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# Outcome and radiographic assessment of the development of osteoarthritis in 15 horses with rupture of collateral ligaments and joint instability in metacarpophalangeal or metatarsophalangeal joints

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**Summary**

In this study, the long-term outcome and the development of osteoarthritis (OA) after collateral ligament (CL) rupture in metacarpophalangeal (MCP) or metatarsophalangeal (MTP) joints with either open or closed MCP/MTP joints was evaluated. Horses were included in the study on the basis of radiographic evidence of subluxation or luxation in stressed MCP/MTP joints in the dorsopalmar/dorsoplantar (DP) view. Horses were clinically and radiographically evaluated at first presentation in the clinc as well as at follow-up examination. Fifteen horses met the inclusion criteria. Lameness varied between 2/5 to non-weightbearing lameness. Three horses presented with a clinically severely instable fetlock. Opening of the MCP/MTP joint as consequence of associated wounds or lacerations was diagnosed in 4 horses. In 11 horses CL rupture without opening of the associated MCP/MTP joint was diagnosed (no wounds communicating with the MCP/MTP joint). Six of these horses were treated conservatively, 5 were treated surgically. Three months after admission 11 horses were sound at walk and trot. Three horses showed a grade 3-4/5 lameness. One of these was euthanatized 6 weeks later because severe OA had developed in the injured MTP joint. Another horse had been euthanized because of laminitis. In 12 horses long-term follow-up examination (9 months – 12 years) was possible. All horses showed radiographic signs of OA in the affected MCP/MTP joint. In 6 horses there was also mild to moderate OA in the PIP joint of the affected limb. 67% (n = 10) of the horses returned to be used for pleasure riding as prior to injury, 13% (n = 2) of the horses remained pasture sound, 20% (n=3) were euthanatized because of persistent lameness. The study shows the long-term prognosis of CL ruptures with open and closed MCP/MTP joints. In horses with chronic lamness after CL rupture in MCP/MTP joint the PIP joint should also be considerd as a potential source of pain.

**Keywords**: Collateral ligament rupture, metacarpophalangeal/metatarsophalangeal joint, outcome, osteoarthritis, proximal interphalangeal joint

**Unilaterale Ruptur des Kollateralbandes vom Fesselgelenk mit folgender Gelenkinstabilität: Radiologische Untersuchung der Arthrosebildung und Langzeitergebnis bei 15 Pferden**

Das Ziel dieser Studie war es, die Arthrosebildung und die Langzeitprognose bei Pferden zu evaluieren, welche eine Ruptur des Kollateralbandes im Fesselgelenk mit oder ohne Eröffnung des Fesselgelenkes erlitten haben. Bei dieser Arbeit handelt es sich um eine retrospektive Studie. Fünfzehn Pferde mit Ruptur des Kollatralbandes im Fesselgelenk konnnten in die Studie eingeschlossen werden. Bei diesen Pferden zeigte die initiale radiologische Untersuchung eine Gelenkinstabilität auf den dorsopalmaren oder dorsoplantaren (dp) Stressaufnahmen des Fesselgelenkes, was nur bei einer Ruptur des Kollateralbandes möglich ist. Bei 11 Pferden gab es keine assoziierten Verletzungen, welche zu einer Eröffnung des Fesselgelenkes geführt hätten. Sechs dieser Pferde wurde konservativ, 5 chirurgisch behandelt. Bei 4 Pferden mit Ruptur des Kollateralbandes im Fesselgelenk war das Fesselgelenk eröffnet. Bei 12 Pferden konnte eine klinische und radiologische Nachkontrolle nach zahlreichen Monaten bis Jahren durchgeführt werden. Alle diese Pferde zeigten eine Arthrosebildung im entsprechenden Fesselgelenk. Bei 6 Pferden konnte ebenfalls leicht- bis mittelgradige Arthrose im Krongelenk festgestellt werden. 67% der Pferde wurden wieder als Freizeitpferd genutzt. Diese Studie zeigt die Langzeitprognose von Pferden mit Ruptur des Kollateralbandes im Fesselgelenk mit oder ohne Eröffnung des Fesselgelenks. Zeigen die Pferde eine chronische Lahmheit, muss eine Arthrose im Krongelenk in Betracht gezogen werden.

**Schlüsselwörter**: Kollateralbandruptur, Fesselgelenk, Langzeitergebnis, Arthrose, Krongelenk

## Introduction

The metacarpo- and metatarsophalangeal (MCP/MTP) joints have a very complex architecture to withstand tremendous tensile, compressive, and rotational (torque) forces during high-speed exercise (*Haynes* 1980). The medial and lateral collateral ligaments (CL) limit motion of these joints to the sagittal plane (*Richardson* 2003). In a prospective study of injuries and disease in a cohort of 169 Australian thoroughbreds in training, fetlock problems were the second most common injury (*Bailey* et al. 1999). However rupture of the lateral or medial CL and resulting instability of the MCP/MTP joint is an uncommon injury in horses (*Yovich* et al. 1987, *Nixon* 1996, *Stashak* 2002).

Although CL rupture of the MCP/MTP joints is discussed in several textbooks (*Nixon* 1998, *Stashak* 2002, *Ross* 2003), reports of affected horses are few (*Edwards* and *Vaughan*

1984, *Yovich* et al. 1987, *van der Harst* and *Rijkenhuizen* 2000, *Tenney* and *Whitcomb* 2008). The etiology of CL rupture in MCP/MTP joints is usually traumatic: entrapment of a foot between two solid objects (fences, cattle guards etc.), stepping into a hole or injury during high speed activities (*Yovich* et al. 1987, *Stashak* 2002).

Previous reports describe rupture of one or both CLs in the affected MCP/MTP joint. Ruptures occur as often in forelimbs as in hindlimbs (*Yovich* et al. 1987). They may be associated with articular fractures of the palmar/plantar eminence. Clinical signs vary from slight lameness and swelling to severe lameness and joint instability with obvious varus or valgus deformity of the fetlock (*Stashak* 2002, *Ross* 2003).

Treatment options for CL rupture include cast or splint immobilization of the instable joint under general anesthesia with stall confinement for an average of 6 to 10 weeks (*Yovich* et al. 1987, *Bertone* 1994, *Nixon* 1996, *Stashak* 2002, *Ross* 2003). Cast application can be performed in the standing sedated horse, however general anesthesia and lateral recumbency are preferred (*Stashak* 2002). Surgical repair of the CL has been described using a polypropylene mesh (*van der Harst* and *Rijkenhuizen* 2000) or carbon fibre implants (*Edwards* and *Vaughan* 1984). If there are any intraarticular fragments caused by the trauma and full athletic performance is aimed for, arthroscopic removal of fragments is recommended (*Stashak* 2002). In cases of severe avulsion fractures of the CL arthrodesis may be indicated (*Stashak* 2002) using a dynamic compression plate (*Zamos* and *Honnas* 1993) or a modified Cloward's technique (*Crawley* et al. 1988). In cases of concomittant opening of the MCP/MTP joint additional joint lavage and debridement is necessary (*Bertone* 1994, *Nixon* 1996, *Stashak* 2002). Prognosis for horses with ruptured CL is reportedly guarded to poor (*van der Harst* and *Rijkenhuizen* 2000, *Stashak* 2002, *Ross* 2003). *Yovich* et al. (1987) presented a series of 10 horses with MCP/MTP CL rupture and joint instability. Whether the associated MCP/MTP joint was closed or open, these horses had a good prognosis for return to breeding status. *Tenney* and *Withcomb* (2008) described in their study 17 horses with CL rupture of the MCP or MTP joint. They showed that if CL ruptures were readily identified and limbs immobilized, if there was widening rather than obvious joint instability of the MCP/MTP joint and if there were no wounds to the MCP or MTP joint, then prognosis for return to riding was about 50%.

The purpose of the present study was to evaluate development of osteoarthritis (OA) after CL rupture in horses without opening of the associated MCP/MTP joint and in horses with opening of the associated MCP/MTP joint. Furthermore the clinical long-term outcome of both groups was compared. Our hypothesis was, that horses with CL rupture without opening of the associated MCP/MTP joint had a better long-term prognosis than those with opening of the associated MCP/MTP joint. Furthermore the PIP joints were evaluated for development of OA in the affected limb.

## Material and Methods

Medical records were reviewed for all horses examined with diagnosis of CL rupture of the MCP/MTP joint from 1995 – 2008. Horses were included in the study on the basis of radiographic evidence of joint instability on non-weightbearing, valgus/varus stressed dorsopalmar/dorsoplantar (DP) views of the MCP/MTP joints. Horses had to be treated for their injuries.

Data obtained from medical records included age, sex, breed, history of injury, findings of the physical examination and results of diagnostic imaging procedures. Physical examination data included degree of lameness (5-point scale (AAEP 2010)), palpable joint instability of the MCP/MTP joint and data whether the MCP/MTP joint was opened or not. Initial radiographic examination included 4 standard projections and non-weight-bearing DP stressed radiographic projections. Radiographic findings included the number and location of fracture fragments, the presence of joint instability on stressed radiographic views and therefore location of CL rupture (medial or lateral), and degree of pre-existing OA in the phalangeal joints. Ultrasonography was usually not performed, because radiographs showed enough evidence to diagnose a complete rupture of the CL in the MCP/MTP joints.

On follow-up examination horses were assessed clinically and radiographically. Four standard radiographic projections and maximally flexed lateromedial (lm) projections of the affected and the contralateral MCP/MTP joint were taken. In the maximally flexed lm projections, the range of motion of the affected and the contralateral limb was measured and the difference between the ranges determined. A difference of more than 20 degrees was considered as severe reduction of flexibility in the traumatized MCP/MTP joint. A reduction of less than 13 degrees was considered as mild reduction. Radiographic changes were assessed by three of the authors, until a consensus was reached on presence and localization of joint instability, presence and grade of OA and presence of articular/ avulsion fragments. The following scoring system was used evaluating the grade of ostheoarthritis in the MCP/MTP and PIP joint: Radiographs which revealed slight osteophyte formation were classified as mild changes. Radiographs showing distinct osteophyte formation and subchondral sclerosis were scored as moderate changes. Radiographs with evidence of osteochondral fragmentation, joint space narrowing and ankylosis were scored as severe changes.

For the statistic analysis SPSS Statistics 17.0 was used. The categorical data were proven with fisher's exact test for significance . Differences with an error probability $p \leq 0.05$ were called significant.

## Results

Fifteen horses of different breeds met the inclusion criteria. Two of the horses were ponies, which are for practical reasons further referred to as horses. Different etiologies were recorded: 9 horses had their leg trapped between solid objects. Three forelimbs and 12 hindlimbs were affected. In 9 horses the medial, in 6 the lateral CL was ruptured. All horses were lame and the grade of lameness ranged from a 2/5 to non-weightbearing lameness (5/5). Three horses presented with a clinically severely instable fetlock. Opening of the MCP/MTP joint as consequence of associated wounds or lacerations was diagnosed in 4 horses.

Radiographic evaluation at initial presentation in the clinic showed joint instability of the MCP/MTP joint on stressed views in all horses. Radiographs were further evaluated for presence of avulsion fragments at the level of the CL (n = 9) and compression fragments on the contralateral side of the affected joint (n = 5). Radiographic evidence of OA was not present in any of the examined joints (MCP/MTP and PIP).

*Treatment*

In 11 horses CL rupture without opening of the associated MCP/MTP joint was diagnosed (no wounds communicating with the MCP/MTP joint). Six of these horses were treated conservatively, 5 were treated surgically. Surgery involved fixation of an avulsed fragment of the CL (n = 3) or removal of intraarticular fragments by arthrotomy (n =1) or arthroscopy (n = 1). The 4 horses with open MCP/MTP joint underwent surgery under general anesthesia for joint lavage and wound revision. In all 15 horses, the distal limb was immobilized with a fibreglass cast for 6-8 weeks, after which it was replaced by a Robert-Jones bandage. Additional treatment involved NSAIDs and systemic antibiosis in horses with associated wounds to the MCP/MTP joint.

Six weeks after admission 14 horses were weightbearing well at a walk. One horse showed a grade 4/5 lameness on the injured limb. This horse was euthanatized two weeks later because it developed laminitis in the contralateral limb (Case 15, Tab. 1). Three months after admission 11 horses were sound at walk and trot. 3 horses showed a grade 3-4/5 lameness. One of these was euthanatized 6 weeks later because severe OA had developed in the injured MTP joint (Case 8, Tab. 1; Fig 1). In 12 horses long-term follow-up examination (9 months-12 years) was possible (Tab. 1). One horse had been sold and was no longer available for follow-up. All horses showed radiographic signs of OA in the affected MCP/MTP joint. In 9 horses maximally flexed lateromedial projections of the affected and the contralateral MCP/MTP joint were taken. In 5 of these horses a severe reduction of the range of motion (20-46 degrees difference between the affected and the contralateral limb; Fig. 2) was evident. In 4 horses the reduction was mild (2-13 degrees difference; Fig. 2). In 6 horses there was also mild to moderate OA in the PIP joint of the affected limb. One further horse was euthanatized after 9 months because of constant lameness localized to the PIP joint by intraarticular anesthesia (Case 5, Tab. 1). 67% (n = 10) of the horses returned to be used for pleasure riding as prior to injury (73% of horses with closed and 50% of those with open MCP/MTP joint), 13% (n = 2) of the horses remained pasture sound, 20% (n=3) were euthanatized because of persistent lameness. The Fisher's exact test did not show any significance comparing the long-term outcome of CL rupture with versus without opening of the associated MCP/MTP joint, nor comparing hindlimb versus frontlimb, nor medial versus lateral CL lesions.

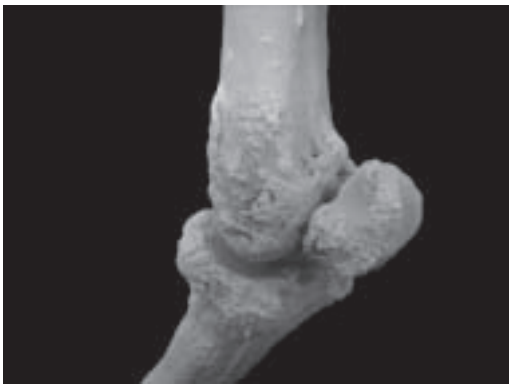

**Fig. 1** Case 8: Severe OA in the MTP joint 4.5 months after lateral CL rupture.

## Discussion

To our knowledge there are no studies comparing the outcome of CL rupture without opening of the associated MCP/MTP joint with conservative and surgical treatment neither are there reports comparing CL ruptures with and without opening of the associated MCP/MTP joint.

Our hypothesis that CL ruptures with opening of the associated MCP/MTP joint would have a worse long-term outcome than those without opening of the joint could not be confirmed statistically. Both horses with closed and horses with open MCP/MTP joint developed mild to severe OA. Nevertheless there is a tendency for CL ruptures without opening of the joint to show a better outcome. However the number of horses involved in this study was too small to make a reliable statement about significance. Furthermore all horses involved in the study were pleasure horses not expected to perform at a high level of exercise after treatment.

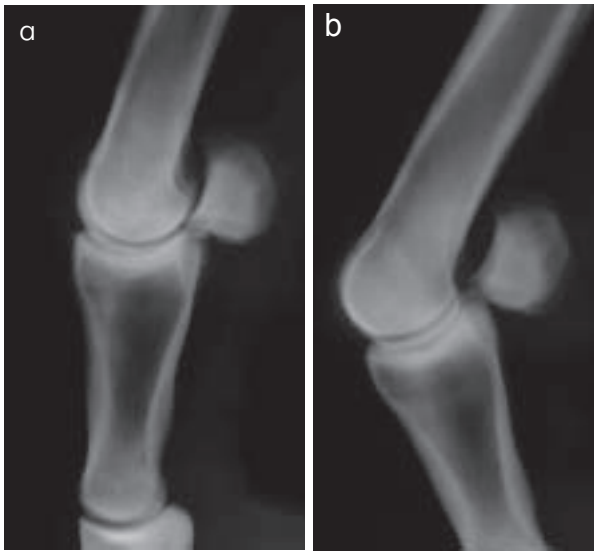


**Fig. 2 a and b** Case 12: 7.5 years after trauma. Difference in the range of motion (ROM) of the affected (left ROM 18°) and contralateral limb (right ROM 48°).

In one study (*Tenney* and *Whitcomb* 2008) prognosis for return to riding was up to 50% if ruptures were readily identified and limbs immobilized, and also if there was only joint widening rather than instability of the joint and if there were no wounds of the MCP/MTP joint.

| Case | Breed Age | Luxation type | Radiographic examination at initial presentation | | | Surgery | Follow-up | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Collateral ligament rupture | Avulsion fragments | Compression fragments | | Time of follow up after injury | Grade of lameness | Difference Range of motion | OA changes in MCPJ/MTPJ | OA changes in PIPJ | Outcome |
| 1 | Arabian 2 y | closed | lateral | none | none | no | 3 years | 1/5 | 20° | severe | none | Pleasure horse |
| 2 | Icelandic 5 y | closed | medial | none | none | no | 12 years | sound | 13° | mild | mild | Pleasure horse |
| 3 | Pony 7 y | closed | medial | none | Very small fragments laterally | no | 9 years | follow up only by calling the owner | | | | Pleasure horse |
| 4 | Arabian 3 y | closed | medial | Multiple small fragments | none | no | 10 months | 2/5 | 26° | moderate | moderate | Pleasure horse |
| 5 | Swiss WB 5 y | closed | medial | none | none | no | 9 months | 3-4/5 | | mild | moderate | euthanasia |
| 6 | Quarter Horse 6 y | closed | medial | Multiple small fragments of the origin of the medial CL | Multiple fragments of the lateral condyle and of the attachement of the lateral CL on MT | no | 14 months | 1-2/5 | 2° | mild | mild | Pleasure horse |
| 7 | Pony 11 y | closed | medial | Multiple very small fragments medially | Big fragment of the lateral MT | Arthrotomy | 7 years | 2/5 | 22° | severe | none | Paddock pony |
| 8 | Thorough-bred 12 y | closed | lateral | Lateral CL avulsion (15x10 mm) of the proximal phalanx | none | Fixation of avulsion fragment with a 3.5 mm lag screw, joint lavage | 4,5 months | 3-4/5 | | severe | none | euthanasia |
| 9 | Russian Thorough-bred 19 y | closed | medial | Medial CL avulsion of the proximal phalanx | Multiple fragments in the region of the lateral condyle | Arthroscopy | 3.5 years | sound | | mild | mild | Pleasure horse |
| 10 | Icelandic 12 y | closed | medial | Medial CL avulsion (12x10 mm) of the proximal phalanx | Multiple small fragments in the region of the attachement of the lateral CL on MT | Arthrotomy and fixation of the avulsion fragment with one position screw (2.7 mm) and one lag screw (3.5 mm) | 4years | sound | 4° | mild | none | Pleasure horse |
| 11 | Welsh Pony 9 y | closed | lateral | Lateral CL avulsion (20x15 mm) of the proximal phalanx | none | Arthrotomy and fixation of the avulsion fragment with three lag screws 1x 2.7mm, 2x 3.5mm) | 4 years | 1/5 | 2° | mild | none | Pleasure horse |
| 12 | Swiss WB 14 y | open | lateral | none | none | Joint lavage (3x) | 7.5 years | sound | 30° | moderate | none | Pleasure horse |
| 13 | Pony 19 y | open | lateral | Multiple small fragments of the lateral CL origin | none | Joint lavage | 9 months | 2-3/5 | 46° | severe | moderate (initally mild) | Pleasure horse |
| 14 | Swiss WB 3 y | open | medial | Multiple small fragments of the medial CL | none | Joint lavage | 10 months | 3/5 | | severe | none | Breeding mare |
| 15 | WB 18 y | open | lateral | none | none | Joint lavage (3x) | 6 weeks | 4/5 | | none | none | euthanasia |

**Table 1** Collateral ligament rupture in MCP/MTP joint in 15 horses Case 1 to 6: Collateral ligament rupture without opening of the associated MCP/MTP joint treated conservatively. Case 7 to 11: Collateral ligament rupture without opening of the associated MCP/MTP joint treated surgically. Case 12 to 15: Collateral ligament rupture with opening of the associated MCP/MTP joint. WB: Warmblood; CL: Collateral ligament, MT: Metatarsus, OA: Osteoarthritis, MCPJ: Metacarpophalangeal joint, MTPJ: Metatarsophalangeal joint, PIPJ: Proximointerphalangeal joint, ____ no long-term follow- up.

In our study the overall prognosis for return to riding was 67% (10/15) for all types of CL ruptures. Progression of OA after CL rupture is reported to be mild (*Tenney* and *Whitcomb* 2008). In the study reported here, development of OA in the MCP/MTP joint 9 months to 14 years later (Tab. 1) was more pronounced. In MCP/MTP joints subchondral sclerosis, osteophytes, and enthesiophytes are common findings also in horses without CL lesions. The high frequency of these findings makes the evaluation of their clinical significance difficult (*Kaser-Hotz* and *Ueltschi* 2006).

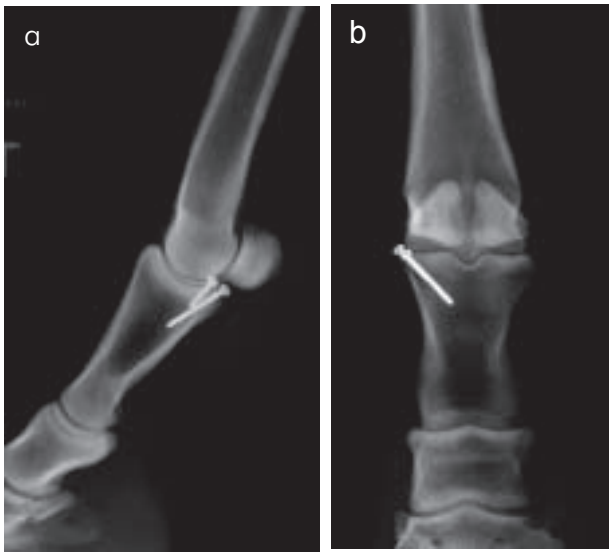


**Fig. 3 a and b** Case 10: Follow up 4 years after injury. Fixation of the avulsion fragment with one 2.7 mm positional and one 3.5 mm lag screw.

To the authors' knowledge no study has to date been performed investigating the development of OA in the PIP joint as a sequel of CL rupture and joint instablity in the MCP/MTP joint. In our study, 40% of the horses also developed OA in the PIP joint of the affected limb several months after the initial diagnosis of CL rupture in the MCP/MTP joint (whereas the contralateral PIP joint did not show any changes). Three of these horses were continuously lame and pain could be localised to the PIP joint through intraarticular anesthesia. One horse had to be euthanatized because of the severity of OA in the PIP joint. We assume that during or as a consequence of the severe trauma to the MCP/MTP joint, the PIP joint may be torsed and thus traumatized as well, possibly with injury to the CL, the joint capsule, the articular cartilage and subchondral bone. This may result in formation of OA in the PIP joint. We suspect different etiologies for rupture of the CL in the MCP/MTP joint prior to rupture of the CL in the PIP joint: presumably the soft tissue structures around the PIP joint are stronger than those of the MCP/MTP joint. Further the lever arm on the PIP joint is centered further distally, therefore the forces acting upon the PIP joint are smaller than those upon the MCP/MTP joint. The PIP joint exhibits less physiologic motion than the MCP/MTP joint. Compensatory increased motion in the PIP joint as consequence to the reduced range of motion in the injured MCP/MTP joint is another possible cause for the development of OA in the PIP joint. We conclude thus that in horses with CL rupture of the MCP/MTP joint, the PIP joint too should be included in the initial and follow-up examinations. Initially the CLs of the PIP joint may be examined ultrasonographically, while at follow-up the PIP joint should be included in the radiographic examination. In horses showing consistent lameness several weeks or months after CL rupture of the MCP/MTP joint, the PIP joint should be considered a potential source of pain. Horses developing concomitant OA in the PIP joint may have a worse long-term prognosis.


**Fig. 4 a and b** Case 13: Follow-up 9 months after injury. Severe OA in the MTP joint and moderate OA in the proximal interphalangeal joint. The horse showed no lameness and was used as pleasure horse.

In all horses radiographic examination showed joint instability of the MCP/MTP joint on stressed views. This finding in addition to palpable laxity of the MCP/MTP joint was considered diagnostic for a ruptured CL. Radiographic examination was also important for documenting fractures and preexisting OA. Avulsion fractures are often associated with ruptured CLs (*Edwards* and *Vaughan* 1984, *Yovich* et al. 1987, *van der Harst* and *Rijkenhuizen* 2000). In this study a correlation between occurrence of avulsion- or compression fragments and clinical outcome could not be demonstrated (not statistically significant). However, in horses with a large avulsion fragment associated with a CL, the reasoning to fix the fragment surgically to re-establish a functioning CL and thereby stabilize the MCP/MTP joint, is convincing because it may reduce the development of OA. Unfortunately these avulsion fragments in the MCP/MTP joint are often too small to be stabilized with screws. In our study avulsion fractures of the CL were repaired by screw fixation in 3 horses. Two of them showed a very good outcome with only mild OA 4 years later (Tab. 1, cases 12 and 13, Fig. 3). The third horse underwent fixation of the fragment with a 3.5 mm lag screw,

but the fragment fractured after three days (Tab. 1, case 10). This horse developed severe OA in the MCP/MTP joint several months later.

To date we have found no literature on the difference in range of motion between affected and contralateral (normal) MCP/MTP joints. We documented in 5 horses severely reduced flexion in the affected limb. All of these horses showed moderate to severe OA in the MCP/MTP joint. In these horses no correlation could be demonstrated between reduced flexibility and CL rupture with or without opening of the associated MCP/MTP joint. In spite of the severe changes, 3 of these horses were used as pleasure horses showing no lameness 10 months to 7 years after the incident.

In conclusion, the overall prognosis for return to riding in the examined group of horses was 67% although some horses showed severe OA in the MCP/MTP joint (which is more than has prevously been reported). The OA was not treated more than once with intra-articular corticosteroids. CL ruptures without opening of the associated MCP/MTP joint tend to have a better long-term prognosis for return to riding than those with opening of the joint. Whether the joint was open or not all unstable joints developed moderate to severe radiographic OA in the MCP/MTP joint. 40% of the horses develeloped concomittant OA in the PIP joint, presumably as a consequence of trauma to the MCP/MTP joint or secondary to the initial injury.

## References


A. A. E. P. (2010) American Association of Equine Practioners Lameness Grading Scale. 2008

*Bailey C. J., S. W. Reid, Hodgson D. R.* und *Rose R. J.* (1999) Impact of injuries and disease on a cohort of two- and three-year-old thoroughbreds in training. Vet. Rec. 145, 487-93

*Bertone A. L.* (1994) Management of orthopedic emergencies. Vet. Clin. North Am. Equine Pract. 10, 603-25

*Crawley G. R., B. D. Grant, Grant B. D., White K. K., Barbee D. D., Gallina A. M.* und *Ratzlaff M. H.* (1988) A modified Cloward's technique for arthrodesis of the normal metacarpophalangeal joint in the horse. Vet. Surg. 17, 117-27

*Edwards G. B.* and *L. C. Vaughan* (1984) Use of carbon fibre implants in the treatment of fetlock joint dislocation in two horses. Vet. Rec. 114, 87-88

*Haynes P. F.* (1980) Disease of the metacarpophalangeal joint and metacarpus. Vet. Clin. North Am. Large Anim. Pract. 2, 33-59

*Kaser Hotz B.* and *G. Ueltschi* (2006) Diagnostic Medical Imaging. Equine Surgery. J. Auer and J. Stick. Missouri, Elsevier, 922-945

*Nixon A. J.* (1996) Fetlock Fractures and Luxations. Equine Fracture Repair, Elsevier Health Sciences, 160-162

*Reef V. B.* (1998) Musculoskeletal ultrasonography. Equine diagnostic ultrasound. V. B. Reef. Philadelphia, WB Saunders Co: 39-186

*Richardson D. W.* (2003) The Metacarpophalangeal Joint. Diagnosis and management of lameness in the horse. M. W. Ross and S. J. Dyson. Philadelphia, Saunders, 348-362

*Ross M. W.* (2003). The Metatarsophalangeal Joint. Diagnosis and Manangement of lameness in the Horse. M. W. Ross and S. J. Dyson. Philadelphia, Saunders, 432

*Stashak T. S.* (2002). Lateral and Medial Luxation of the Metacarpophalangeal and Metatarsophalangeal Joints (Fetlock Luxation). Adam's Lameness in Horses. Philadelphia, Lippincott Williams and Wilkins. 5th 790-792

*Tenney W. A.* and *M. B. Whitcomb* (2008) Rupture of collateral ligaments in metacarpophalangeal and metatarsophalangeal joints in horses: 17 cases (1999-2005). J. Am. Vet. Med. Assoc. 233, 456-462

*van der Harst M. R.* and *A. B. Rijkenhuizen* (2000) The use of a polypropylene mesh for treatment of ruptured collateral ligaments of the equine metatarsophalangeal joint: a report of two cases. Vet. Q. 22, 57-60

*Yovich J. V., A. S. Turner, Stashak T. S.* und *MacIllwraith C. W.* (1987) Luxation of the metacarpophalangeal and metatarsophalangeal joints in horses." Equine Vet J 19, 295-298

*Zamos D. T.* and *C. M. Honnas* (1993) Principles and Applications of Arthrodesis in Horses. Comp. Cont. Educ. Pract. Vet. 15, 1533-1540



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