Area of cartilage accessible to curettage for subsequent arthrodesis of the equine proximal interphalangeal joint

Comparison of conventional and collateral ligament sparing approaches

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Summary
This study compared the areas of cartilage accessible for curettage in arthrodesis of the equine proximal interphalangeal joint using the conventional and collateral ligament sparing approaches. For this purpose, forelimbs and hindlimbs of six equine cadavers without radiographic evidence of proximal interphalangeal joint disease were used. One limb of each pair of limbs was randomly assigned to a dissection using a standard approach to the proximal interphalangeal joint including transection of the collateral ligaments, while each contralateral limb was exposed using the same approach but leaving the collateral ligaments intact. Hohmann retractors and Spratt curettes were then used to remove as much articular cartilage as possible. Finally, proximal interphalangeal joints were photographed and image analysis was performed.

Using the collateral ligament sparing procedure, the mean percentage of articular cartilage surface removed (41.2%) was significantly less than using the conventional procedure (79.6%) (p <0.01). The difference between forelimbs and hindlimbs was not significant.

Introduction
Arthrodesis of the proximal interphalangeal joint is a well-established procedure in equine surgery and is associated with a good prognosis for return to previous levels of activity. A variety of implants have been described to provide compression and achieve stable fixation of the joint. Currently, the most accepted technique is the combination of an axial plate applied dorsally and two abaxial transarticular cortex screws applied in lag fashion (1). Besides using implants to achieve compression of the joint and provide stable fixation, surgical removal of articular cartilage to promote bone fusion is part of each standard arthrodesis procedure. The conventional approach performed for arthrodesis of the proximal interphalangeal joint involves transection of the collateral ligaments (1). This allows good exposure of the articular surfaces and easy access for curettage of the cartilage. However, it was recently demonstrated that fixation constructs applied via a collateral ligament sparing approach have significantly greater mean yield load and mean maximum load under lateromedial bending compared to identical fixation constructs applied using a conventional approach with transection of the collateral ligaments. Furthermore, surgical time was significantly reduced with the collateral ligament sparing technique (2). For collateral ligament sparing procedures, drilling has been used to achieve destruction of articular cartilage (2, 3). However, drilling can result in excessive bone removal and creation of uneven joint surfaces and this could potentially result in impaired stability of the fixation (2). Therefore, a curette is routinely used to remove articular cartilage in proximal interphalangeal joint arthrodesis procedures, but it is unknown how much cartilage can be removed from the articular surfaces when using a collateral ligament sparing approach.

The aim of this study was to compare the area of cartilage that can be removed by curettage in arthrodesis of the equine proximal interphalangeal joint using a conventional approach including transection...
The subcutaneous tissues were separated from the coronary band. The transverse incision was made 2 cm proximal to the joint capsule extended to the dorsal border of the collateral ligaments but the collateral ligaments were left intact. Then Hohmann retractors were used to expose the articular surface maximally and Spratt curettes were used in all specimens to remove as much cartilage as possible. Cup size of the curettes ranged from size 000 (height 3 mm, width 4.5 mm, length 5.5 mm) to 0 (height 4 mm, width 6 mm, length 8 mm).

After this procedure, the proximal interphalangeal joints were disarticulated completely. The first and second phalangeal bones were placed in a fixation device with the proximal interphalangeal joint articular surface facing upwards and the joint surfaces were photographed in a standardized manner using a tripod with the camera angled perpendicularly to the articular surfaces at a fixed distance and constant camera settings. Using image analysis software, the percentages of articular cartilage that had been curetted were calculated. Then the data were examined statistically using a commercially available statistics software programme. Normal distribution was tested using the Shapiro-Wilk test and a general linear model was employed to compare the percentages of curetted cartilage between both groups and determine potential influences of forelimbs versus hindlimbs and bone (proximal versus middle phalanx). Values of p <0.05 were accepted as being significant.

Results
The percentage of articular cartilage surface removed using the collateral ligament sparing procedure (41.2% ± 10.3%, range: 23.6 – 55.0%, 95% confidence interval: 36.0 – 46.4%) was significantly less than using the conventional procedure with transection of the collateral ligaments (79.6% ± 13.5%, range: 53.8 – 98.6%, 95% confidence interval: 74.3 – 84.8%; p <0.01; Figure 1).

With both techniques, the area of curetted cartilage in relation to the total articular surface was significantly larger at the proximal articular surface of the second phalanx compared to the distal joint surface of the first phalanx (p = 0.02). The difference between forelimbs and hindlimbs was not significant.

With use of the collateral ligament sparing procedures, areas that were not accessible for curettage were usually located in the palmar or plantar aspect of the articular surfaces (Figure 2).

Discussion
These results demonstrate that the area of articular cartilage that can be curetted during an arthrodesis procedure of a cadaveric proximal interphalangeal joint is significantly smaller when using a collateral ligament sparing approach compared to a conventional approach with transection of the collateral ligaments.

Material and methods
Paired cadaveric forelimbs and hindlimbs were collected from six horses (12 – 27 years of age; body weight 550 – 650 kg) that were without any history of musculoskeletal disease and were euthanatized for reasons unrelated to this study. Each limb was examined radiographically with dorsopalmar or dorsoplantar and lateromedial projections of the proximal interphalangeal joint to rule out diseases of the proximal interphalangeal joint before inclusion in the study. Then one limb of each pair was randomly assigned for dissection following a standard approach to the proximal interphalangeal joint including transection of the collateral ligaments while each contralateral joint was exposed using the same approach but leaving the collateral ligaments intact (1).

The initial approach through the soft tissues was identical for both techniques: a standard inverted T-incision which started just distal to the metacarpophalangeal or metatarsophalangeal joint and ended at a transverse incision made 2 cm proximal to the coronary band. The transverse incision extended 4 cm on either side of the midline. The subcutaneous tissues were separated sharply until the common digital extensor tendon was exposed. This tendon was transected with an inverted Y-shaped tenotomy at the level of insertion of the extensor branches of the suspensory apparatus. The tendon stumps were reflected and the proximal interphalangeal joint capsule was sharply incised transversely. In the limbs assigned to the conventional technique, both collateral ligaments were subsequently transected and the joint was disarticulated. For the collateral ligament sparing technique, the incision through the joint capsule extended to the dorsal border of the collateral ligaments but the collateral ligaments were left intact. Then Hohmann retractors were used to expose the articular surface maximally and Spratt curettes were used in all specimens to remove as much cartilage as possible. Cup size of the curettes ranged from size 000 (height 3 mm, width 4.5 mm, length 5.5 mm) to 0 (height 4 mm, width 6 mm, length 8 mm).

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Figure 1: Boxplots of the percentages of curetted cartilage area of the proximal interphalangeal joint using a collateral ligament sparing approach (left boxplot) versus a conventional approach including transection of the collateral ligaments (right boxplot). The box is bordered by the 25% and 75% quartiles. The line in the box is the mean and the antennas represent the maximal and minimal values.
However, our finding that the collateral ligament sparing approach allowed curettage of 41.2% of the total articular cartilage surface was similar to the results in another study using a collateral ligament sparing approach but relying on 4.5 and 5.5 mm drill bits to achieve cartilage destruction (2). With 4.5 mm drill bits, 35% of total proximal interphalangeal joint articular cartilage surface was removed, and with 5.5 mm drill bits it was 45%. The use of 5.5 mm drill bits was not recommended by the authors of that study because it resulted in excessive bone removal (2). Therefore, the efficiency of cartilage removal using Spratt curettes and Hohmann retractors is similar to drilling techniques and has the additional advantage that smooth subchondral bone surfaces are created. Smooth and congruent bone surfaces should add to the stability of subsequent fixation during the arthrodesis procedure. However, in our opinion, the effective use of Hohmann retractors is necessary to achieve maximal exposure for curettage via a collateral ligament sparing approach.

Although maximal removal of cartilage is considered a standard part of an arthrodesis procedure, the minimum percentage of cartilage surface that needs to be removed to achieve surgical fusion has not been determined (1, 2). Some arthrodesis procedures that are used in equine surgery completely rely on only partial cartilage removal (e.g. arthrodesis of the distal tarsal joints), laser-facilitated proximal interphalangeal joint arthrodesis, and transfixation casting of the distal interphalangeal joint (4-6). Furthermore, there is evidence from experimental studies in rabbits that complete surgical destruction of cartilage is not necessary to achieve osseous fusion (7). The loss of movement and synovial depletion resulting from stable fixation and firm compression of cartilage surfaces due to implants promoted cartilage degradation and bone union in a rabbit model (7). Currently, less invasive collateral ligament sparing techniques for proximal interphalangeal joint arthrodesis in horses are mainly used in patients suffering from advanced osteoarthritis. It is thought that the pre-existing degradation of cartilage in combination with partial surgical cartilage destruction allows successful fusion and clinical results achieved with this technique are favourable (3, 5). In reports of collateral ligament sparing techniques, an axial longitudinal incision is made through the skin and the common digital extensor tendon to approach the proximal interphalangeal joint (2, 3). In our study, we used a standard inverted T-incision through the skin and an inverted Y-incision through the common digital extensor tendon. This is more invasive than just incising longitudinally, but this approach is necessary if one uses curettes and takes advantage of their characteristics of cartilage removal.

The study we performed is not without limitations. The calculation of the articular surface area accessible for curettage was based on analysis of a two-dimensional photograph. However, the articular surfaces of the proximal interphalangeal joint are convex (distal aspect of the first phalanx) and concave (proximal aspect of the second phalanx), respectively, and this leads to slight distortion of the surface area when two-dimensional analysis is performed. Furthermore, we did not assess the depth of curettage histologically to confirm that the calcified cartilage layer was penetrated. However, this is mainly influenced by the force applied to the curette while the aim of this study was to determine the surface area accessible for curettage. Another limitation is that we used horses without evidence of proximal interphalangeal joint disease. Periarticular soft tissues in joints affected by significant osteoarthritis or chronic subluxations are likely to have altered elasticity and this might affect access into the joint especially in the collateral ligament sparing approach in such patients.

Clinical studies are necessary to determine whether the significantly greater area of cartilage removal achieved with a conventional approach and transection of the collateral ligaments is sufficiently beneficial to justify increased soft tissue traumatization and reduced mechanical stability, or if the partial cartilage removal achievable with collateral ligament sparing techniques is outweighed by the benefits of reduced soft tissue trauma also in patients without pre-existing severe osteoarthritis.
In summary, a substantial area of articular cartilage of the proximal interphalangeal joint can be removed with curettes and a less invasive approach sparing the collateral ligaments. However, significantly more cartilage can be curetted with the exposure achieved using a conventional approach including transection of the collateral ligaments.

Conflict of interest

The authors report no financial or other conflicts of interest related to any products used in this report. No funding was received for this study.

References