BIOMECHANICAL COMPARISON OF A LESS INVASIVE TECHNIQUE AND THE CURRENT ACCEPTED TECHNIQUE FOR ARTHRODESIS OF THE EQUINE PROXIMAL INTERPHALANGEAL JOINT

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ABSTRACT

Objective - To compare the biomechanical characteristics of the currently recommended (CR) technique and a less invasive (LI) surgical approach for arthrodesis of the proximal interphalangeal joint (PIPJ). Additionally, to describe a technique for cartilage removal and disruption of the subchondral bone.

Study design - Randomized paired limb design for biomechanical comparison. Cartilage removal and subchondral bone disruption was accomplished using an orthopedic drill bit.

Sample Population – 76 cadaver limbs.

Methods - Cadaver PIPJs were drilled using a 3.5mm, 4.5mm or 5.5mm drill bit. Articular surfaces were digitally photographed and analyzed. Other paired PIPJs were arthrodesed using either the CR or the LI surgical technique. Implants consisted of a 3-hole DCP and two 5.5mm transarticular screws. Constructs were tested to failure in dorso-palmar/plantar and latero-medial in single cycle 3-point bending. The maximum load and yield load was measured and composite stiffness was calculated and statistically compared.

Results - The LI technique had significantly greater mean yield load (11.3 ± 2.8 kN vs. 7.68 ± 1.1 kN, P=0.008) and mean maximum load (13.5 ± 3.1 kN vs. 10.1 ± 1.94 kN, P= 0.02) under latero-medial bending. Under dorso-palmar/plantar bending there was no statistical difference between the surgical approaches (P=0.5). The 4.5mm drill bit removed 42% ± 7.3 of the cartilage and disrupted subchondral bone. The LI technique had a decreased surgical time (19 ± 3 min.) when compared with the CR (31 ± 3 min.) technique.

Conclusion – The LI technique results in a stronger composite as measured in 3-point bending, loaded to failure.

Clinical Relevance – The LI surgical technique may be considered for clinical cases requiring arthrodesis of the PIPJ as there is no reduction in composite strength.

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INTRODUCTION

Proximal interphalangeal joint (PIPJ) arthrodesis is indicated in horses with chronic osteoarthritis (OA), articular fractures of the second phalanx, luxation and subluxation of the pastern joint, developmental orthopedic diseases, and septic arthritis that results in end-stage OA. Regardless of the inciting cause, OA of the PIPJ results in diminished athletic performance, and ultimately a decrease in quality of life. [3] Due to the high-load, low-motion characteristics of the PIPJ, successful fusion of the PIPJ results in many horses returning to their previous athletic performance. [2, 4, 6]

Over the past three decades, several surgical methods of PIPJ arthrodesis have been evaluated in biomechanical and clinical studies to identify the optimal use and configuration of orthopedic implants. One study described trans-articular (TA) lag screws inserted in a diverging or parallel orientation. [8] This technique proved successful but only 80% of horses returned to their previous level of performance. [5,7-9] Biomechanical studies evaluating TA lag screws found no difference in bending moment or composite stiffness when comparing three 4.5 mm and two 5.5mm cortical screws inserted in a parallel orientation. [10] Similar results were obtained when two 5.5 mm and three 5.5 mm cortical screws were evaluated. [3] Where as the 3 parallel TA screw technique has been used with success, retrospective studies have identified a disadvantage. There may be minimal stability at the dorsal aspect of the PIPJ which can resulting in persistent patient discomfort and excessive peri-articular new bone formation.[11]

Recently, techniques combining TA cortical screws with a dynamic compression plate (DCP) with the goal of improving stability in the dorsal aspect of the PIPJ have been reported. One study reported success rates of 81% for forelimb and 95% for hind limb arthrodesis with

87% of horses returning to their intended use. [4] Benefits of the combined DCP-TA screw technique include a shorter duration of post operative cast support and hospitalization, a more stable construct, and a faster return to intended use. [2, 4] Biomechanical studies have demonstrated that the DCP-TA construct provides a stronger composite when compared to TA screws. [12, 13] Currently, the technique advocated for arthrodesis of the PIPJ is a 3-hole narrow DCP combined with two abaxial 5.5 mm TA cortical screws inserted in lag fashion. [11]

While several studies have been conducted to identify optimal implants for arthrodesis, studies investigating the effect of the surgical approach are lacking. The described surgical approach for PIPJ arthrodesis consists of an inverted 'T' skin incision, followed by transection of the extensor tendon in an inverted 'V' or 'Y" configuration. Transection of the joint capsule, collateral ligaments and peri-articular soft tissues are required to disarticulate the joint to expose the remaining articular cartilage for removal. [11] In chronic cases of PIPJ-OA, large amounts of peri-articular fibrosis and ossification interferes with the accurate dissection of these structures, making exposure of the remaining articular cartilage difficult.

Recently, less invasive (LI) techniques have been described for arthrodesis of the distal limb resulting in a reduction in infection rate, surgical time, hospitalization, post operative coaptation, and cost. [14,15,26] Two retrospective studies reported a LI surgical approach via a longitudinal skin incision and longitudinal splitting of the extensor tendon for arthrodesis of the PIPJ.[15,26] This technique avoids transection of the collateral ligaments and joint capsule and does not require disarticulation of the joint. Forage of the articular cartilage was accomplished with a drill bit, similar to that described for the distal tarsal joints.[16] This technique was reported to result in 89% of the horses returning to their intended use. In another study, cartilage debridement was achieved with a diode laser through fourteen gauge needles used as entry cannulas into the PIPJ. [17] These findings suggest that arthrodesis of the PIPJ can be accomplished with a LI surgical technique which would be expected to reduce surgical time, hospitalization, post operative coaptation, and cost.

The purpose of this study was to compare the biomechanical characteristics of the currently recommended (CR) technique and the LI surgical approach for arthrodesis of the PIPJ in dorso-palmar/plantar and latero-medial to failure in single cycle 3-point bending. Moreover, the purpose was to determine the optimal drill bit size for removal of articular cartilage with disruption of subchondral bone. We hypothesized that a LI technique and by leaving the collateral ligaments intact would result in a stronger construct when tested to failure in 3-point bending. Additionally, we hypothesized that the LI would be a faster surgical technique compared to the CR technique for arthrodesis of the PIPJ.

MATERIALS AND METHODS

Cartilage Removal

Methods for removal of articular cartilage and disruption of the subchondral bone plate were studied using thirty cadaver limbs collected from horses (weight range, 430-540 kg; age range, 3-24 years) that were euthanized at the Veterinary Medical Teaching Hospital for reasons unrelated to orthopedic disease. Limbs were severed at the proximal metacarpus and metatarsus, labeled, and frozen at -20˚C.

To determine the optimal drill bit size for articular cartilage removal and subchondral bone disruption, fifteen limbs were randomly allocated to three treatment groups drilled using a 3.5mm (n=5), 4.5mm (n=5) or 5.5mm (n=5) drill bit. The orthopedic drill bit was inserted through the PIPJ, in a tangential plane to the cartilage surface of the distal first phalanx (P1) and the proximal second phalanx (P2) at an angle 80-84 degrees (determined with a protractor) from the dorsal surface of P1 (Figure 1). The drill bit was inserted in a dorsal-to-palmar/plantar direction, with three passes in the medial and lateral articular surface of P1/P2, with the initial pass beginning one centimeter off of axial midline and were placed approximately one centimeter apart.

Based on the preliminary observations from the various drill bit sizes, it was determined to focus on the abilities of the 4.5mm drill bit for removing articular cartilage. The remaining fifteen limbs were then drilled with three passes in the medial and lateral articular surface of P1/P2, plus an additional pass through the center of the PIPJ with the 4.5mm drill bit, using the aforementioned technique. Preliminary observations also indicated that the proximal palmar/plantar portion of the intermediate phanlax were penetrated by the drill bit without removing cartilage, demanding that the drill bit angle be adjusted as it was passed into the deeper portions of the joint. Subsequently, the drill bit angle was started at 80-84 degrees and was increased to 90 degrees as bone and cartilage stock were removed as the drill bit was running.

All joints were disarticulated by transecting the collateral ligaments, the flexor and extensor tendons, and the depth of the drill tracts measured using a digital caliper to document the removal of articular cartilage and penetration of the subchondral bone. Due to the curvature of the PIPJ, the drill tract depths were measured in three different locations (dorsal, middle, and palmar/plantar surface of the joint) and the mean calculated for each limb. The articular surface of the distal P1 and proximal P2 were then digitally photographed for objective measurement of area of cartilage removal. Digital images were analyzed using a software imaging program (Alpha Ease, Alpha Innotech Corp, CA), and the cartilage removal was calculated and reported as a percent (area of cartilage removed/total area of cartilage).

Surgical Procedure

In a separate experiment, twenty three limb pairs were harvested from horses that were euthanized for reasons unrelated to orthopedic disease (weight range, 430-540 kg; age range, 3-24 years). Limbs were harvested and stored as previously described. One limb was randomly assigned to a treatment group, either the CR or LI technique[27], with one limb relegated to the other technique.

In the CR technique, the PIPJ was approached through an inverted-T skin incision on dorsal midline that started just distal to the level of the metacarpo/metatarsophalangeal joint and ended at a horizontal skin incision made 1.5 cm proximal to the coronary band. The subcutaneous tissue was separated sharply down to the common/long digital extensor tendon. The two triangular skin flaps were dissected from the common/long digital extensor tendon, and the tendon transected with an inverted V-shaped tenotomy at the level of insertion of the extensor branches of the suspensory ligament. The dorsal attachments of the PIPJ capsule were sharply incised, the collateral ligaments transected, and the joint disarticulated. All the cartilage was removed from both articular surfaces with a curette. Implants were applied as described by Watkins, et al. Briefly a narrow, three hole DCP was contoured to the dorsal cortices of the proximal and middle phalanges on midline over the joint in conjunction with one 5.5mm TA cortical screw inserted in lag fashion on either side of the plate. Latero-medial (L-M) and dorso-palmar/plantar (D-P) digital radiographic images were taken to verify proper placement of the TA cortical screws. [11]

In the LI surgical technique, the PIPJ was approached by a longitudinal skin incision made on dorsal midline distal to the metacarpo/metatarsophalangeal joint to 1 cm proximal to the coronary band. The common/long digital extensor tendon was longitudinally incised and the dorsal surface of the PIPJ exposed with the aid of sharp dissection and retraction with 2 gelpi retractors (Figure 2). Based on the results of the cartilage removal study, a 4.5mm drill bit was used in a dorsal to palmar/plantar orientation to drill across the joint space. The drill bit was guided in the same manner for all seven passes, and with a distance of one centimeter between passes, three in the medial and lateral articular surface of P1/P2 and one on midline. Arthrodesis of the PIPJ was accomplished using the previously described technique for the CR technique. [11]

For the placement of the two TA lag screws, a glide hole was drilled with a 5.5 mm drill bit passed in normograde fashion until it reached the articular surface of the PIPJ. The 4.0 mm drill insert was place into the glide holes and the thread holes drilled with a 4.0 mm drill bit into the intermediate phalanx. The holes were countersunk, measured with a depth gauge and tapped with a 5.5mm tap. These two TA lag screws were tightened, prior to tightening the screws with in the 3-hole DCP, which was similar to the sequence for the CR technique.

Both surgical techniques were closed in the same manner. The incised edges of the extensor tendon were re-apposed using #0 Polyglactin 910[a] (Ethicon, Inc., Somerville, NJ) in a cruciate pattern; the subcutaneous tissue was closed using # 2-0 Polyglactin 910[a] in a simple continuous pattern and the skin closed with staples(Autosuture™, Tyco Healthcare Inc., Norwalk,CT). In both surgical techniques surgical time was recorded starting with the incision and ending when the last skin staple was placed.

Mechanical Testing

Twenty three limb pairs were randomly allocated to mechanical testing, thirteen pairs under dorso-palmar/plantar and ten under latero-medial single cycle 3-point bending. (Jose need to add the front and hind limbs-we decided just mentioned in the comments that there was no difference statistically between front and hindlimbs, therefore the limbs were grouped.)To determine the strength provided by an individual collateral ligament in the PIPJ, four limb pairs from the group of ten limbs were biomechanically tested in latero-medial bending until failure (defined as fracture or dislocation of the PIPJ), signified by the abrupt drop in the load-displacement curve) with no orthopedic implants. One limb was randomly assigned to treatment groups, with the other relegated to the other approach technique. The only difference on the modified approach was that only the down collateral ligament (closest to the hoof support) was transected while the limb was mounted on the steel holding fixture under latero-medial bending.

A steel mounting frame similar those used in previous research was customized for this study.[3, 10, 13, 18] Thirteen limb pairs were mounted and mechanically tested in dorso-palmar/plantar, single cycle, 3-point bending (Figure 3). Ten limb pairs were tested in latero-medial bending (Figure 4). The metacarpo/metatarsophalangeal joint was secured in a double-V-shaped vice that was tightened to hold the proximal limb firmly. The hoof was fixed in place to an angled platform at the distal end of the fixture by a 13-mm T-bolt entering the apex of the frog and exiting just below the coronary band in the medial plane. The mounting frame was adjustable, so that the metacarpo/metatarsophalangeal joint was always in the angle bracket and the loading would occur just distal to the second plate screw. A modification of the T-bolt was used in the sagittal plane, to provide more support to the hoof. The "T" end of the bolt was extended and curved in to cradle the hoof more.

In the dorsal-palmar/plantar bending, the dorsal surface of the limb was perpendicular to the load, which was applied just distal to the second plate screw. The fixture that was used for loading in this direction was ¾"-thick and contoured to fit to the dorsal curvature of the limb at the PIPJ. A notch in the center of this fixture allowed the joint to be loaded before any load could be directly applied to the narrow DCP. In the lateral-medial direction, the lateral aspect of the limb was perpendicular to the load, which was applied distal to the second plate screw by a separate custom-fit fixture. This fixture was ¾"-thick with a shallower radius than the dorsal-palmar/plantar direction fixture, designed to fit to the lateral and medial curvature of the limb at the PIPJ. A notch was not necessary in this plane, as the implant was not located in the plane of load application.

Constructs were loaded to failure at a controlled displacement rate of 19 mm/s using an Instron 8516 digitally controlled, 22 kip, servo-hydraulic material test system. The load ram was positioned just distal to the second plate screw before loading, and no conditioning of the construct in the loading fixture was performed. Load (in Newtons) and load ram displacement (in meters) signals were collected (20 points/s) for data reduction and analysis.

Maximum and yield load was measure and construct stiffness (the linear portion of the load versus displacement curve) was calculated to compare the biomechanical properties of the CR and LI surgical technique for arthrodesis of the PIPJ. In cases where two distinct slopes were observed prior to yield load, the slope of the region closest to the yield load was defined as the construct stiffness. Post-mechanical testing digital radiographs (L-M and D-P) were obtained to ascertain the mode of failure.

Statistical Analysis

Paired t-tests were used to analyze mean ($\pm$SD) differences in surgical time, amount of articular cartilage removed from PIPJs subjected to the 4.5mm drill bit with 6 passes versus 7 passes through the PIPJ, and results of biomechanical tests. A one-way ANOVA was used to analyze the mean ($\pm$SD) amount of articular cartilage removed from the PIPJs subjected to six passes with the 3.5mm, 4.5mm, or 5.5mm drill bit. Statistical significance was set at $P< 0.05$.

RESULTS

Cartilage Removal

Based on analysis of the digital imaging of gross specimens, the mean amount of articular cartilage removed from the PIPJ in limbs subjected to six passes of the orthopedic drill bits was 24% ± 4, 35% ± 5, and 45% ± 7 for the 3.5mm, 4.5mm and 5.5mm respectively. The mean amount of cartilage removed from the distal surface of the proximal phalanx and the proximal surface of the middle phalanx was 23% ± 5, 33% ± 6, and 41% ± 6 (proximal phalanx) and 26% ± 3, 38% ± 2, and 46% ± 7 (middle phalanx) for the 3.5mm, 4.5mm and 5.5mm orthopedic drill bits respectively. The mean amount of articular cartilage removed from the PIPJ in limbs subjected to seven passes was 42% ± 7 for the 4.5mm drill bit (figure 5). When comparing limbs subjected to either six passes through the PIPJ with a 4.5mm drill bit versus limbs subjected to seven passes, a significantly higher percentage of articular cartilage removal ($P < 0.005$) was accomplished with the additional pass through the center of the joint.

Maximum mean depth of penetration into the subchondral bone plate from the articular surface, as measured at 3 points along the furrow, for the 3.5mm, 4.5mm, and the 5.5mm orthopedic drill bit was 3.17mm ± 0.46, 4.11mm ± 0.70, and 5.13mm ± 0.61, respectively.

Mechanical testing

The LI surgical technique had significantly greater mean yield load (11 ± 3 kN vs. 8 ± 1 kN, $P=0.008$) and mean maximum load (13 ± 3 kN vs. 10 ± 2 kN, $P= 0.02$) under latero-medial bending than the CR technique. However, there was no significant difference in composite stiffness (443 ± 115 kN/m vs. 470 ± 94 kN/m, $P= 0.6$) between the two fixation techniques.

Under dorso-palmar/plantar bending there was no significant difference between the CR and the LI surgical technique in yield load (20 ± 7 kN vs. 23 ± 6 kN, P=0.5), maximum load (23 ± 6 kN vs. 23 ± 6 kN, P= 0.8), and composite stiffness (962 ± 240 kN/m vs. 911 ± 195 kN/m, P= 0.5), respectively.

In latero-medial bending (n=12), 50% of the constructs failed by fractures in the proximal phalanx and 50% in the middle phalanx. In the middle phalanx, all the fractures occurred in the lateral palmar/plantar eminence in both surgical techniques. In the proximal phalanx, the fracture configurations included highly comminuted (CR n=2, LI n=1), transverse (CR, through proximal plate screw n=1, through TA screws n=1), and long oblique fracture (LI n=1).

In dorso-palmar/plantar bending (n=26), fractures occurred in the middle phalanx most commonly (n=21). Fracture configurations in this plane included the palmar/plantar eminence only (CR n=4, LI n=5), palmar/plantar eminence with a transverse fracture line through the distal plate screw (CR n=2, LI n=3), lateral plantar eminence with a transverse fracture line through the TA screws (CR n=1), plantar eminence with a transverse fracture line through the metaphysis of the middle phalanx (CR n=1), plantar eminence with a sagittal fracture through the middle phalanx (LI n=1), fractures in the cis cortex of the distal screw of the DCP (CR n=2), sagittal fracture in the middle phalanx (LI n=1), and highly comminuted (CR n=1). The fractures that occurred in the proximal phalanx (n=5) failed in the proximal phalanx including three highly comminuted (CR n=2, LI n=1), one with a lateral condylar fracture (LI), and one with a transverse fracture line through the second screw of the DCP (CR).

When comparing limbs with no orthopedics implants with the LI technique or limbs with a modified technique from the CR technique (transection of one collateral ligament), the LI surgical technique had significantly greater mean maximum load (15.1 ± 2.9 kN vs. 9.73 ± 1.7 kN, $P=0.008$) under latero-medial bending than the CR technique. The intact collateral ligament therefore appears to withstand a mean of 5 kN of force applied in this plane.

Surgical Time

The LI technique had a significantly ($P < .0001$) shorter surgical time (19 ± 3 min.) when compared with the CR technique (31 ± 3 min.).

Discussion

Based on the results of this study, we concluded that leaving the PIPJ collateral ligaments intact with a LI technique results in a stronger composite, in lateral to medial bending, compared to the CR technique. Also, a 4.5mm orthopedic drill bit removed 42% ± 7 of articular cartilage and disrupted the subchondral bone plate. We further demonstrated that surgical time was reduced with the new LI surgical technique.

It has been well-documented in human orthopedic surgery that maintaining the collateral ligaments plays a critical role in construct stability. [19] To our knowledge there is no data documenting the benefit of maintaining the collateral ligaments during PIPJ arthrodesis. Condylectomy of the distal third metacarpal/metatarsal bone has been advocated during metacarpo/metatarsophalangeal arthrodesis instead of transection of the collateral ligaments in order to provide greater stability. [20] In this study, by leaving the collateral ligaments of the PIPJ intact, the joint was able to withstand an additional 5 kN of force on average when load was applied in latero-medial bending. Maintaining the collateral ligaments of the PIPJ would appear biomechanically advantageous, and should be considered if clinical circumstances allow it.

The PIPJ is loaded *in vivo* in a combination of bending (dorso-palmar/plantar being the most critical plane), axial compression, and torsion. [3, 10, 12,13,18,21] Most of the research on arthrodesis of the PIPJ has focused on the selection and configuration of implants. [2,3,6,10,18] Many of the researched implant configurations utilized biomechanical testing to demonstrate strength; however, these were tested in only one bending plane. [3, 10,12,13,18] As other studies have reported, testing in torsion or compression would have been biomechanically difficult to accomplish. [13,21] In previous models, when equine limbs were transected at the distal radius and axially loaded in compression, the metacarpophalangeal joint and proximal sesamoid bones were displaced distal to the foot plate to which the hoof was mounted. [3, 10,17,18,21] Subluxation of the coffin joint and metacarpophalangeal joint occurred while the arthrodesed PIPJ was unaffected. [3,10,18,21] To successfully load the limb in axial compression, attempts have been made to add support to the metacarpophalangeal joint with 3/16-inch cable placed in a “figure 8” fashion on the palmar aspect of the joint or by incorporating the metacarpophalangeal joint in a fiberglass cast material. In one study, full limb preparations (limbs transected from the mid-humerus) were successfully loaded axially to closely simulate the *in vivo* biomechanical loading. [12] For our study, we decided to test in single-cycle-3-point bending in two planes, latero-medial and dorso-palmar/plantar bending, rather than axial loading to evaluate the CR technique vs. the new LI surgical approach for PIPJ arthrodesis. This choice was made to document any potential value of leaving collateral ligaments intact.

In previous studies, cartilage was not removed from the PIPJ during the experimental procedure for implant testing, but one of the goals of this study was to determine the optimal method for removal of articular cartilage and disruption of the subchondral bone plate with an orthopedic drill bit. [3, 10, 18] It has been proposed that incomplete removal of articular cartilage would result in asymmetry and decrease contact surface. [10, 18] In addition, there are concerns with incomplete removal of articular cartilage in clinical cases. The main question is whether the implants loosen once the remaining cartilage degrades, subjecting the construct to loosening from excessive cycling stresses resulting in implant failure. Also, it has been suggested that the radii of opposing bones is altered when cartilage removal is performed. [10,18] While removal of the remaining articular cartilage is strongly recommended, there is some doubt as to the amount of cartilage that needs to be removed to result in eventual surgical fusion of the joint(there is no reference for this, this is what one of the reviewers mentioned before.JOSE insert ref). Recently, several studies have reported a LI surgical approach in which cartilage removal was accomplished with an orthopedic drill bit. [14, 15, 26] In one retrospective study, 89% of horses returned to their intended use.[26] Recently, articular cartilage removal was accomplished by "fanning" a 5.5mm drill bit from the dorsal and lateral aspect of the PIPJ .[15] Five out of their six horses were considered sound within 6 months of surgery.[15] In another study, cartilage debridement was achieved with a diode laser through 14 gauge needles into the PIP joint. [17] These findings suggest that cartilage removal of the PIPJ can be accomplished with a LI surgical approach, reducing surgical time, hospitalization, post operative coaptation, and cost.

At the beginning of the study, the orthopedic drill bit was directed from dorsal-palmar/plantar at 80-84 degree angle from the dorsal surface of P1 and P2, but it was evident that penetration of the subchondral bone plate at the most palmar/plantar aspect of the middle phalanx was excessive with minimal penetration of the subchondral bone plate at the proximal phalanx. Therefore, the angle of the orthopedic drill bit was increased to 90 degrees midway through the PIPJ to accomplish a more even penetration through the subchondral bone plate of the middle and proximal phalanx. The angle of drilling can be change as the bit removes bone and cartilage stock. By forcing the drill bit to change angle mid-way through the joint, bending of the drill bit is inevitable. Therefore, we recommended using a new drill bit to avoid bending or breaking the drill bit.

Our preliminary observations found that the 5.5mm drill bit was too aggressive, leading to excessive loss of bone. Therefore, we relied on the 4.5mm orthopedic drill bit. By adding the center pass, we were able to remove more articular cartilage because it is a straight pass through the joint based on confirmation of the PIPJ. In addition there is no fear that excessive bone stock removal because implants are not placed in this area. Entering the lateral aspect of the PIPJ and directing the orthopedic drill bit in a lateral-to-medial direction for articular cartilage removal and subchondral bone plate disruption, the method described by Lescun[15], we felt may weaken the collateral ligaments.

It has been well-documented in human orthopedic surgery that reduction in surgical trauma reduces the likelihood of surgical site contamination, speeds healing, minimizes hospital stays, controls costs, and promotes early rehabilitation, culminating in superior results. [22-25] The LI technique described here, demonstrates not only the benefits of decreased surgical time but also a reduction in tissue exposure, trauma, and dead space. Moreover, with chronic OA there is a large amount of articular fibrosis and ossification, which is the very tissue we desire to assist in the healing and final outcome of a PIPJ arthrodesis..

While maintaining similar biomechanical properties under dorso-palmar/plantar bending and demonstrating superior properties under latero-medial bending, there appears to be a biomechanical advantage of utilizing a LI surgical approach in clinical cases of chronic OA within the PIP joint that require arthrodesis.

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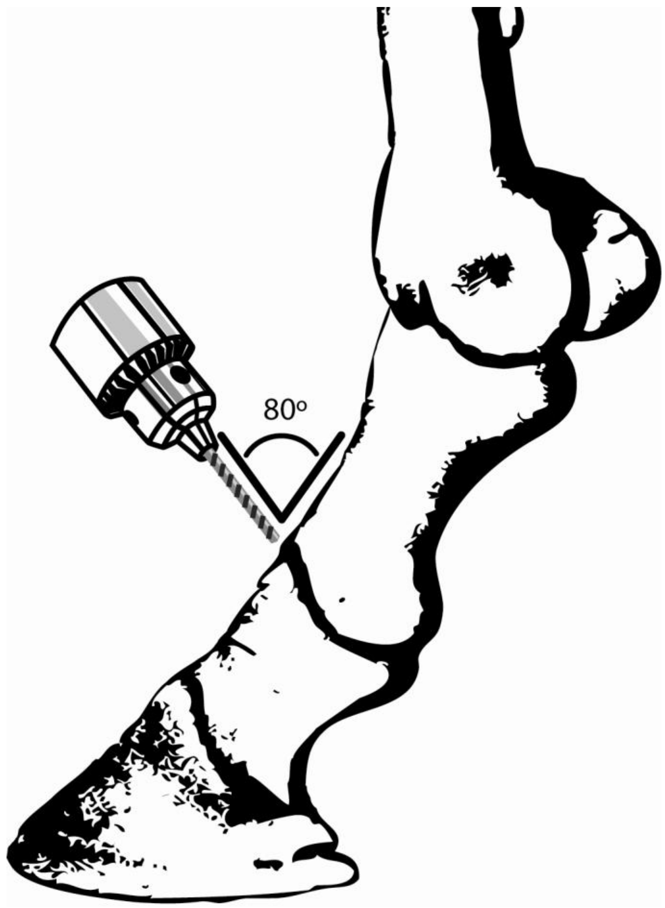
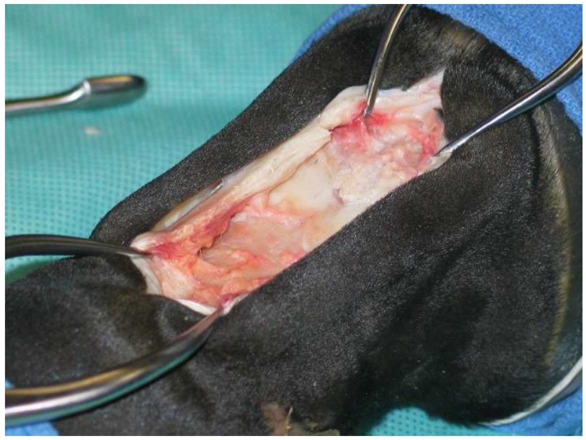
Figure 1



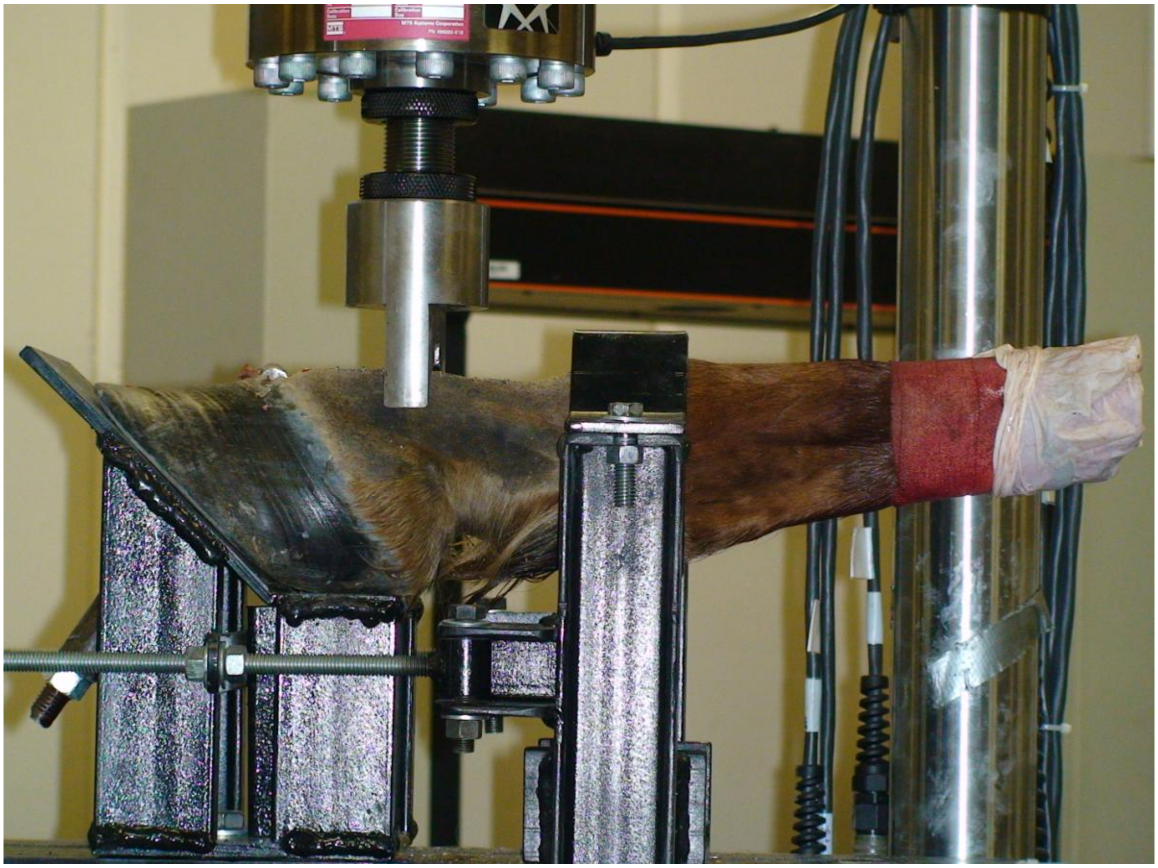
The orthopedic drill bit was inserted through the PIPJ at an angle 80-84 degrees from the dorsal surface of P1.

Figure 2



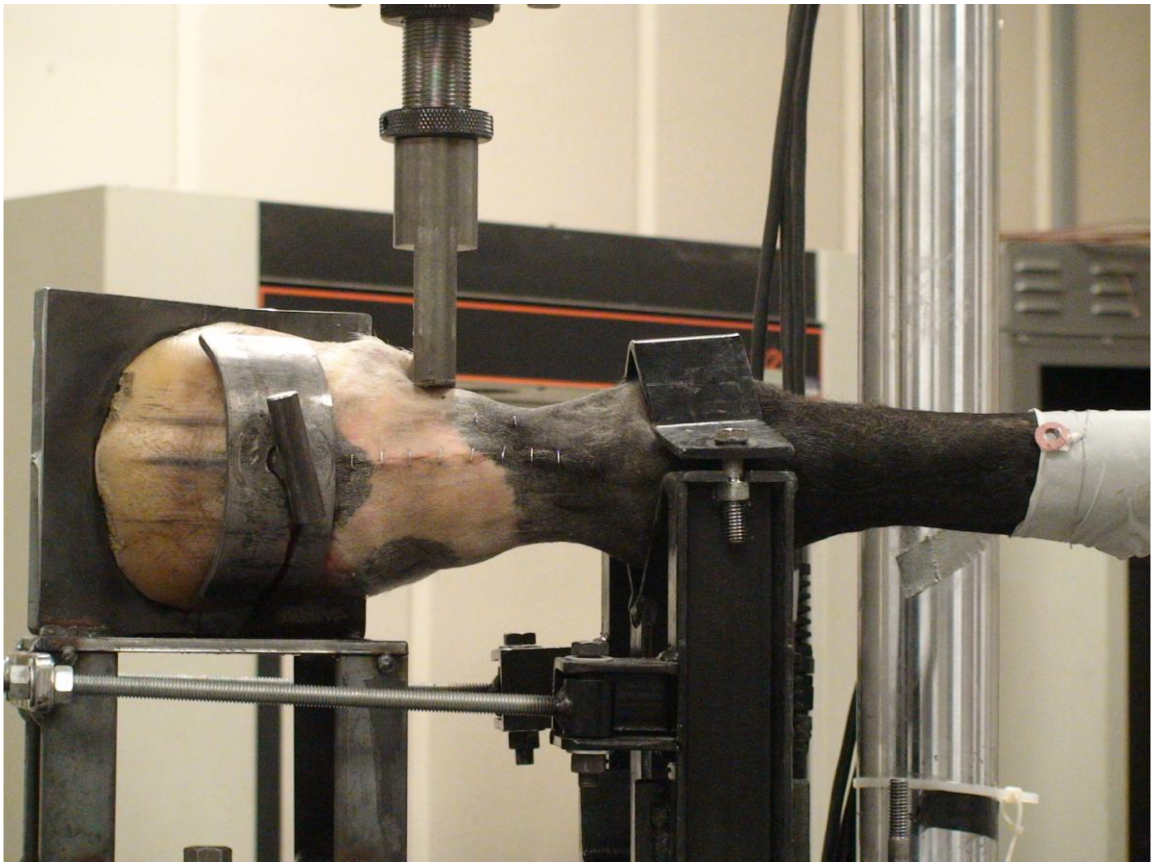
In the LI technique the dorsal surface of the PIPJ was exposed with the aid of sharp dissection and retraction with 2 gelpi retractors.

Figure 3



Mounting frame for biomechanical loading in dorso-palmar/plantar in 3-point bending.

Figure 4



Mounting frame for biomechanical loading in latero-medial in 3-point bending.

Figure 5

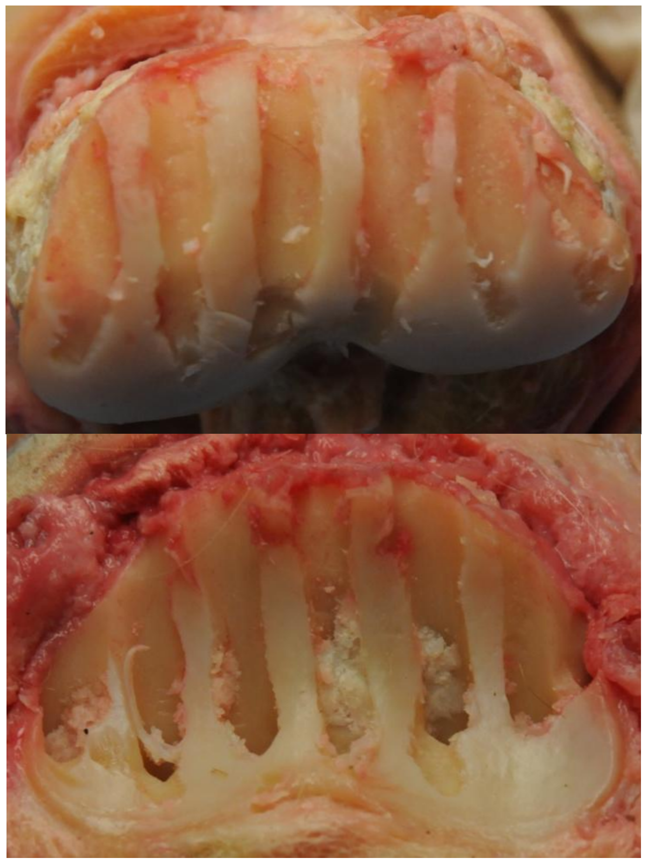


Photo illustrating the amount of cartilage removed from the distal surface of the proximal phalanx and the proximal surface of the middle phalanx in limbs subjected to seven passes with a 4.5mm orthopedic drill bit.