Distal Interphalangeal and Thumb Interphalangeal Joint Arthrodesis with New Generation Small Headless, Variable Pitch Fixation Devices

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Distal interphalangeal (DIP) joint and thumb interphalangeal joint (IP) arthrodeses are well-accepted procedures for the treatment of painful or unstable joints. Numerous techniques for accomplishing fusion have been described in the literature, using methods of fixation including Kirschner Wires (K-wires), interosseous wiring,[1] standard bone screws,[2-4] bioabsorbable implants,[5] plates,[6] external fixators,[7] and headless variable pitch screws such as Herbert (Zimmer, Warsaw, Indiana)[8-12] or Acutrak (Acumed USA, Hillsboro, OR)[13-16] screws. An arthroscopic-assisted technique has been described as well.[17]

Implant size plays an important role in fixation of DIP joint arthrodeses, in light of the small size of the distal phalanx, especially in the small finger. Wyrsch et al[18] noted that the average dorsopalmar diameter of the distal phalangeal neck (3.55mm) was smaller than the diameter of the lagging threads of the Herbert screw (3.90mm). In 10 of 15 male cadaveric specimens and 15 of 15 female specimens, these threads penetrated either the volar or dorsal cortex. In those penetrating dorsally, this lead to apparent nail matrix injury.

There are commercially available headless variable pitch devices now available in smaller sizes than previous implants (Table 1). These devices should theoretically decrease the risks of nail injury and distal phalanx fracture, be more technically forgiving, and permit a greater bone-to-bone contact area at the fusion site. We present a retrospective case series summarizing our experience with smaller, headless, variable pitch implants for DIP and IP joint arthrodeses along with our technique and observed complications.

Materials And Methods

Patients were located by querying our billing database for CPT codes 29860 or 29862. Between July 2007 and January 2012 there were 57 fusions in 36 consecutive patients treated with arthrodesis of the DIP or thumb IP joint with either the Acutrak Micro or Fusion (9 digits in 9 patients) or AcuTwist (48 digits in 28 patients)*. Revision arthrodeses were excluded.

Radiographic healing of the arthrodesis site was defined as bridging callus on two or more cortices on plain radiographs. All procedures were performed by one of two attending hand surgeons within a tertiary referral academic practice in a metropolitan setting. Hospital charts were reviewed for clinical data and radiographs were evaluated for alignment and healing.

*Note: One patient had IF, MF, RF, SF arthrodeses with Acutwist devices and a T arthrodesis with an Acutrak Fusion device.

TABLE 1. Selected Commercially Available Cannulated Headless Screws

Implant	Leading Thread Diameter (mm)	Trailing Thread Diameter (mm)
AcuTwist	1.5	2.0
Acutrak Micro	2.5	2.8
SBI AutoFix	2.0	3.0
Synthes 2.4mm Cannulated Headless Screw	2.4	3.1
Zimmer Herbert Mini	2.5	3.2
Acutrak Mini	2.8	3.2
Synthes 3.0mm Cannulated Headless Screw	3.0	3.5
Zimmer Herbert Screw	3.0	3.9

Surgical Technique

The technique for Acutrak micro screws is similar to the technique described by Brutus et al.[13] The technique for the Acutwist is described below.

Patients were positioned supine utilizing a hand table. Pre-operative antibiotics were administered. A transverse incision was made at the level of the DIP joint. This was carried down sharply through skin and extensor tendon to the bone. The flap was not undermined distally so as to protect the germinal matrix. After exposing the DIP joint any remaining cartilage was curetted out and osteophytes were removed with a rongeur. The bone was contoured at this point, if necessary, to correct any coronal or sagittal plane deformities, but the overall shape of the two opposing surfaces was maintained except for correcting angular deformity and exposing deep to the subchondral bone. A small K-wire was used to penetrate the subchondral surfaces of the surface of the distal phalanx in areas of dense sclerotic bone.

Then, a 0.045-inch diameter double tipped wire was advanced in an antegrade fashion through the flexed distal phalanx, exiting through the tip of the finger in the midline, just volar to the nail plate. This was then advanced until the tip was just proximal to the surface of the distal phalanx. The finger was then reduced to a position of neutral coronal plane alignment and 0-10 degrees of flexion, and the wire was advanced proximally into the middle phalanx. Positioning was confirmed on anteroposterior and lateral mini-C arm fluoroscopy. The skin was incised at the tip to a 2mm opening. The length was then measured, either with a supplied depth gauge or with a second guide wire and ruler. Next, while holding the reduction, the wire was removed and the tract tapped (when necessary); in our series tapping was used only when the surgeon felt the bone was particularly dense. The appropriate length Acutwist device was inserted inserted taking care to maintain the reduction of the arthrodesis site to allow the screw to follow the proper wire tract. Once seated to the desired depth, the implant placement and clinical alignment were again confirmed. The device was then toggled in the anteroposterior and mediolateral planes while securing the arthrodesis site. The shaft of the device then would break off from the screw at the machined "snap-off groove". Final fluoroscopic images were then taken. Bone grafting was used at either at this point or prior to the final placement of the implant depending on surgeon preferences. Wounds were then irrigated and typically closed with 5-0 or 6-0 nylon sutures. Soft bandages and a finger cap splint were placed, leaving the PIP joint completely free.

Sutures were removed at 10-14 days post-operatively. Hand therapy was not typically deemed necessary, unless required for any concomitantly performed procedures. Patients were followed with interval clinical visits and radiographs until bony and clinical union occurred.

Results

There were 7 males and 29 females. Average age was 58.3 years (range 33-84) at the time of surgery. Average duration of follow up was 321 days. 2 patients were lost to follow up at a time period before radiographic union would have been expected (0 days and 35 days). The primary diagnosis was osteoarthritis in 23, trauma in 4, Lupus in 3, Mallet/Boutonniere deformity in 3, and there was one case each of Dupuytren's, post infectious arthritis, and neuromuscular disorder. There were 7 thumbs, 17 index fingers, 12 long fingers, 9 ring fingers, and 12 small fingers included. 21 patients (58%) had other associated procedures performed concomitantly.

There were no cases of nail deformity, significant skin sloughing, or clinically significant malalignment. There were no cases of implant breakage intra-operatively at another site than the planned site. There was one case of prominent hardware at the volar pulp requiring hardware removal following union. This patient was asymptomatic at the most recent follow up. There was one intraoperative distal phalangeal fracture that occurred in the small finger of a patient with lupus. This was noted on final fluoscopic imaging; however, the arthrodesis site was noted to be stable. The fracture healed uneventfully and the arthrodesis site went on to union.

Radiographic union was noted in 50 of 55 fingers (91%). [2 fingers in 2 patients were lost to follow up]. Local autograft (typically from the dorsal osteophytes) was used in 27 of 57 digits. In 2 cases, bone graft from a distant site (e.g. distal radius) was used.

There were five non-unions. One was in an osteoarthritic patient who underwent 3 simultaneous DIP/IP arthrodeses, all with AcuTwist devices, which resulted in loss of fixation of the thumb IP arthrodesis site around 6 months post-operatively. This was treated with revision to an Acutrak Fusion screw with distal radius autograft and a supplementary 26-gauge interosseous wire, progressing to union at 4 months after the revision surgery. Another patient underwent ring finger DIP joint arthrodesis for post-traumatic arthritis did not demonstrate radiographic union at a 7 month follow up visit, but he was asymptomatic at that time.

There was one case of a deep infection occurring prior to bony union. This required implant removal. The patient was left with a flail joint, but was pain free in an orthosis and declined further operative intervention. The remaining non-union occurred in a patient with lupus who underwent arthrodesis of the thumb, index, and long fingers. The thumb and long figers healed uneventfully; the index did not. No further operative intervention has been performed, although she does report discomfort at this site.

Our major complication (nonunion, deep infection) rate was 10.5% and our minor complication (intraoperative fracture, symptomatic hardware) rate was 3.5%.

Conclusions

Arthrodesis of the DIP/IP joints is proven and effective for dealing with a myriad of painful and deforming ailments of the DIP and IP joints. In this setting, headless variable pitch screws have many theoretical benefits compared to other potential fixation methods. Unlike K-wires they are buried deeply and avoid having a potential conduit for deep infection. This may explain the low instance of either deep or superficial infections seen in this series. Unlike standard bone screws, they are completely intraosseous and avoid having a prominent screw head situated in the sensitive volar pulp region. This may account for the lack of complaints of tip sensitivity and the limited need for hardware removal in our series.

Our results compare favorably to prior reported series. In 1992, Stern and Fulton[12] published a series of 181 arthrodeses of DIP and IP joints. Their major complication rate was 20% (infections, non-unions, etc) and their minor complication rate was an additional 16% (skin necrosis, prominent hardware, paresthesias, etc). They reported non-unions in 21 (12%), however, 13 of these were pain free. A variety of techniques were employed.

Several case series have documented usage of headless variable pitch screws, which have the theoretical benefit of being completely intraosseous to avoid hardware prominence while providing inter-fragmentary compression. Faithfull and Herbert[9] noted 100% union and no complications in 11

DIP joints in their early series using Herbert screws. In Stern's[12] subgroup of Herbert screws, a major complication rate of 19% and minor complication rate of 44% was documented in 27 cases. More recent case series have documented variable results. El-Hadidi and Al-Kdah[8] documented fusion in 14 of 15 digits. They had one case of poor screw placement causing pain. Lamas Gomez et al[11] had fusion in 19 of 20 digits with one case of amputation related to dorsal skin necrosis. They recommended using the mini-Herbert screw to facilitate placement. Brutus et al[13] utilized mini-Acutrak screws and noted nonunions in 3/22 (14%), infection in 4/22 (18%), and nail bed injury in 3/22 (14%). They noted the difficulty of using the mini-Acutrak screws, especially in the small finger.

The smaller diameter of these devices is more appropriate for the tight confines of the distal phalangeal medullary canal. Perhaps due to this sizing, we had no instances of nail plate deformities due to penetration of the dorsal cortex of the distal phalanx as seen in the biomechanical study by Wyrsch et al.[18]

While our case series is larger than any other series utilizing headless variable pitch screws for DIP/IP arthrodeses, there are several limitations worth noting. Its retrospective nature makes it difficult to make direct comparisons with other studies. Our radiographs were obtained at non-standardized intervals, thus making a determination of time to healing unreliable. Our patients had a broad array of diagnoses, which limits the ability to elucidate different subgroup characteristics. We also were unable, given the low complication rate, to determine the relative complication rates for DIP/IP arthrodeses for these differing diagnoses. One of the nonunion cases was in a thumb IP joint and this patient went on to heal with a larger diameter implant. As the distal phalanx of the thumb is typically significantly larger then the other digits, larger implants may be preferable. The authors have switched to using larger diameter implants for arthrodesis of the thumb IP joint. We were unable to determine the role or effect of autogenous bone grafting.

Reliable fusion rates were achieved with a modest complication rate. Insertion of these implants is perhaps more technically forgiving than with prior generations of larger implants. These devices seem to be an improvement over prior generations of headless variable pitch screws.

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