftiofur (2 mg/kg, IV, Excenel, Zoetis, New Jersey, USA) and morfine (0.1 mg/kg, IV, Morphine Sulfate 10 mg/ml, Sterop, Belgium) using the left saphenic vein was performed once a day for the first three days after the surgery.

During the hospitalization period, the horses did not develop any complications and were both discharged from the hospital seven weeks after the surgery. Follow-up clinical and radiographic examinations were performed postoperatively, at six weeks, and at four and ten months after the surgery (Figures 5 and 6C-H).

A double-layer bandage enclosing the distal limb replaced the fiberglass cast for two weeks, followed by a single layer distal limb bandage for another two weeks. An exercise program was initiated eight weeks after the surgery, starting with hand-walking for ten minutes twice per day for a week and followed by an increase up to thirty minutes twice per day at fourteen weeks after the surgery.

FOLLOW-UP

Case 1

The postoperative radiographic examination showed good alignment between P1 and P2 and successful positioning of the surgical implants. The PIPJ demonstrated a complete collapse following the surgical debridement (Figures 5C and 5D).

At six weeks postsurgery, the visualization of the joint space was significantly decreased on the DPl view. On the LM view, a moderate amount of new bone formation was present on the dorsal aspect of P1 and P2, and at the medial and lateral aspect of the PIPJ.

The following radiographic examinations four months after surgery demonstrated a progressive loss of visualization of the joint space (Figures 5E and 5F). There was only a minimal increase in the amount of new bone formation, and the bone margin was less irregular. At ten months postsurgery, there was minimal visualization of the joint space (Figures 5G and 5H). The new bone formation had regained a smooth outline consistent with a non-active state. During the follow-up examinations, the bony alignment remained static with only mild hyperextension of the distal interphalangeal joint. No radiographic signs of osteoarthrosis of the DIPJ and metacarpophalangeal joint were seen at ten months.

The horse was fully weight-bearing on the cast after the surgery and remained so during the entire casting period. On removal of the cast six weeks after the surgery, there were only minor partial thickness pressure sores located at the dorsoproximal aspect of the cannon bone, which healed by second intention within two weeks. During the entire hospitalization period, the horse remained sound at walk. Sixteen weeks postoperatively, two minutes of trotting was introduced into the daily exercise plan. During this period, the owner noted only mild lameness on the operated limb (AAEP grade 1/5), which resolved spontaneously as the horse adapted to the increased level of exercise. For the rest of the postoperative period, the horse remained sound at walk and trot, and successfully returned to the previous level of showjumping ten month after surgery.

Case 2

The postoperative radiographic examination showed excellent alignment between P1 and P2, and good positioning of all surgical implants. The joint was completely collapsed following the surgical debridement (Figures 6C and 6D).

At six weeks postsurgery, the soft tissue swelling decreased, and there was increasing, mild new bone formation at the dorsal aspect of P2, at the distal aspect of the plate and at the medial and lateral articular margins. At four months postsurgery, there was progressive loss of visualization of the joint space, with an irregular outline of the persisting articular margins (Figures 6E and 6F). At ten months postsurgery, the joint space was only minimally visible at its plantar aspect, with smooth new bone formation bridging the joint at the dorsal, medial and lateral aspects (Figures 6G and 6H). The bone alignment remained constant.

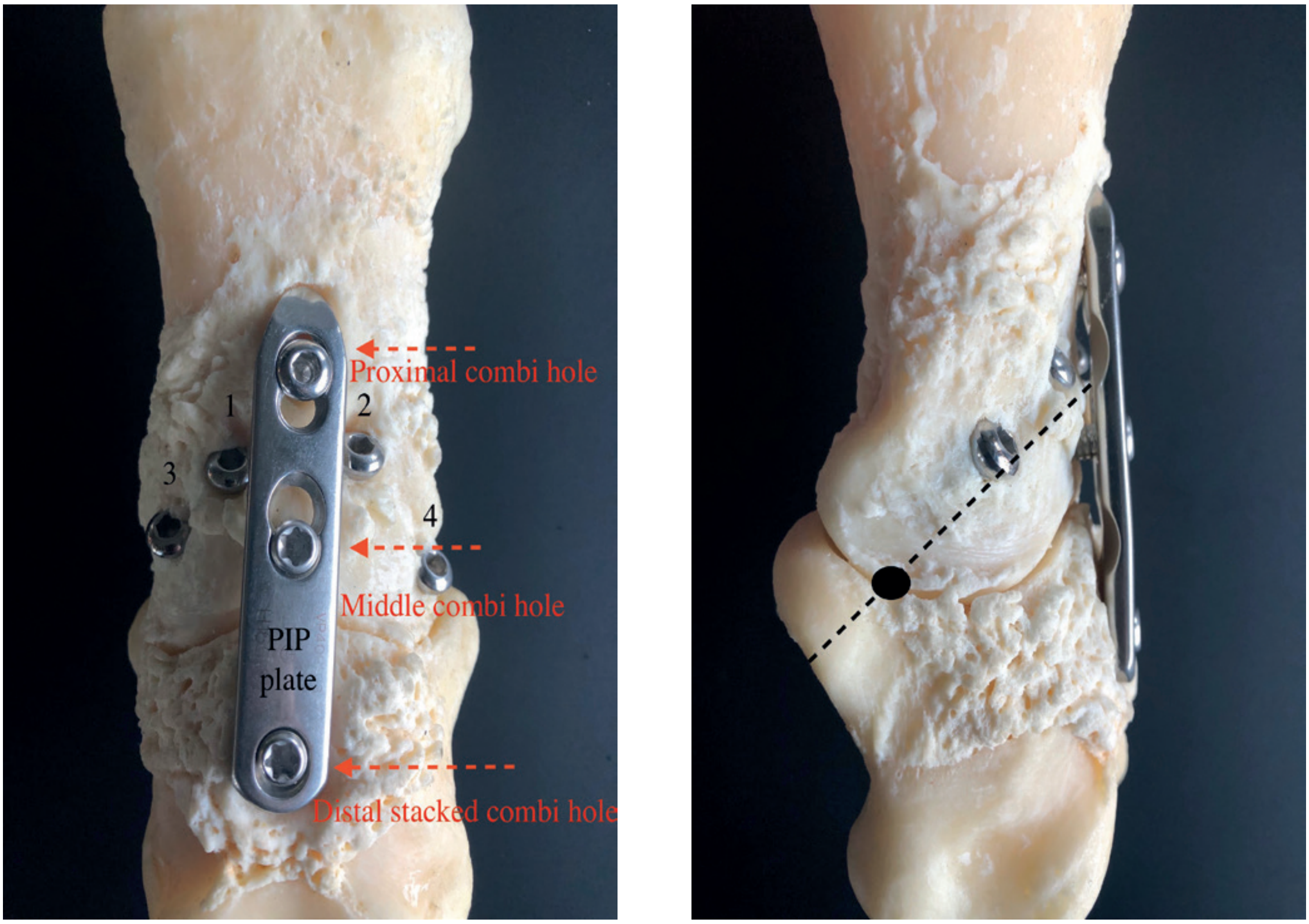

Figure 7. A. Dorsoplantar and B. lateromedial view of a bone model showing positioning of the proximal interphalangeal locking compression plate (PIP plate) and four trans-articular cortical screws placed in lag fashion (TCS-LF). PIP plate with proximal and middle combi holes and distal stacked combi hole (red dashed arrows). The distal edge of the PIP plate is shortened and rounded to minimize interference with the distal interphalangeal joint (DIPJ). The entrance points of the glide holes of the first (1) and second (2) TCS-LF were positioned approximately 2.5 cm proximal to the dorsal margin of the proximal interphalangeal joint (PIPJ), as close as possible to the PIP plate. In B., the angle of drilling is shown for placement of the TCS-LF (black dashed line). The exits of the TCS-LF glide holes (black dot) were centered just palmar/plantar to a half distance between the dorsal and plantar surface of the condyle of P1.

There were no pressure sores detected at the cast removal six weeks after the surgery. During the entire casting period, the mare was sound at walk. Once the cast was removed, the mare showed a mild increase in lameness on the operated limb (AAEP grade 1/5). The mare was treated with a low dose of NSAID (2.2 mg/kg phenylbutazone, PO, Butagran Equi, Dopharma, the Netherlands) once per day for three days resulting in a full alleviation of the lameness at the walk within a week.

Limited controlled exercise (hand-walking for ten minutes per day and free movement in a small paddock) was initiated eight weeks after the surgery. Walking exercise was gradually increased up to thirty minutes twice per day at fourteen weeks. Short periods of trotting (two minutes once per day) were initiated at fifteen weeks after the surgery. Once the trotting was introduced into the exercise plan, the mare showed increased lameness on the operated limb (AAEP grade 2/5). The lameness significantly alleviated with time. Nevertheless, during the final control ten months after the surgery, the horse remained slightly lame (AAEP grade 1/5) at trot on a hard surface with the operated limb on the inside of a circle. The mare presented with a severe distention of the left hind DIPJ and was medicated with an intra-articular (IA) injection of corticosteroids (7 mg/ml, Betamethasone sulfate, IA, Celestone Chronodose, MSD, Belgium) and hyaluronic acid (22 000 mg/ml, Sodium hyaluronate, IA, KD intra-articular gel 2.2%, Albomed, Germany). Lameness resolved after this treatment.

DISCUSSION

In this case series, both horses successfully underwent surgical arthrodesis using a PIP plate and four, instead of two, transarticular 5.5 mm TCS-LF.

The PIP plate is a three-hole LCP specifically designed for PIPJ arthrodesis in horses. Dorsal compression of the PIPJ is achieved by placement of a 5.5 mm cortical screw in an eccentric fashion through the proximal or middle combi hole of the plate (Figure 7A). Compared to a standard three-hole LCP, the PIP plate has a shortened and rounded distal edge to minimize interference with the dorso-proximal aspect of the DIPJ. For this reason, using a PIP plate may minimize development of osteoarthrotic changes in the DIPJ.

Transarticular screws placed in a lag fashion provide palmar/plantar compression to the PIPJ (Lischer and Auer, 2012). The palmar/plantar compression is essential for the final stability and stiffness of the construct (Lischer and Auer, 2012; Herthel et al., 2016; D.W. Richardson, personal communication, 2016). When placing 4 TCS- LF, precise planning of the position of the glide holes is essential due to the large size of the implants and the limited amount of space on the distal P1. With correct surgical planning, the distal aspect of P1 provides sufficient space for both a PIP plate and four 5.5mm TCS- LF screws in large breed horses.

Firm compression of the palmar/plantar aspect of the PIPJ can only be achieved if the TCS- LF are anchored in palmar/plantar eminences of P2 (Herthel et al., 2016). Enhanced stability of the implant construct might lead to less peri-articular new bone formation and a faster bony ankylosis after surgery. In case 2, the new bone formation at the dorso-proximal aspect of P2 associated with the DIPJ was already present on the preoperative radiographs. This new bone formation was partially caused by the PIPJ instability and might have been exacerbated by the plantar digital neurectomy. It is unclear how much additional new bone formation dorsal to P2 was caused by the partial ostectomy performed during the surgery. Nevertheless, in this case, the lameness resolved after intra-articular treatment of the DIPJ.

A return to the intended use was achieved in both horses within ten months. The age of the horse can also influence the speed of the fusion of adjacent bones (Lischer and Auer, 2012) and most likely, could have improved the outcome in case 1. Despite the different age groups, both horses showed similar speed of radiographic bone fusion. It is possible that this could be attributed to the increased plantar compression achieved with two additional TCS-LF. However, the mare in case 2 was kept only for breeding purposes and as such, did not have to return to a full athletic use.

Stability of the implant construct affects the post-operative comfort of the horse (Zubrod et al., 2005; Lischer and Auer, 2012), minimizes the need of analgesics and thereby, decreases the incidence of secondary induced gastrointestinal complications. In this case series, the horses required only minimal analgesic treatment, which consisted of a short-term administration of NSAIDs and opioids. Long-term use of phenylbutazone in horses may have a negative impact on the digestive tract (McConnico et al., 2008), similar to excessive use of opioids (Boscan et al., 2006).

The affected limb influences the return to the previous level of work. In general, the hind limbs carry a better prognosis (85%) than the forelimbs (76%), most likely due to a different weight distribution (Schaer et al., 2001; Lischer and Auer, 2012; Herthel et al., 2016). Both horses in this case series underwent hind limb arthrodesis and this may have contributed to the successful outcome. Further studies are required to compare the outcome of the arthrodesis technique of the PIPJ performed with the combination of PIP plate and two TCS-LF versus the PIP plate and four TCS-LF, both in hind limbs and forelimbs.

A half-limb fiberglass cast was placed on the affected limb prior to the recovery and left in place for six weeks in total. At the cast removal, only minor, partial thickness pressure sores located at the dorso-proximal aspect of the cannon bone were noted in case 1. It is the authors' opinion that in a hind limb, if tolerated well by the horse, the fiberglass cast can be left in place for six weeks without major complications. The immobilization improves surgical wound healing and minimizes peri-articular new bone formation, a common problem in heavy and nervous horses. However, in case of cast complications, the implant construct should be strong enough to safely remove the cast two weeks after the surgery, and replace it by a Robert-Jones bandage (Herthel et al., 2016).

Fast alleviation of the detectable lameness resulted in an early postoperative introduction of both horses into a walking and trotting exercise program. During the final check-up at the hospital ten months after the surgery, both horses were sound at walk and at trot on a soft surface. By this time, showjumping exercise was already a routine part of the training plan of the horse in case 1.

The mare in case 2 remained slightly lame at trot on a hard surface, most likely due to new bone formation on P2 interfering with the dorsoproximal attachment of the DIPJ joint capsule. The lameness resolved after an intra-articular treatment of the DIPJ with hyaluronic acid and betamethasone. It remains unclear if the new bone formation of P2 was already affecting the DIPJ preoperatively, given the advanced clinical presentation related to the PIPJ at the time. The duration and long-term effect of the treatment of the DIPJ also remain to be seen, and it is possible that repeated intra-articular treatments might be necessary.

In conclusion, the modified arthrodesis technique using a central dorsal three-hole PIP plate and four 5.5 mm TCS- LF is technically feasible in adult warmblood horses. Increased plantar compression improves the stability of the implant construct and might have resulted in the fast return of case 1 to the full athletic use. More studies comparing surgical arthrodesis of the PIPJ with four versus two TCS- LF in various age groups of horses need to be performed to objectively assess the speed of bone fusion and the time required to return to the intended use.

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Uit het verleden

DUIVEN EN KIKKERS ALS ‘GENEESMIDDEL’

Een bekend gegeven in de volksgeneeskunde en volksdiergeneeskunde bij zowat alle volkeren is het geloof in de overbrengbaarheid van aandoeningen van mens en dier op voorwerpen, planten (vooral bomen) of andere dieren. Dat moeten we niet begrijpen in de zin van overbrenging van besmetting, maar in het afleiden van een ziekte naar iets anders, waardoor de lijdende ervan verlost wordt. Men geloofde sterk in ‘contagium’ door aanraking of ander contact. Daardoor kon niet enkel het kwade, ook het goede overgebracht worden. Denk aan het aanraken of kussen van een heiligenrelikwie of een voetballersamulet.

Ook de overbrenging van mens naar dier hoorde bij die praktijken. Een bepaald niet zachtzinnig, blijkbaar wijdverspreid gebruik bestond er in een stuipenaanval van een baby te ‘genezen’ door een duif levend te plukken, ze levend in twee te snijden en ze dan op het hoofd, of op de keel of op de aars van het lijdende kind te binden.

Niet minder bekend was een middel om ‘fijt’ (nagelbedontsteking, panaritium) te behandelen. De aangetaste vinger werd tot in de keel of tot in de buikholte van een levende kikker gestoken. Deze nam de kwaal over, zo geloofde men.

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