acumed®

Acutrak 2® Headless Compression Screw System

Field Guide—Bunions and Forefoot Reconstruction

A COLSON ASSOCIATE

Forefoot Reconstruction: What is Hallux Valgus?

Hallux valgus is defined as a lateral deviation of the hallux (great toe) on the first metatarsal. The deviation of the hallux occurs primarily in the transverse plane. The deformity often also involves rotation of the toe in the frontal plane causing the nail to face medially (ie, eversion). These two deviations have led to the use of different terms to describe the deformity. In orthopedic texts, it is often called “hallux valgus” (HV) whereas many podiatry texts prefer the term “hallux abducto valgus” (HAV). The general public is more familiar with the term “bunion.”

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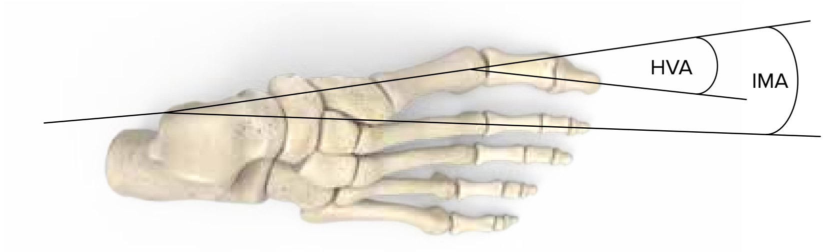
Forefoot Reconstruction: What Is Hallux Valgus?

Characteristic Angles Associated with Bunion Deformities

	Hallux Valgus Angle	Intermetarsal Angle
Mild	<19	<13
Moderate	20–40	14–20
Severe	>40	>20



HVA: Hallux Valgus Angle—Normal < 15 Degrees

IMA: Intermetatarsal Angle—Normal < 9 Degrees
Mild (HVA up to 19°, IMA up to 13°)
Moderate (HVA 20° to 40°, IMA 14° to 20°)
Severe (HVA > 40°, IMA > 20°)

Symptoms

- Pain in the bunion, the pressure-sensitive prominence on the medial side of the head of the first metatarsal
- Valgus deviation of the great toe, crowding smaller toes, which become displaced, typically upwards, leading to pressure against footwear
- Valgus deformity interferes with great toe's ability to press into ground during gait, causing metatarsal heads 2–5 to accept additional load, resulting in pain referred to as transfer metatarsalgia

Bunion Data and Frequency of Procedures

Hallux valgus is the most common forefoot deformity, with an estimated prevalence of 23% in adults and 35% in the elderly (over 65 years in age). It is estimated that approximately 350,000 bunion surgeries are performed in the United States each year (iData Research 2014). Hallux valgus deformities will cause symptoms on the medial edge of the foot, the sole, and the small toes. There are a multitude of procedures commonly used to correct the positioning of the great toe responsible for this pain, with the first metatarsal osteotomy being the most common.[1] The use of fixation, especially screw fixation, in first metatarsal osteotomies is commonplace and may be considered the standard of care. Screw fixation offers good bone-to-bone contact with interfragmental compression, allows early range of motion, and primary bone healing.[2–6]
In addition to compression, consideration must also be given to technologies which provide sustained stability and resist rotation—traits necessary to promote healing.[7] The procedures focused on in this guide include osteotomies of the first metatarsal as well as other common metatarsal reconstructive procedures.

Complications Associated With Bunion Procedures

Non-union/Delayed union

Caused by vascular injury, thermal necrosis, infection, inadequate fixation, or excessive tension forces at the osteotomy site.

Shortening

Commonly associated with a wedge resection, particularly proximal Chevron osteotomies.

Elevation

Result of dorsiflexion malunion of proximal first metatarsal osteotomies.

Biomechanical and Clinical Rationale for Use of Acutrak 2® in Hallux Valgus Corrections

Retrospective Results Involving use of Acutrak® Fully Threaded Compression Screw for Fixation of First Metatarsal Osteotomies

A 2008 retrospective investigation by John G. Fleischli, DPM, Terese J. Laughlin, DPM, and Jeffery W. Fleischli, DPM, highlighted outcomes of Acutrak usage in hallux abducto-valgus deformities.[13] A summary of this investigation, which was performed with financial support from Acumed, can be found below.

Fleischli et al (aka the reviewers) retrospectively identified patients by diagnosis code with *hallux abducto valgus* or *hallux rigidus* with the following inclusion criteria:

1. First metatarsal osteotomy using Acutrak screw fixation (at least one year postoperative)
2. A complete medical record
3. Preoperative and healed postoperative weight-bearing radiographs

The patient records were reviewed for the following:

1. Radiographic healing of the osteotomy
2. Complications associated with the screw, or other problems requiring removal of hardware
3. Measurements of pre and postoperative intermetatarsal angle using the Mitchell method[8]
4. Postoperative infections
5. Total number of office visits from the date of surgery to discharge
6. Patient age, and body mass index (BMI)

Results[13]

Total Charts Reviewed	316
Total Charts Meeting Inclusion Criteria	124
Total Complete Radiographic Union	124
Average Preoperative IM Angle	13
Average Postoperative IM Angle	8
Total Screws Removed	3
Total Other Hardware Removed	5
Total Postoperative Infections	3
Average No. of Visits	10
Average Age	53
Average BMI	28
Male	12
Female	112

Discussion

The results of this retrospective investigation demonstrate that fully threaded headless compression screws (Acutrak®, from Acumed LLC, Hillsboro, OR) are effective as a primary form of fixation for first metatarsal osteotomies.[13]

Of the three screws removed in this study only one was removed because of pain associated with the hardware. “In review of this case, the screw had been left proud and as such caused irritation. Surgeon error was the cause for extraction, and not hardware failure. The other screws were removed for infection and per patient request (no pain reported).”[13]

While complications have been reported with hallux valgus surgery, hardware irritation or failures have not always been documented. “Removal of hardware has been reported in up to 7% of the cases.”[10] In this investigation the researchers found only 2% of the screws required removal, with no failure of fixation noted.[13]

Acutrak screws offer the surgeon an alternative to conventional hardware. The fully threaded screw provides the greatest push-out force, highest amount of retained compression after cyclic loading, and highest resistance to torsional loading compared to AO and Herbert screws in cadaveric and synthetic bone material.[9] Compression is achieved through two key features that work together—the variable thread pitch and tapered profile. The wider thread pitch at the tip of the screw penetrates the bone faster than the finer trailing threads, compressing the two fragments gradually as the screw is advanced. The tapered profile allows the threads to purchase new bone with each turn, gaining compression and maximizing pullout strength along its entire length.

Parallel Fixation and Immediate Weight Bearing of the First Metatarsal

A 2011 retrospective investigation by John G. Fleischli, DPM, Terese J. Laughlin, DPM, and Jeffery W. Fleischli, DPM, highlighted outcomes of Acutrak usage coupled with a 3 to 4 hole plate in Lapidus arthrodesis.[14] A summary of this investigation, which was performed with financial support from Acumed, can be found below.

Introduction

First metatarsal cuneiform arthrodesis (Lapidus arthrodesis) is popular for the correction of hallux valgus deformity. Traditional fixation techniques require prolonged periods of non-weight bearing including suture, Kirschner wires, screws, and plates. "Incorporating plate fixation stabilizes the arthrodesis site, yet most surgeons agree plate fixation alone is not optimal."[14]

Gruber et al (quoted by Fleischli) speculates that "the addition of the compression screw across the fusion site in combination with plate fixation achieves interfragmentary friction and neutralizes plantar tensile forces."[16] Position of the plate for the Lapidus arthrodesis varies in published reports. "While medial placement over the joint remains popular, this position does not resist the forces of weight-bearing (torsional and sagittal plane) adequately. Optimal plate position would be on the plantar surface of the arthrodesis site, yet this is not practical due to technical difficulties."[14]

Traditional postoperative care includes non-weight bearing for up to six weeks. More recently Basile et al (quoted by Fleischli) notes that, "early ambulation with full weight bearing has been described with success."[23] To assure complete union of the arthrodesis site, extremely stable fixation is advisable. Klos et al "used locking (fixed angle) plates to allow earlier resumption of weight bearing and improve bony union with the Lapidus procedure."[18] Flieschli et al hypothesized that "the combination of a plantar headless compression screw with dorsal plating will produce the needed compression and stabilization following a Lapidus arthrodesis to allow immediate protected weight bearing with predictable and consistent results." In this retrospective, Fleischli et al retrospectively evaluated patients treated for hallux valgus deformity with a Lapidus type arthrodesis using a combination of plantar headless compression screw with dorsal plating.[14]

Results[14]

Twenty-three patients were identified, with 20 meeting inclusion criteria. 20 patients had demonstrated healing. Union was observed via radiograph in all patients.

No plantar gaping was noted in this group.

One minor complication occurred (delayed union), which was subsequently addressed via bone stimulation.

The mean preoperative intermetatarsal angle was 12.8 (Median: 12.5) and the average postoperative angle was 7.6 (Median: 7) for an average reduction of 5.2 degrees.

Eighteen patients underwent adjunctive procedures, with the second metatarsal osteotomy (Weil type) predominating. The average number of office visits was 6.6 (range 5–9). Patients were followed for an average of 12.2 weeks (range 8–20).

Three patients experienced hardware issues (painful) and underwent hardware removal. No infections were noted.

One patient was an active smoker and one was a type II diabetic. There were no complications or hardware issues noted with either of these patients.

The Mean BMI was 28 (Median: 25) with a range of 18–57.

Discussion

Non-healing rates for the first metatarsal cuneiform arthrodesis with patients non-weight bearing postoperatively have been reported to be 3%–12%.[18] In this retrospective evaluation of 23 patients, the reviewer found “superior results with no non-unions and 1 patient experiencing delayed union.”[14]

“Parallel fixation is achieved by placing a compression screw along the plantar arthrodesis site in combination with a dorsal plate. This allows the strongest compressive forces at the plantar surface where failure usually occurs as demonstrated by plantar gapping. The dorsal plate resists the torsional and sagittal plane forces of weight bearing.”[14]

The reviewers noted that screw choice is important in these procedures and the choice of the Acutrak 2 was made due to the screw’s ability to provide compression along its entire length, making it a preferred choice for fixation.

The reviewers concluded that “parallel screw and plate fixation of first metatarsal-cuneiform arthrodesis offers an excellent alternative to previously described fixation techniques.”[14]

Gruber et al (quoted by Fleischli) found that friction between the bones was an important part of stability surrounding the Lapidus arthrodesis site. Plate fixation alone was found to provide inferior compression between the bones when compared with screw fixation. “Screw fixation demonstrated superior stability in cadaver models.”[16]

The reviewers speculate that the combination of screw and plate fixation when placed in a parallel fashion would allow better outcomes. “The plantar placement of the screw offers stability, compression and friction between the bone ends, while better resisting the sagittal plane forces of weight bearing. The dorsal plate further stabilizes the arthrodesis in the sagittal plane and helps neutralize the torsional forces.”[14]

Conclusions

The reviewers found that "a combination of a plantar screw with a dorsal plate offers excellent fixation of the Lapidus arthrodesis in a retrospective evaluation."[14] The parallel nature of the two types of fixation, in combination with good bone to bone compression and resistance to sagittal (weight-bearing) forces may allow immediate ambulation without an increase in complications.[14]

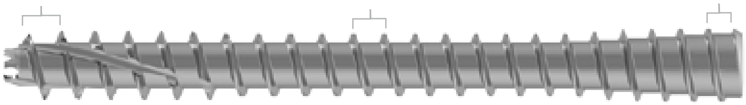
Acutrak 2® Technology

Acumed developed Acutrak screw technology to provide a headless compression-holding solution to fix fractures. It features the first fully threaded bone screw with a continuously variable thread pitch along the entire length of the screw.

The Acutrak 2 Headless Compression Screw System is composed of 65 unique screw size options to fit a wide variety of applications throughout the body. Backed by more than 25 years of clinical data and referenced in more than 100 studies in peer-reviewed journals, the Acutrak family of screws has demonstrated efficacy in hand, wrist, foot, and ankle applications.

Design Objectives

1. Minimize likelihood of soft tissue irritation through headless fixation[1]
2. Achieve compression in fracture fixation with a fully threaded construct
3. Achieve compression over a wider range of insertion depths than Standard AO cannulated screws and Herbert/Whipple HCS screws
4. Enable fixation in bone with cancellous-based thread design



Fully Threaded Continuously Variable Pitch

Designed to meet the above objectives, Acutrak screws deliver a new category of bone screw fixation that goes beyond headed and differential pitch screw options. It features a unique, patented thread pitch that varies continuously from tip to tail. This enables each screw rotation to engage threads into new bone along the screw's entire length. As each successive individual thread advances faster than the trailing thread counterpart, the conical shape becomes seated into bone.

Key Features of the Acumed Acutrak 2® Headless Compression Screw System

- Sterile and non-sterile implants
- Compression
  - Continuously variable pitch is created by having a wider thread pitch at the tip of the screw followed by finer trailing threads; this allows the screw to penetrate the bone faster at the tip than at the tail, which generates compression across the fracture site
- Headless feature
- Intended to reduce risk of impingement or soft tissue irritation compared to that of headed screws when implanted in or around articular regions.
- Soft tissue dissection may be minimized through percutaneous insertion, which is facilitated by cannulation of the screw
- Refinements when compared to the original Acutrak screw
  - Helical relief flutes at the tip of the screw are designed to aid in the removal of bone during screw insertion
    - Available in Acutrak 2: 4.7, 5.5, and 7.5 screws only

- When used with the long drill, the cutting flutes at the tip of the Acutrak 2 screws feature self-cutting capabilities to aid during screw insertion
- The large diameter guide wires are designed to allow for provisional stabilization of the fixation site and accurate screw placement while reducing the risk of bending the wire
- Decreased screw depth sensitivity is achieved through pairing a cylindrical drill with a tapered profile drill; this eliminates the requirement of "downsizing" as described for the original Acutrak screw and other headless compression screws
- Surgical technique is consistent between screw families

- Biomechanical performance
  - Biomechanical studies have shown fully threaded, headless screws maintain compression for a greater number of cycles in comparison to partially threaded screws[9]
  - When compared to traditional (AO) and differential (Herbert) bone screws, Acutrak screws were shown to have:
    - Greater push-out force than the Herbert bones screws[9]
    - The highest amount of retained compression after cyclic loading[9]
    - The highest resistance to torsional loading in cadaveric and synthetic bone material[9]
- Broad base of patient indications addressed
  - The Acutrak 2 families of product address nearly 20 of the most common indications in the hand, wrist, foot, and ankle
- Clinical and biomechanical data breadth
  - More than 100 published studies offer biomechanical and clinical usage analysis

Biomechanical Support

Interfragmentary Compression and Durability of Interfragmentary Compression Significantly Influence Healing

At least one animal study suggests that fracture stabilization that allows excessive shear motion at the fracture site impairs healing. The authors suggest that fracture fixation should therefore be performed with a minimization of shear motion.[11] Cadaveric studies have demonstrated that carpal and metacarpal fractures may also fail to heal due to bending, rotational, and translational forces that strain the fracture site and cause shearing.[19-22] These studies indicate that internal fixation should be as rigid as possible.

A previous study by Wheeler et al demonstrated that the Acutrak screw enabled fracture fragment stability in terms of compression achieved, pullout strength, and resistance to torque.[9] In comparison to Herbert screws, the Acutrak screws achieved greater compression, maintained compression over a greater depth, and had a greater push-out force.[9] The Acutrak screw also required greater torque to break fragment contact and maintained compression after cyclic loading better than either AO or Herbert screws.[9]

Improved Compression in Second Generation Headless Screws

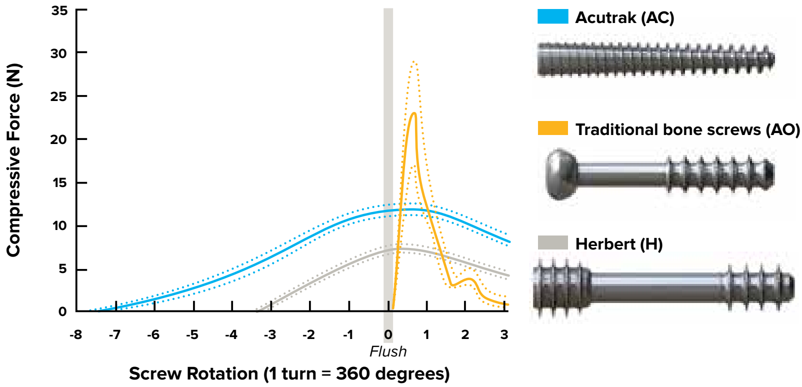
Prior to the headless compression screw, internal fixation options included open or percutaneous guide wire fixation or open reduction with headed lag screws. "Guide wire fixation had a propensity for fracture distraction, fracture instability, and secondary loss of reduction. Open lag screw fixation could result in either poor compression or joint arthrosis, as the head of the screw could reside on the articular surface and therefore cause secondary joint injury."[12] During the 1990s, cannulated headless compression screws were popular, when used with an open or percutaneously placed guide wire, from the volar and dorsal approach. Assari et al (quoted by Fleischli) assessed the biomechanical characteristics of the first generation Herbert/Whipple screw versus various next generation headless compression technologies.[12]

The Acutrak 2 Mini was cited as generating the greatest compressive force when compared with these other second generation technologies.[12] In the same study, the Acutrak 2 Mini was shown to have no reduction in compression due to over-fastening, unlike some of the other screws studied.[12]

Acutrak® Technology's Larger "Window of Compression"

All bone screw technologies have a "window of compression" that determines the number of screw rotations needed to reach a maximum compressive force (beyond which further rotations decrease this value). Traditional bone screws have a narrow window of compression as compared to differentially pitched screws. This narrow window results in a fixation construct that is more sensitive to loss of compression due to over rotation and the stripping of thread purchase. Conversely, Acutrak technology has a wide window of compression, which is less sensitive to stripping the bone and is more flexible in its placement depth enabling a maximum amount of compression.[9]

The diagram below illustrates the window of compression for Acutrak technology, traditional bone screws (AO) and differential pitch screws (Herbert).[9]

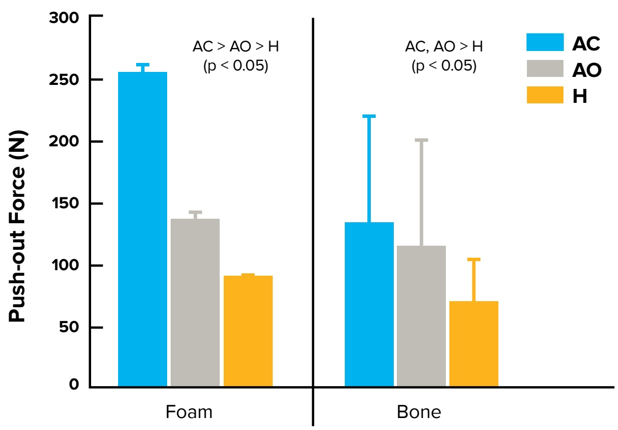


The above graph illustrates the window of screw rotations during which each screw delivers maximum compressive force. The Acutrak screw has the largest window of compression, which is attributed to the additive property of each variable thread pitch providing compression on the fully threaded screw.

Enhanced Facture Fixation Biomechanics

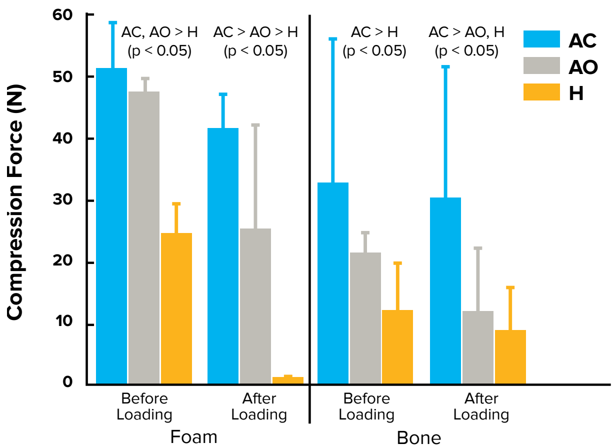
Pullout strength and resistance to cyclic and torsional loading are key measurable elements of bone screw fixation performance. The performance of Acutrak (AC) in each of these elements was compared to traditional (AO) and differential (Herbert/H) bone screws. A summary of the results is shown in the figures below:

1. Greater Push-out Strength



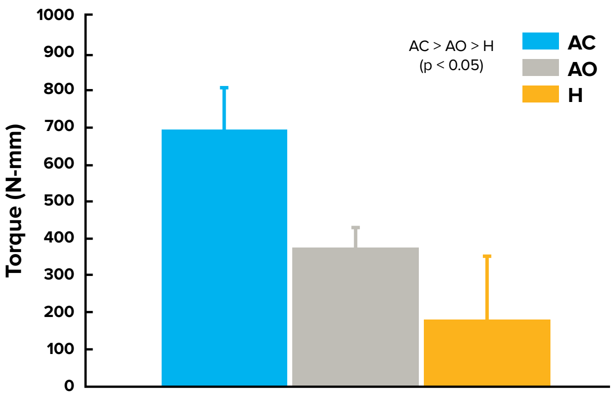
Acutrak® screws have the highest push-out force when compared to AO & Herbert bone screws (AC)[9]

2. Greater Resistance to Cyclic Loading

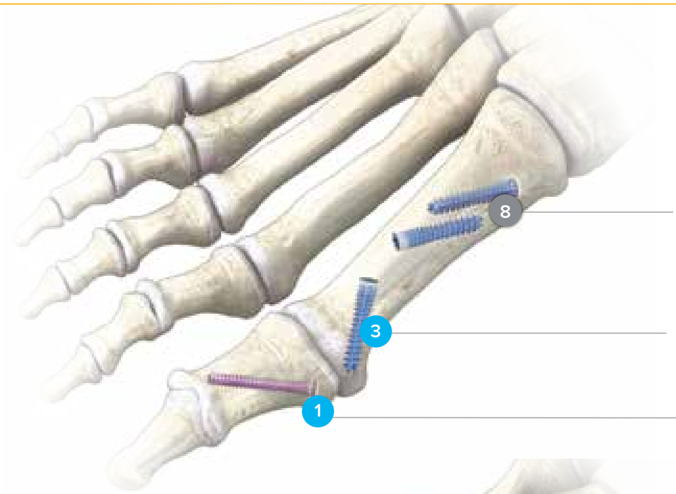


Acutrak® screws have the highest amount of retained compression after cyclic loading when compared to AO & Herbert bone screws (AC)[9]

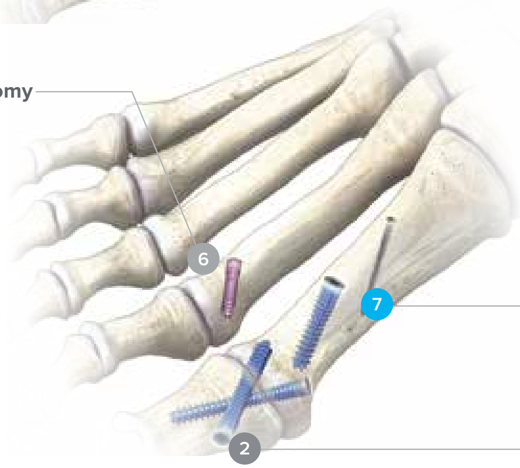
3. Greater Resistance to Torsional Loading



Acutrak® screws have the highest resistance to torsional loading when compared to AO & Herbert bone screws (AC)[9]


8
Ludloff Osteotomy
3
Chevron Osteotomy
1
Akin Osteotomy

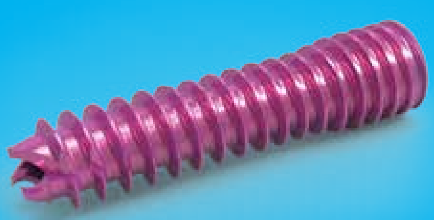

4
Lapidus
5
Scarf


Weil Osteotomy
6
7
Mau Osteotomy
2
MTP Fusion

Section

Atlas of Procedures

Akin Osteotomy



Akin Osteotomy

Product: Acutrak 2® Micro

Typical Size: 18–24 mm

Akin Osteotomy

Incision

- The incision is made from the medial side and extended distally
- The capsule is opened longitudinally and the joint is presented

Osteotomy

- A wedge osteotomy is performed, to allow the toe to be moved into a more transverse medial plane

Note:

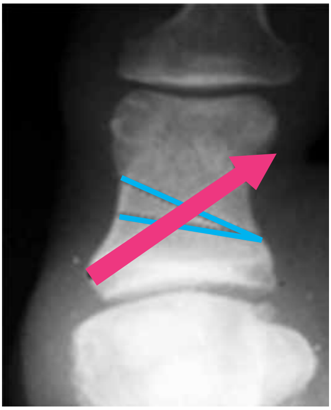
- The more perpendicular the bone cuts are to the long axis of the proximal phalanx, the more correction obtained with the procedure—an oblique osteotomy may offer the benefit of greater compression upon screw insertion but allows for less correction in the transverse plane

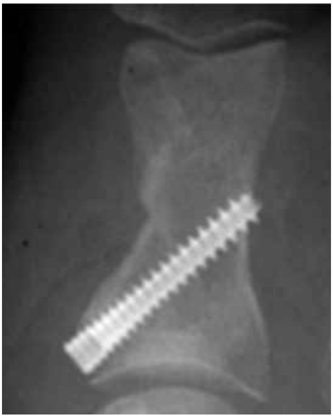
Fixation

Acutrak 2® Micro

- The guide wire is aimed in a lateral/distal/dorsal direction until it breaches the lateral cortex just proximal to the interphalangeal joint
  - The guide wire can be visualized (depending on incision placement) or felt with the finger just under the skin
- The wire is then retracted so that the tip is just penetrating the lateral cortex
- The screw sizer is used to measure the depth of the guide wire insertion
  - Downsizing is unnecessary in this application
- In particularly hard bone, the entire length of the wire can be drilled using the long drill, otherwise just the proximal aspect is drilled with the profile drill
- By design, most of the screw threads will purchase the soft intramedullary bone of the phalanx upon insertion
  - If one of the threads purchases the cortex this is acceptable
- Screw placement is made from the proximal medial aspect of the proximal phalanx

Akin Osteotomy Images





First Metatarsophalangeal Joint Arthrodesis

First Metatarsophalangeal Joint Arthrodesis

Product: Acutrak 2® Mini and Optional 3- or 4-Hole Acumed Dorsal Plate

Typical Size: 26–30 mm

First Metatarsophalangeal Joint Arthrodesis (MTP Joint Fusion)

Incision

- The incision is made dorsal or dorsal medial to allow good exposure to the entire joint

Joint Preparation

- Joint preparation is critical for this procedure
  - As with any arthrodesis, removal of all hypertrophic bone from the joint and resection of cartilage is the first step
  - With good exposure, the subchondral bone is removed down to the level of good bleeding bone
    - Reamers are recommended for removal of this subchondral bone
  - To use the reamers, a guide wire is placed centrally in the metatarsal head
  - An appropriate size convex reamer is then used to form the surface of the metatarsal head and remove bone down to the level of good bleeding bone

- Next a guide wire is placed centrally in the base of the proximal phalanx
    - A concave reamer of the same size used earlier is used here with reaming down to the level of good bleeding bone
- Fenestrations can then be placed on both sides of the joint if the surgeon wishes

Position

- Proper positioning of the joint is critical to the success of this procedure
    - The great toe should be placed parallel to the second toe, and in enough dorsiflexion to allow comfortable ambulation in shoes postoperatively

Fixation

Screw Fixation

- The joint is placed in the desired position and temporarily fixated with a guide wire
- A second guide wire is inserted from the proximal side of the metatarsal head and directed distally at an angle across the joint space
- Fluoroscopy may be used to evaluate the exact position of the guide wire
- Use the screw sizer to measure for length of the implant
- In particularly hard bone the entire length of the wire can be drilled using the long drill, otherwise just the proximal aspect is drilled with the profile drill
- The appropriate size Acutrak 2 screw is then inserted
- A second Acutrak 2 screw (using the same series of steps described previously) is inserted from the dorsal surface of the first metatarsal head to avoid contact with the plantar screw; this screw is directed proximally across the joint space and in a plantar direction

Optional Additional Fixation

Optional Plate Fixation

- A 4-hole or 3-hole plate is applied dorsally across the joint space
  - Screws are measured so that they will engage the plantar cortex

First Metatarsophalangeal Joint Arthrodesis Images

Chevron Osteotomy

Chevron Osteotomy

Product: Acutrak 2® Mini

Typical Size: 12–22 mm

Chevron Osteotomy

Incision

- The incision placement is on the dorsal-medial side of foot, with typical dissection down to the subperiosteal level

Osteotomy

- Once any desired soft tissue work is completed, there are several different versions of a Chevron osteotomy that may be performed; one such procedure is described below
  - The basic osteotomy is a cut of approximately 60 degrees
  - The apex of the V should rest in the center of the metatarsal head
  - The center of the osteotomy is marked with a guide wire that will then become the apex of the V osteotomy
    - To ensure proper alignment of the arms of the V, the guide wire may be kept in place while cutting the osteotomy, attempting to keep the blade and therefore the plane of the osteotomy maintained in alignment with the apex wire
  - Following the osteotomy, the capital fragment (portion of bone being corrected) is manipulated along the apex for approximately one-quarter to one-half the width of the bone
  - Temporary fixation is accomplished using a guide wire or bone clamp

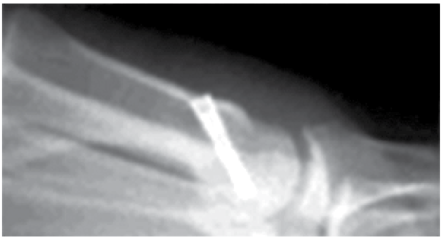
Fixation

Acutrak 2® Mini

- The guide wire is placed from the dorsal aspect of the metatarsal across the osteotomy into the capital fragment, with the aim toward the plantar first metatarsal head crista (bony ridge on the plantar portion of the first metatarsal head)
- A second guide wire may be used to aid in rotational stability
- The screw sizer is used to measure the length of the implant once this guide wire is in place
    - Screw size is typically one size below that measured to ensure proper placement of the screw and avoid the protrusion of the screw into the joint space
- After measuring, the guide wire should be advanced to prevent it from backing out during drilling
- In particularly hard bone the entire length of the wire can be drilled using the long drill, otherwise just the proximal aspect is drilled with the profile drill
- The appropriate size Acutrak 2 screw is then inserted

Remove medial eminence after screw placement

Chevron Osteotomy Images



Lapidus Bunionectomy

Lapidus Bunionectomy

Primary Fixation

Product:	Acutrak 2® Standard
Typical Size:	28–32 mm

Optional Additional Fixation

Product:	Acumed 3-Hole or 4-Hole Plate

Secondary Fixation

Product:	Acutrak 2® Mini or Standard
Typical Size:	28–32 mm

Lapidus Bunionectomy

Incision

- The incision is made medially or dorsal medially with typical dissection to the joint level
    - Any soft tissue work or distal bone work is completed prior to joint preparation
    - The initial exotosis is removed from the medial side of the first metatarsal
- The tarsometatarsal (TMT) joint is opened and presented longitudinally through expansion of the dorsal incision

Joint Preparation

- Initially the distal joint is resected in a vertical direction by means of an oscillating saw
- Correction is realized through removal of a lateral wedge from the proximal joint surface
    - In order to prevent elevation, the wedge is removed from the plantar surface
- Joint preparation is critical for this procedure
    - As with any arthrodesis, all hypertrophic bone and cartilage is removed from the fusion site—a combination of an AO elevator, a quarter-inch osteotome, straight and curved currettes, and a rongeur are recommended to facilitate this removal
    - Subchondral bone is then removed down to the level of good bleeding bone
        - Rongeurs are recommended for removal of this subchondral bone

- Use a 2 mm drill bit to create a series of perforations in the arthrodesis surfaces to optimize surface area and blood flow—a limina spreader can be helpful for distraction

Positioning

- The joint is positioned and temporarily fixated using a guide wire placed from the medial aspect of the base of the first metatarsal into the cuneiform
- Positioning is checked with fluoroscopy

Initial Fixation Using an Acutrak 2® Standard Screw

- A guide wire is inserted approximately 1 cm proximal to the joint surface on the plantar aspect of the first metatarsal and placement is confirmed using fluoroscopy
- The guide wire is angled from plantar slightly dorsal and in a lateral direction
- The screw sizer is then used to determine depth and near cortex drilled with the profile drill
- The self-drilling design of the Acutrak 2 screw eliminates the need for use of the long drill
- A second Acutrak 2 screw (using the same series of steps described previously) is inserted from the dorsal surface of the first metatarsal head to avoid contact with the plantar screw; this screw is directed proximally across the joint space and in a plantar direction

Optional 3- or 4-Hole Plate Placement

- A 3- or 4-hole plate is placed across the dorsal surface of the joint
- The plate will be roughly parallel to the plantar screw
- The plate is held with a cortical screw placed distally and a cortical or cancellous screw placed proximally in the cuneiform

Secondary Fixation Using an Acutrak 2® Mini Screw

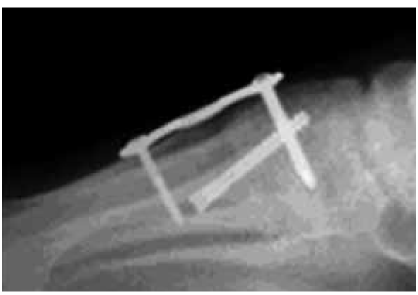
- The second Acutrak screw is placed through the plate, utilizing the large central hole. The screw should be positioned so that it does not engage the plate
- Positioning is checked using fluoroscopy
- This construct has allowed for immediate postoperative weight bearing in a cast boot[14]

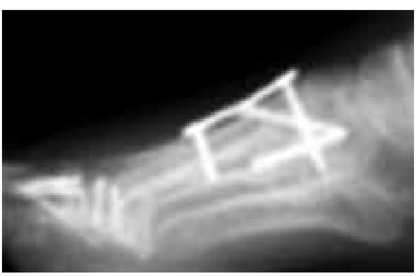
Rationale for Plate and Screw in Combination

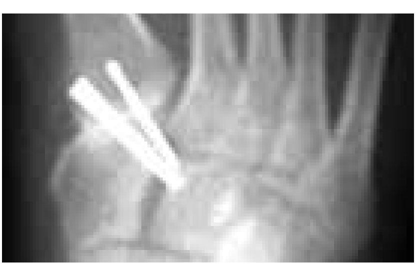
According to Fleischli et al, this plate and screw combination may provide the following benefits:

- Parallel fixation is achieved by placing a compression screw along the plantar arthrodesis site in combination with a dorsal plate (a simpler technique than plantar placement which is often used)—this allows the strongest compressive forces at the plantar surface where failure usually occurs as demonstrated by plantar gapping[14]
- The dorsal plate resists the torsional and sagittal plane forces of weight bearing[14]
- The plantar placement of the screw offers stability, compression and friction between the bone ends, while better resisting the sagittal plane forces of weight bearing[14]
- The dorsal plate also further stabilizes the arthrodesis in the sagittal plane and helps neutralize the torsional forces[14]

Lapidus Bunionectomy Images







Scarf (Z) Bunionectomy

Scarf (Z) Bunionectomy

Primary Fixation

Product: Acutrak 2® Mini

Typical Size: 16–22 mm

Secondary Fixation

Product: AcuTwist®

Typical Size: 12–18 mm

Scarf (Z) Bunionectomy

Incision

- Incision is made on the dorsal medial side of the foot, with typical dissection down to the subperiosteal level
- Once any desired soft tissue work is completed, a Scarf (Z-shaped) bone cut is performed

Osteotomy

- The Z-shaped osteotomy is performed using a microsagittal saw from the medial aspect of the first metatarsal
- The longitudinal portion of the osteotomy should NOT be made directly in the midline of the metatarsal
    - Instead, this longitudinal limb is slightly dorsal where it meets the distal, more vertical limb and more plantar where it intersects with the oblique proximal limb
        - With this pattern, the proximal intersection of the osteotomy's limbs is supported by adequate dorsal bone and less prone to stress fracture
- The longitudinal cut is made first, directing the saw blade slightly plantar, thereby diminishing the risk of first metatarsal elevation

- The cuts for the two oblique limbs are then performed
  - The two shorter oblique limbs of the osteotomy should be made in the same plane, from medial to lateral, to ensure the osteotomy can be laterally translated
    - If these shorter limbs are parallel but directed distally, the metatarsal may be slightly lengthened, and if directed proximally, the metatarsal may be shortened slightly
- The capital fragment is then positioned per surgeon preference
- Temporary fixation using a guide wire or bone clamp is achieved

Fixation

Initial Fixation Using an Acutrak 2® Mini

- The guide wire is placed from the dorsal aspect of the metatarsal across the osteotomy into the capital fragment; the point of aim is the plantar first metatarsal head crista
  - The guide wire can be passed through the plantar cortex of the crista and then retracted to ensure the guide wire is in the subcortical bone of the first metatarsal head; fluoroscopy may also be used to confirm positioning
- Measurements are taken once this wire is in place using the screw sizer
  - Screw size is typically one size below the measured length to ensure proper placement of the screw and avoid protrusion of the screw into the joint space
- Drill the dorsal cortex prior to insertion of the screw using the profile drill
- The self-drilling design of the Acutrak 2 screw eliminates the need for full drilling; however, if desired, the long drill can be used to drill the entire length of the guide wire

Secondary Fixation

Secondary Fixation Using an Acutrak 2® Micro or AcuTwist®

- The second screw is placed proximally to the first
    - The guide wire or AcuTwist is pre-drilled in dense bone and measured with the appropriate screw sizer
- Fixation is accomplished in both the dorsal cortex and plantar cortex of the first metatarsal
    - Several threads should engage both cortices

Remove medial eminence after screw placement

Scarf Osteotomy Images

Weil Osteotomy

Weil Osteotomy

Product: Acutrak 2® Micro or AcuTwist®

Typical Size: 10–12 mm

Weil Osteotomy

Incision

- Incision is made over the joint of the impacted lesser metatarsal (2–5)

Osteotomy

- The toe is plantar flexed to aid in exposure of the joint
- The incision is started at the dorsal surface of the joint and cut through the articular cartilage
- The osteotomy starts at the dorsal quarter of the lesser metatarsal bone at an angle of approximately 45 degrees for the second metatarsal and 60 degrees for the third through the fifth metatarsals, making the osteotomy parallel with the floor
    - This cut is made parallel to the weight-bearing surface of the foot to avoid elevating the toe postoperatively
    - The superior portion of the metatarsal is removed (2–3 mm) with the oscillating saw and the capital fragment is transposed

- The guide wire is then retracted to a level just below the plantar cortex prior to measurement
- The head of the bone is then repositioned

Fixation

Acutrak 2® Micro

- Measure the guide wire using the screw sizer provided
- After measuring, the guide wire should be advanced to prevent it from backing out during drilling
- In particularly hard bone the entire length of the wire can be drilled using the long drill, otherwise just the proximal aspect is drilled with the profile drill
- Insert screw
- The screw should not penetrate the plantar cortex

Remove dorsal eminence following screw placement

Alternative Fixation

AcuTwist® Compression Screw

- Measure the size of metatarsal head on lateral radiographs preoperatively
- In particularly hard bone, pre-drill with guide wire and measure from this wire
  - In soft bone, predrilling may not be required
- Insert the AcuTwist to the level of dorsal cortex and break off flush
- Check the stability of the fixation
- If further stability is desired, an additional screw or an additional AcuTwist may be added

Remove dorsal eminence following screw placement

Weil Osteotomy Images

Mau Osteotomy

Mau Osteotomy

Primary Fixation

Product:	Acutrak 2® Mini
Typical Size:	16–22 mm

Secondary Fixation

Product:	Acutrak 2® Mini or Micro
Typical Size:	12–16 mm; 14 mm is the most common

Mau Osteotomy

Incision

- Incision is made on the medial side of the foot longitudinally

Osteotomy

- Osteotomy begins 1 cm distal to the first tarsometatarsal (TMT) joint at the plantar cortex in the medial side
- Osteotomy is angled from plantar proximal to dorsal distal
- Once the osteotomy is complete, an axis guide is established at the proximal portion of the osteotomy using a small guide wire which is angled perpendicular to the osteotomy, allowing the distal fragment to pivot laterally and reduce the intermetatarsal angle

Fixation

Primary Fixation

- The first screw is placed across and perpendicular to the completed portion of the osteotomy from dorsal to plantar

Secondary Fixation

- A second screw is placed dorsal to plantar and parallel to the first screw perpendicular to the osteotomy

Remove medial eminence after screw placement

Ludloff Osteotomy

Ludloff Osteotomy

Primary Fixation

Product:	Acutrak 2® Mini
Typical Size:	16–22 mm

Secondary Fixation

Product:	Acutrak 2® Mini or Micro
Typical Size:	12–16 mm

Ludloff Osteotomy

Incision

- Incision is made on the medial side of the foot longitudinally

Osteotomy

- Osteotomy begins at the dorsal aspect of the proximal metatarsal, near the tarsometatarsal (TMT) joint
- The osteotomy is made parallel to the weight-bearing surface from dorsal proximal to plantar distal
- Only the dorsal two thirds of the osteotomy are completed with the initial cut

Fixation

Primary Fixation

- The screw is placed across and perpendicular to the completed portion of the osteotomy from dorsal to plantar, tightened enough to demonstrate effective compression and then backed off to allow for pivoting of the fragments
- The osteotomy is then completed
- The distal fragment of osteotomy is then rotated about the screw to correct the intermetatarsal angle

Secondary Fixation

- A second screw is placed plantar to dorsal, perpendicular to the osteotomy

Remove medial eminence after screw placement

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Appendices

Appendix 1: Correctional Procedures[15]

No.	Name	Principle	Site	Application
1	Akin	Corrective Osteotomy	Proximal Phalanax	Used in hallux valgus interphalangeus
2	Chevron	Corrective Osteotomy	First Metatarsal, Diaphyseal	Used in mild deformities
3	Lapidus	Fusion	Tarsometarsal Joint	Used in cases of TMT-1 joint instability or osteoarthritis
4	Metatarsophalangeal Joint Arthrodesis	Fusion	Metatarsophalangeal Joint	Used in severe deformities and/or hallux rigidus
5	Scarf	Corrective Osteotomy	First Metatarsal, Diaphyseal	Suitable for correction of mild to moderate deformities
6	Weil	Corrective Osteotomy	Lesser Metatarsals (2-5)	Used to repair toe clawing or metatarsalagia
7	Mau	Corrective Osteotomy	First Metatarsal, Diaphyseal	Used in moderate to severe hallux valgus deformity associated with metatarsus primus varus
8	Ludloff	Corrective Osteotomy	First Metatarsal, Diaphyseal	Used in moderate to severe hallux valgus deformity associated with metatarsus primus varus

Appendix 2: Severity and Treatment[15]

	Mild Deformities	Severe Deformities	Hallux Valgus et Rigidus
Characteristic Population	Young women	Middle-aged and elderly, predominantly women	Elderly patients
Principle Complaints	Pain in moderately prominent bunion	Significant pain in substantially prominent bunion	Insidious onset of pain and stiffness about the great toe, with or without activity
Deformity Characteristics	Flexibility in deformity, hallux can be restored to normal position manually	Toe unable to be fully repositioned manually and appears incongruent on X-ray; displacement of lesser metatarsals, leading to pressure against the shoes	Very limited dorsiflexion of MTP with adequate plantar flexion—limited to no motion at MTP joint
Displacement	Slightly splayed metatarsus, with intermetatarsal angle < 15 degrees bearing weight	Significant splay, with intermetatarsal angle > 15 degrees bearing weight	Limited space in the first MTP joint relative to other toes; slight to significant splaying characteristic of mild to severe deformities
Treatment	Distal first metatarsal osteotomies (Chevron osteotomy)	Soft tissue procedure at the MTP joint combined with a proximal metatarsal osteotomy (Scarf, Akin, Lapidus, Mau, Ludloff)	Resection arthroplasty with removal of the base of the proximal phalanx of the great toe (Metatarsophalangeal Joint Arthrodesis)

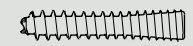
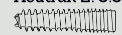
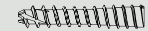
Appendix 3: Procedures and Recommended Screw Families

Product	Mild	Medium	Severe	Tips
Micro	Distal Chevron/Austin fixation and Akin procedures	Midshaft osteotomies such as Scarf, Mau, Ludloff, Weil		Screws are self-drilling, but hard bone may require predrilling Joint preparation is critical for proximal procedures (MTP and Lapidus)
Mini	Distal Chevron/Austin fixation and Akin procedures	Midshaft osteotomies such as Scarf, Mau, Ludloff, Weil	Proximal osteotomy, MTP fusion	
Standard			Proximal osteotomy, Lapidus	

Appendix 4: Correctional Procedures—Products and Common Range of Lengths[16]

No.	Procedure	Product	Common Range of Lengths
1	Akin	Acutrak 2® Micro or AcuTwist®	18–24 mm
2	Chevron	Acutrak 2 Mini	12–20 mm
3	Lapidus	2 x Acutrak 2 Standard	28–32 mm
		Optional 3- or 4-Hole Locking Plate	
4	Metatarsophalangeal Joint Arthrodesis	2 x Acutrak 2 Mini	26–30 mm
		Optional 3- or 4-Hole Locking Plate	
5	Scarf	Acutrak 2 Mini	16–22 mm
		AcuTwist	12–16 mm
6	Weil	Acutrak 2 Micro or AcuTwist	10–12 mm
7	Mau	Acutrak 2 Mini	16–22 mm
		AcuTwist	12–18 mm
8	Ludloff	2 x Acutrak 2 Mini	12–18 mm

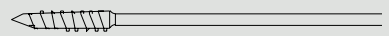
Appendix 5: Acumed Screw/Pin Reference Chart

Acutrak 2®	Acutrak 2: Micro  8 mm*	Acutrak 2: Mini  16 mm*	Acutrak 2: Standard  16 mm*	Acutrak 2: 4.7  20 mm*	Acutrak 2: 5.5  25 mm*	Acutrak 2: 7.5  40 mm*
Acutrak 2 Part No.	AT2-CXX-S and AT2-CXX	AT2-MXX-S and AT2-MXX	AT2-SXX-S and AT2-SXX	30-0XXX and 30-0XXX-S	30-00XX and 30-00XX-S	30-0XXX and 30-0XXX-S
Lengths	8 mm–14 mm (1 mm increments), 16 mm–30 mm (2 mm increments)	16 mm–30 mm (2 mm increments)	16 mm–34 mm (2 mm increments)	20 mm–30 mm (2 mm increments) 30 mm–50 mm (5 mm increments)	25 mm–60 mm (5 mm increments)	40 mm–120 mm (5 mm increments)
Tip Diameters	2.5 mm tip	3.5 mm tip	4 mm tip	4.5 mm tip	5.2 mm tip	7 mm tip
Tail Diameters	2.8 mm tail	3.6 mm tail	4.1 mm tail	4.7 mm tail	5.5 mm tail	7.5 mm tail
Guide Wire	WS-0906ST, 80-1524 Single Trocar, 80-1525 Double Trocar	WS-1106ST	WS-1407ST	80-0950	80-0950 80-0413 in AT2-5.5 System	80-0970 non-threaded 80-0971 threaded
Guide Wire Diameter	.035″ (.9 mm)	.045″ (1.1 mm)	.054″ (1.4 mm)	.062″ (1.6 mm)	.062″ (1.6 mm)	.094″ (2.4 mm)
Hex Driver	HT-0915	HT-1120	HT-1725	80-0958 (cannulated) 80-0959 (solid)	80-0958 (cannulated) 80-0959 (solid)	80-0978 (cannulated) 80-0979 (solid)
Hex Size	1.5 mm	2 mm	2.5 mm	3 mm	3 mm	4 mm
Profile Drill Part No.	AT2-1509	AT2M-1813	AT2-2515	80-0945	80-0955, 80-0055 in AT2-5.5 System	80-0975
Profile Drill Tip Diameter	1.8 mm tip	2.5 mm tip	3.1 mm tip	2.8 mm tip	4 mm tip	4.5 mm tip
Profile Drill Tail Diameter	2.9 mm tail	3.4 mm tail	4.1 mm tail	4.7 mm tail	5.5 mm tail	6.9 mm tail
Profile Drill Length	4.6 mm	8.2 mm	8.2 mm	16.2 mm (to 2 mm band)	14.5 mm (to 2 mm band)	24.3 mm (to 2 mm band)
Long Drill Part No.	80-0100, 80-1522	AT2M-L1813	AT2-L2515	80-0946	80-0956, 80-0056 in AT2-5.5 System	80-0976
Long Drill Diameter	1.9 mm	2.7 mm	3.2 mm	3.3 mm	4 mm	5.3 mm
Long Drill Length	20 mm, 36 mm	30 mm	34 mm	50 mm	60 mm	120 mm

*Shortest length available in each screw family

Acutrak®	Acutrak Mini 8 mm*	Acutrak Standard 12.5 mm*	Acutrak 4/5 25 mm*	Acutrak Plus 35 mm*	Acutrak 6/7 40 mm*
Acutrak Part No.	ATM-XXX-S	AT-1XXX-S	AM-00XX-S	AP-00XX-S	AP-67XX-S or AP-671XX-S
Lengths	8 mm–26 mm (2 mm increments)	12.5 mm–30 mm (2.5 mm increments)	25 mm–50 mm (5 mm increments)	35 mm–80 mm (5 mm increments)	40 mm–120 mm (5 mm increments)
Tip Diameters	2.8 mm tip	3.3 mm tip	4 mm tip	5.2 mm tip	6 mm tip
Tail Diameters	3.1 mm–3.6 mm tail	3.8 mm–4.6 mm tail	5 mm tail	6.5 mm tail	7.5 mm tail
Guide Wire	WS-0906ST	WS-1106ST	WS-1407ST	WS-1609ST	WS-2408ST
Guide Wire Diameter	.035″ (0.9 mm)	.045″ (1.1 mm)	.054″ (1.4 mm)	.062″ (1.6 mm)	.094″ (2.4 mm)
Hex Driver	HD-1509	HD-2011	HD-2515 or HP-2515	HD-3016 or HP-3016	HT-4000 (may need T-Handle MS-8043)
Hex Size	1.5 mm	2 mm	2.5 mm	3 mm	4 mm

*Shortest length available in each screw family

AcuTwist®	AcuTwist  10 mm*
AcuTwist Part No.	AI-00XX-S (non-cannulated)
Lengths	10 mm–30 mm (2 mm increments)
Tip Diameters	1.5 mm tip
Tail Diameters	2 mm tail
Guide Wire	WS-1106ST
Guide Wire Diameter	.045″ (1.1 mm)
Tap Part No.	AI-NG30

*Shortest length available in each screw family

Drill Tip and Tapered End Diameters	Regular Drill Part No.	Regular Drill Part No.	Regular Drill Part No.	Tip Diameter	Taper End Diameter
Acutrak Mini	ATM-078 ATM-099	 80-0295		80-0295	3.4 mm 3.4 mm
Acutrak Standard	AT-7032 AT-7044	80-0493 80-0296	 Dense	2.5 mm 2.8 mm	4.7 mm 4.7 mm
Acutrak 4/5	AM-5010 AM-5014	80-0494 80-0297	 Dense	3 mm 3.1 mm	4.4 mm 4.6 mm
Acutrak Plus	AP-0100 AP-0104	80-0495 80-0298	 Dense	4 mm 4.4 mm	5.6 mm 6 mm
Acutrak 6/7	AP-67011 AP-67012 AP-67013 AP-67014 AP-67015 AP-67016	80-0496 80-0497 80-0498 80-0477 80-0478 80-0479	 Dense Dense Dense 	4.4 mm 4.6 mm 4.6 mm 5.1 mm 5.3 mm 5.3 mm	6.7 mm 6.7 mm 6.7 mm 6.7 mm 6.7 mm 6.7 mm

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