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# Distal Interphalangeal Joint Arthrodesis in Seven Cattle Using the Acutrak Plus Screw

ANDREW J. LEWIS, DVM, GARY A. SOD, DVM, PhD, MARJORIE S. GILL, DVM, MS, Diplomate ABVP, and COLIN F. MITCHELL, BVM&S, MS, Diplomate ACVS

**Objectives**—To report a technique for arthrodesis of the distal interphalangeal joint (DIPJ) with two 6.5 mm Acutrak Plus (AP) compression screws from a solar approach and outcome in 7 cattle.
**Study Design**—Case series.
**Animals**—Cattle (n = 7) with DIPJ arthritis.
**Methods**—Retrieved data from medical records of cattle that had undergone DIPJ arthrodesis using 2 AP screws via a solar approach were signalment, history, clinical signs, preoperative blood work, preoperative radiographs, complications, postoperative radiographs, and postoperative lameness evaluation. Outcomes, assessed by owner interview 6–26 months after surgery, were classified as excellent, good, or poor.
**Results**—Fusion of the DIPJ was evident by 6 months. All cattle returned to full function with minimal lameness and normal appearance to the distal aspect of the limb. Four thoracic limbs and 3 pelvic limbs were affected; 3 medial and 4 lateral claws. Complications included moderate lameness associated with implants (n = 2) that resolved after screw removal.
**Clinical Relevance**—Use of the AP screw system in cattle is an excellent option for DIPJ arthrodesis with minimal postoperative morbidity and excellent return to function.


## INTRODUCTION

DISEASE PROCESSES of the distal interphalangeal joint (DIPJ) and distal phalanx (P3) are a common source of lameness in cattle, may be life limiting, and resulted substantial economic loss for the producer. Diseases affecting the DIPJ and/or the 2nd phalanx (P2) or P3 include septic and nonseptic arthritis, DIPJ luxations, septic and nonseptic pedal osteitis, and P3 fractures.[1] Reported therapeutic options include conservative management by placing the healthy claw on a block to alleviate weight-bearing on the affected claw, digital amputation, facilitated ankylosis,[1] and fenestration of the abaxial hoof wall, and implantation of gentamicin-impregnated collagen sponges.[2]

Digital amputation is commonly performed in cattle with variable success ( ~ 27–73%).[3–5] Median survival times after digital amputation are significantly decreased compared with controls[4]; however, comparison of digital amputation with solar DIPJ resection showed no significant difference in life span between groups.[5] Major factors affecting successful outcome after digital amputation include the size and weight of the animal as well as the affected claw.[1] Amputation of the rear medial claw tends to have the best possible outcome for return to function and long-term survival, probably because most weight distribution in the pelvic limbs is primarily through the lateral claw.[3]

Fusion of the DIPJ is most commonly achieved by facilitated ankylosis. There are many advantages of DIPJ fusion compared with amputation, including prolonged patient survival thus longer production life,[1,4] more mechanically stable repair, no weight or claw predisposition to better outcome, as well as a more cosmetic end result.[1]

From the Department of Veterinary Clinical Sciences, School of Veterinary Medicine, Louisiana State University, Baton Rouge, LA.
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Address reprint request to Dr. Andrew J. Lewis, DVM, Department of Veterinary Clinical Sciences, School of Veterinary Medicine, Louisiana State University, Baton Rouge, LA 70803. E-mail: ajlewis@vetmed.lsu.edu.
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Facilitated ankylosis can be performed through either a solar or dorsal approach, depending on the disease process. Disadvantages associated with facilitated ankylosis include increased expense compared with amputation and a prolonged and typically painful recovery period, resulting in slower return to production.

We report our experience with DIPJ arthrodesis using the Acutrak Plus screw ([AP] Acumed, Beaverton, OR), a titanium alloy 6.5 mm tapered, headless, variable-pitch compression screw. This screw was initially designed for human orthopedic procedures, including acute and nonunion scaphoid waist fractures,[6] as well arthrodesis techniques for the hand, foot, and digits (Orthopedic Techniques, Acumed). Use of this screw in veterinary surgery has been limited to repair of nondisplaced lateral condylar fractures of the 3rd metacarpal or metatarsal bones[7] and frontal slab fractures of the 3rd carpal bone in horses.[8] The major benefit of this screw design is that it allows the entire screw to be buried in the bone, thus avoiding impingement on the surrounding soft tissue structures,[7,8] including the sole, therefore minimizing lameness. We report our technique for DIPJ fusion with the AP screw from a solar approach and short- and long-term outcomes in 7 cattle with advanced osteoarthritis of the DIPJ.

## MATERIALS AND METHODS

### *Criteria for Case Selection*

Medical records (May 2005–January 2008) of 7 cattle with advanced osteoarthritis of the DIPJ secondary to fracture or septic arthritis, treated by arthrodesis of the coffin joint using AP screws via a solar approach were reviewed.

### *Retrieved Data*

Signalment (age, breed, and gender) and historical data (duration and cause of lameness, limb, and claw affected, current use, and type and duration of antimicrobial use) were retrieved from the medical records. Preoperative variables retrieved included results of physical examination, degree of lameness,[9] preoperative radiographs, and antimicrobial and nonsteroidal antiinflammatory drug (NSAID) administration. Postoperative variables of interest were postoperative radiographic evaluation, complications (including inappropriate screw placement, infection, or persistent lameness), antimicrobial and NSAID administration, and days of hospitalization.

### *Surgical Technique*

Feed was withheld for 48 hours and water for 12 hours before surgery. Procaine penicillin G (22,000 U/kg subcutaneously every 12 hours) and ceftiofur hydrochloride (4.4 mg/kg subcutaneously once daily) or ceftiofur crystalline-free acid (6.6 mg/kg subcutaneously once) was administered. Flunixin meglumine (1.1 mg/kg intravenously [IV]) was administered for its analgesic and antiinflammatory effects.

Cattle were physically restrained (n = 1) or had general anesthesia (6) using premedication with xylazine (0.05 mg/kg IV) and butorphanol (0.025 mg/kg IV), induction with ketamine hydrochloride (2.2 mg/kg IV) and maintenance with isoflurane in oxygen. Cattle were positioned in lateral recumbency with the affected limb up. In the cow that was physically restrained, regional IV anesthesia (20 mL, 2% lidocaine) of the affected limb was performed.[10]

The entire distal aspect of the affected limb from the proximal aspect of the cannon bone distally was clipped and prepared for aseptic surgery. The affected claw was pared out, trimmed, and prepared for aseptic surgery. Two 14-gauge needles were placed in the sole to determine correct location for trephination and position was confirmed using fluoroscopic guidance. A 1/2 in. Galt trephine was used to create a circular defect centered on midline of the sole of the affected claw $\sim$ 2 cm palmar or plantar to the dorsal solar margin of P3 to allow exposure to the solar surface of P3. A 0.62-mm-diameter threaded guide pin was placed with the aid of a pneumatic air drill from the solar surface of P3 through the DIPJ into P2 parallel to the dorsal surface of P3. The correct angle and approximate depth was confirmed by fluoroscopic guidance. Pin depth was measured using a depth gauge. The thread hole was then created to the previously determined depth using a cannulated tapered dense bone drill bit with the guide pin centered through the bit. The hole was lavaged and tapped using a tapered bone tap to the appropriate predetermined depth by rotating the tap until it was snug. The tap was then rotated clockwise an additional 1/4 turn, followed by 4 counterclockwise turns, repeating the process each time. Care was taken to ensure that the tap was not backed out beyond 4 turns, as this increased the risk of accidentally double-tapping the hole. After tapping, the hole was copiously lavaged to clear all debris.

A 6.5-mm-AP screw 5 mm shorter than the depth of the thread hole was then inserted (Fig 1) until the screw head was buried in the solar surface of P3 and the screw could not be

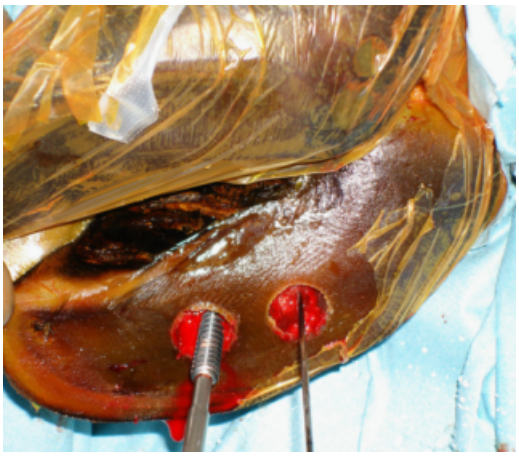

**Fig 1. Intraoperative photographs showing location of trephine holes on the solar surface of P3 and placement of the dorsal screw.**

safely tightened further. A 2nd screw was inserted similarly $\sim 1.5$ cm palmar or plantar to the 1st screw in the same sagittal plane but at a slightly convergent angle to the 1st screw. Correct placement of both screws was confirmed using fluoroscopy. After both screws had been inserted, the solar defects created by the trephine were closed using hoof acrylic, which extended along the entire solar surface and along the entire hoof wall, thus creating a water-tight seal. A 3/4 in. Lexan claw block (SABIC Innovative Plastics, Riyadh, Saudi Arabia) was placed on the healthy claw to remain for 3 months, and the distal aspect of the limb excluding the healthy claw was protected in a sterile bandage for 2 weeks. Stall rest was recommended for 3 months.

### *Outcome*

Short-term (hospital discharge) and long-term ( $\geq$ 6 months) outcome were recorded. Postoperative return to function, complications that developed after hospital discharge and owner satisfaction were obtained during recheck appointments and/or by telephone conversation.

## RESULTS

Seven cattle (4 females, 3 males), aged 2–7 years, and weighing 364–909 kg, had DIPJ fusion. Breeds were Angus (2), Simmental (1), Holstein (1), Hereford (1), and Angus cross (2). Duration of lameness ranged from 1 to 90 days in 4 cases; there was no recorded duration of lameness for 3 cases. Cause of lameness included septic arthritis of the DIPJ because of chronic severe subsolar abscesses (3), septic arthritis of the distal and proximal interphalangeal joints (1), nonseptic arthritis of the DIPJ joint (2), articular P3 fracture with pedal osteitis, and DIPJ degenerative joint disease (1). Distribution of limb and claw affected was right fore medial claw (1), right rear lateral claw (1), left rear lateral claw (2), left fore medial claw (2), and left fore lateral claw (1). Current or intended uses were rodeo bucking bull (1), breeding bull (2), and breeding cow (4).

On admission, 4 cattle were grade 4/5 lame and 3 were grade 5 lame. For those cattle with a septic process, antibiotic regional limb perfusion over 30 minutes was performed with either ticarcillin (1 g) or cefazolin (1 g) diluted in sterile water to a final volume of 30 mL. Joint lavage was not performed because in our experience DIPJ lavage is not very rewarding. Duration of regional antimicrobial before surgery ranged from 4 to 90 days. Radiographic findings included bridging but incomplete ankylosis of the DIPJ (5), articular fracture of P3 (1), and/or pedal osteitis (2).

Surgical times ranged from 60 to 186 minutes (mean, 108.7 minutes). The most common intraoperative complication was incorrect pin placement; however, this was easily corrected using fluoroscopic guidance. Additional intraoperative complications included pin breakage (1), pin bending (1), premature screw binding leading to head exposure from the solar surface of P3 (1). No other major complications occurred.


**Fig 2. Postoperative lateromedial (A) and dorsopalmar (B) radiographic views of the distal interphalangeal joint. Note the angulation of the 2 screws with respect to the solar surface of P3 (A) and the sagittal alignment (B).**

All cattle had mild to moderate discomfort (grade 3–4/5 lameness) for the first 48 hours, which then improved after this to either a grade 1–2/5 over the first week. A mechanical lameness because of the claw block on the unaffected claw, resolved after removal of the block. Postoperative radiographs confirmed correct screw placement (Fig 2). Postoperative complications included implant infection necessitating implant removal (2), persistent or reoccurring lameness (3), and palmar fracture of P2 associated with screw break-out requiring screw replacement (1).

Duration of hospitalization ranged from 10 to 227 days (mean, 86.6 days). Short-term outcome showed no lameness (n = 5), mild lameness (1), and moderate lameness (1). Long-term follow-up radiographs (6–26 months) in 3 cattle showed excellent DIPJ fusion (Fig 3) without lameness. Operated limbs had a normal external appearance. Long-term outcomes based on client conversation showed that all clients were satisfied with the end result and all cattle returned to their previous function.

## DISCUSSION

We report a minimally invasive technique for DIPJ arthrodesis by facilitated ankylosis using a solar approach and AP screws. The headless design of the AP screw makes it ideal for DIPJ fusion because the entire screw can be successfully buried. Interfragmentary compression studies comparing the AP and 4.5 mm AO cortical bone screw


**Fig 3. Lateromedial (A) and dorsoplantar (B) radiographic views of the distal interphalangeal joint at 4 months. Note obliteration of the joint space, new bone formation, and mild screw track lysis.**

in simulated lateral condylar fractures of equine 3rd metacarpal bone have shown that the AP achieves only 65% of the compressive pressure of the AO screw.[11] For DIPJ arthrodesis, the goal is not to achieve maximal compression, but rather to immobilize the joint (to decrease pain associated with severe degenerative joint disease) as well as to promote more rapid ankylosis; the AP screw accomplishes both objectives by immobilization of the DIPJ joint immediately after screw insertion.

Intraoperative complications in 2 cattle were binding of the drill bit in the dense bone of P2(1), which caused premature locking of a screw leading to partial screw exposure ( $\sim 3$ mm), and bending of the guide-pin in the nonanesthetized cow after movement of the limb (1). Although bit binding occurred, the screw was of adequate depth in P2 to immobilize the joint; however, we believe this complication, led to the premature locking of the screw, as the drill hole was most likely not of adequate depth to bury the screw in P3, and ultimately required removal of the screw because of lameness associated with screw exposure. A shorter screw was not available for use. Patient movement led to guide-pin bending, necessitating multiple attempts to replace the pins, which complicated the procedure. We do not recommend this procedure be performed in the nonanesthetized patient despite adequate regional anesthesia, because delays caused by movement increased surgical time (186 minutes) compared with that in anesthetized cattle (mean, 70 minutes).

Postoperative lameness was associated with a palmar P2 fracture because of inappropriate placement of the palmar screw in 1 bull, leading to screw replacement. This bull subsequently developed a subsolar abscess 1 month after the 2nd surgery leading to implant infection, and requiring removal of the palmar screw; however, there was sufficient ankylosis that additional screw use was unnecessary and P3 (implant-associated osteitis) infection resolved after implant removal. Palmar fracture of P2 in 1 cow was associated with poor client compliance because the cow was turned out on pasture after hospital discharge, leading to excessive limb use. One could argue that failure of this screw was because of excessive strain on the palmar aspect of P3 from the pull of the deep digital flexor tendon; however, given an appropriate period of stall rest, we do not believe this repair would have failed. Postoperative lameness was also associated with implant loosening because of infection. Although appropriate techniques were performed to ensure aseptic technique, it has been reported that regardless of preparation technique, there is still a large enough bacterial population on the sole to lead to infection.[12] This is one possible complication that owners must understand initially, when comparing the risks and benefits this procedure compared with digital amputation or joint resection. Postoperative complications that can occur with digital amputation and joint resection include breakdown injury of the remaining claw, digital flexor tenosynovitis, osteomyelitis, coronary band abscesses, tipping claw, and pododermatitis circumscripta[5,13–16] did not occur in our cattle.

Mean hospitalization was $\sim 87$ days, which largely reflected an inability of owners to adequately confine their animals. One bull was sent home, and because of poor client compliance, returned to the hospital for lameness after jumping a fence. On radiographic examination, the joint was fusing adequately without evidence of decreased stability or fracture, so soft tissue strain was suspected and after box stall confinement and administration of flunixin meglumine (1.1 mg/kg IV every 48 hours for 6 days), lameness resolved. Mean hospitalization time was also high because earlier cases were hospitalized for longer to allow appropriate postoperative monitoring as potential complications were unknown.

A previous study[1] reported that success rates after digital amputation in cattle decreased drastically with weights $>682$ kg. Three of our cattle weighed $>770$ kg and all 3 returned to previous activity, including 1 bucking bull that is currently in full use. It has been reported that ankylosis takes between 7 and 12 months[13] but we found with our technique that radiographic fusion was evident by 6 months.

We reported a practical and cosmetic means of arthrodesis of the DIPJ using the AP screw system. This procedure allowed for stable repair and rapid fusion of the DIPJ, with all cattle returning to their previous level of function. Because of implant cost, this procedure may be limited to valuable breeding animals or athletes.

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