THE AKIN OSTEOTOMY AND ITS MODIFICATIONS

The Akin osteotomy is a medially based, wedge shaped phalangeal osteotomy. Over the years, the procedure has been modified numerous times to achieve better results. These modifications have involved pre-operative planning, operative technique and fixation methods. Currently, there are four modifications that include the proximal, distal, cylindrical (midshaft), and derotational types, each having unique indications. Each also has consistently been a primary, as well as an adjunctive procedure, in the operative treatment of hallux abducto valgus deformity.

HISTORICAL REVIEW

The Akin osteotomy was described by OF Akin, in 1925, as a method of correcting hallux valgus deformity. The procedure resected the first metatarsal head medial exostosis and a portion of proximal phalangeal base. A cuneiform osteotomy was performed in the phalanx, with fracture and alignment of the toe and splintage in a rectus position. Fifteen years after Akin originally described the procedure FG Allan, a British surgeon, described a similar procedure removing a small wedge of bone from the medial side of the proximal phalanx with a fine saw. No mention was made of the phalangeal base prominence and a slipper cast was employed for four weeks with weightbearing after one week. In 1963, Butterworth and Clary described a bunion operation by Vann. This procedure also called for the removal of the medial exostosis, cutting of a medially based wedge from the proximal phalanx with rongeurs and a concomitant lateral green stick fracture. The procedure utilized a U-shaped capsular incision that was advanced distal to the osteotomy site and sutured into periosteum. The advancement served to close the osteotomy site and hold the toe in a corrected position. Four years later, in 1967, Colloff and Weitz theorized that when articular surfaces are congruous, pain free and mobile, a medial capsulorrhaphy was unnecessary. They advocated adductor hallucis tenotomy and lateral metatarso-phalangeal joint capsulotomy through an intermetatarsal incision. A medial wedge of bone was resected from the proximal phalanx and the osteotomy was fixated with a small staple formed from a K-wire.
In 1971, Gerbert-Melillo published a method of calculating the wedge size needing to be removed for optimal correction. In addition to a Silver type bunionectomy, they scored the dorsal portion of the proximal phalanx with an osteotome, with the shape of wedge to be removed. Power was used to drill the lateral apex of the wedge transversely in a medial direction. The lateral cortical hinge was preserved and fixated with braided steel sutures.

Later Silberman suggested using an electric saw to remove the wedge along with manual greenstick fracture and pin fixation. Giannestras described the same procedure but preferred a needle-nosed rongeur to remove the wedge of bone. He used a K-wire driven longitudinally through the osteotomy site as a means of fixation. In 1974, Gerbert along with Spector and Clark revised their original concept of the Akin osteotomy by advocating an oscillating power saw to remove the wedge with fixation using 28-30 gauge monofilament stainless steel wire. Even more important than revisions of technique, they described a cylindrical osteotomy for a long proximal phalanx, a midshaft wedge osteotomy, and distal medial closing wedge for hallux interphalangeus (HAI) deformity.

In 1981, Langford introduced a method of fixation for the Akin osteotomy. He described an oblique osteotomy that facilitated fixation using an ASIF screw. Green and Bosta, in 1986, used a Richards R1 mini staple to fixate a transverse Akin osteotomy. They followed 10 cases, none with complications, and declared the ease of fixation. In 1986, Schwartz described a procedure to correct abnormal transverse and/or frontal plane deformity of the hallux. This procedure was modified in 1987 and is now known as the "derotational" Akin osteotomy. When structural deformities such as valgus rotation are present within the hallux, the flexor hallucis longus tendon may become an aggravating force, tending to cause abduction with flexion. This may present as an exacerbated bunion deformity or a pinch callus. The pinch callus his located at the plantar medial aspect of the interphalangeal joint and if the dynamic deforming force of the tendon is not neutralized, recurrence of the bunion deformity is possible.

Barca and Busa used re-sorbable poly-L lactic acid mini staples for Akin fixation in 1997. In 2002, Burns described variations on the big toe through similar surgical approaches, including hallucal IPJ sesmoid reduction, excision and management, IPJ arthroplasty and exostectomy, later confirmed by Marcinko and Scherer, in 2005-2006.

### INDICATIONS AND CONTRA-INDICATIONS

**Indications:**

A thorough evaluation of interphalangeal abduction is taken into consideration, prior to choosing a proximal or distal Akin osteotomy. The location of correction is directly dependent upon the apex of deformity. In 1935, Daw used the term "hallux abductus interphalangeus" to describe the lateral deviation of the hallux. Barnett’s study, in 1962, defined two parameters that contribute to the overall abduction of the great toe.
He defined obliquity as an oblique orientation of the articular surface of the head of the proximal phalanx, and asymmetry as the asymmetric contour of the distal phalanx. Sorto and colleagues added a third component called joint deviation, described as the angular relationship between the articular surfaces of the base of the distal phalanx and the head of the proximal phalanx. The total amount of hallux abductus interphalangeus is the summation of joint deviation, asymmetry and obliquity. The final component evaluated is the distal articular set angle (DASA), or the angular relationship between the articular surface of the base of the proximal phalanx, and a perpendicular to the bisection of the proximal phalanx.

**Proximal Akin Osteotomy**

The indication for a proximal Akin osteotomy is an abnormal hallux abductus secondary to an increased distal articular set angle, or a moderately elevated angle of obliquity. Clinical observation should reveal fibular deviation in the transverse plane of the hallux, with or without metatarsus primus adductus. This must be correlated with radiographic evaluation. Although this procedure has been utilized to correct hallux abductus secondary to elevated proximal articular set angle (“Cheater Bunionectomy”), the joint will remain deviated in spite of a cosmetically rectus hallux. The long-term result can be further deviation of the metatarso-phalangeal joint with return of the hallux abductus deformity. The proximal Akin osteotomy is a more stable osteotomy than the distal Akin, and has a lower incidence of post-operative hallux interphalangeal joint stiffness.

**Distal Akin Osteotomy**

This procedure most accurately reduces hallux abductus interphalangeus secondary to asymmetry and obliquity and will not reduce the distal articular set angle. In a 1976 study, Sorto found asymmetry to be the most common cause of hallux abductus interphalangeus. If the principle of correcting the apex of deformity is maintained, a distal phalangeal osteotomy would, in theory, yield more accurate correction. However, this is often not technically feasible and a distal Akin is reserved for correcting the osseous deformity.

**Derotational Akin Osteotomy**

The indication for a derotational Akin osteotomy is frontal plane deviation of the hallux in a valgus direction. This may be seen through clinical observation, radiographic evaluation or a prominent plantar-medial pinch callus with a laterally positioned fatty toe pulp leaving an unprotected medial condyle at the interphalangeal joint. A valgus rotation of the hallux will alter the axis of motion at the interphalangeal joint. Clinically, this will be seen as abduction of the distal phalanx upon flexion at the interphalangeal joint.
Cylindrical Akin Osteotomy

Several authors have noted the presence or recurrence of hallux valgus deformity in patients with a long hallux. In 1970 McGlamry, Kitting and Butlin described causes for recurrent hallux valgus and associated treatments. They found frequent recurrence in patients with a long hallux, especially if it was 1/8 inch longer than any lesser toe. The long hallux was subjected to pressure from the shoe and stocking, pushing it into a valgus position. They stressed the importance of correcting hallux length in addition to the hallux valgus deformity.

In 1974 Gerbert, Spector and Clark addressed an excessively long hallux when concomitantly present with a transverse plane deformity of the hallux. They acknowledged McGlamry’s previous procedure and modified it to remove a trapezoidal shaped wedge to correct for an interphalangeus deformity. It was fixated with 28-30 gauge monofilament wire. Re-sorbable poly-L lactic acid mini staples may also be considered.

Hallux Interphalangeal Joint Fusion

Arthrodesis of the hallucal interphalangeal joint is performed for the same reasons as for any other joint, specifically to improve first metatarso-phalangeal joint function when severe deformity exists. However, the mechanics of this joint and its importance in gait dictate additional indications. The hallux must be converted into a rigid lever during the propulsive phase of gait and precluding deformities produce symptomatology elsewhere. Such deformities may be induced by iatrogenic, congenital or neuromuscular causes. Therefore, the primary indications for interphalangeal joint fusion include 1) recalcitrant arthritic pain during motion, 2) primary arthrosis after severe trauma, 3) alleviation of symptoms from sagittal plane deformities (hammered hallux, hallux flexus or hallux extensus), 4) transverse plane deformities (hallux abductus or hallux adductus), or 5) frontal plane deviations (hallux varus or valgus). The above conditions may not necessarily cause pain in the IPJ, but rather affect the stability of the hallux and refer symptoms to the metatarso-phalangeal joint proximally. The final indication for interphalangeal joint arthrodesis is as an adjunctive procedure with first metatarso-phalangeal joint arthroplasty, with or without implant. The intrinsic muscle insertions stabilizing the joint are occasionally sacrificed, which lead to post operative hallux malleus. This can be avoided by fusion of the IPJ. When considering the necessity of this procedure, the surgeon must realize that arthrodesis is permanent and represents an end stage in deformity correction.

Contra-indications:

Although osteoporosis is a relative contraindication to any osteotomy, it is especially important in the transverse Akin procedure (proximal, distal and cylindrical) because it is perpendicular to weight bearing forces. Unlike metatarsal osteotomies, these forces are perpendicular not only during stance but throughout propulsion, producing a distractive force on the surgical site. This concern can be overcome if the principles of internal fixation are properly applied.
Unaddressed hallux limitus/rigidus poses another post-operative problem. Stress is accentuated across the osteotomy. Also, correction of interphalangeus alone eliminates a means of compensation for hallux limitus/rigidus, by causing the hallux to form a longer lever arm. As the foot goes through the propulsive gait phase, the rectus hallux places excess stress across the metatarso-phalangeal joint.

Finally, using an Akin osteotomy for correction of hallux abducto valgus when the intermetatarsal angle and PASA are elevated, will eventually cause further joint deviation to occur at the metatarso-phalangeal joint level. This is due to abductory forces placed against the rectus hallux by ambulation and shoegear. When combined with the already deviated metatarso-phalangeal joint, progression is inevitable.

In general, contraindications to a hallux interphalangeal joint fusion are few. Osteoporosis should not prevent union at the arthrodesis site, as long as suitable fixation is utilized, and external immobilization is enforced for at least six weeks. Specifically however, Tillmann has stated that the interphalangeal joint should never be arthrodesed if the metatarso-phalangeal joint is also fused. To do so precludes mobility of the first ray resulting in painful ambulation, even in the apropulsive patient.

**SURGICAL RECONSTRUCTION TECHNIQUES**

**Proximal Akin Osteotomy**

A three-centimeter linear incision is made on the medial aspect of the hallux over the proximal phalanx. The center of the incision is located at the area of the osteotomy. Alternately, the incision may be made dorsally and is deepened through subcutaneous tissue down to periosteum. The dorsal and plantar digital nerves remain in the subcutaneous tissue that is retracted. Periosteum is incised in a linear fashion and reflected dorsally and plantarly.

There are two types of proximal Akin osteotomies, transverse and oblique. The oblique osteotomy facilitates screw fixation, although the choice between the procedures is purely preferential. When attempting a transverse proximal Akin osteotomy, the first (distal) osteotomy is made perpendicular to the long axis of the proximal phalanx, in the region of the metaphyseal-diaphyseal junction. The lateral cortex is preserved. A second osteotomy is made parallel to the cartilage of the proximal phalanx, also preserving the lateral cortex. This should form an apex with the distal osteotomy, so that the dorsal, medial and plantar cortices are cut leaving the lateral cortex to act as a hinge for the osteotomy. These cuts join approximately three quarters the distance from the medial cortex, and parallel the frontal plane. The remaining portion of bone is completely removed, the size of which, is dependent upon the degree of deformity. Trial closure is performed to determine the amount of "spring" in the hinge. Ideally, the distal bone should lightly remain in contact with the proximal, while the hinge remains intact. To achieve this, the saw blade is passed through the center of the osteotomy to the hinge and turned on while the osteotomy is being gently compressed. The saw blade is extracted while in motion with compression.
Again, the osteotomy is checked for closure. The process of "reciprocal planing" is continued until the desired result is achieved.

An oblique proximal Akin osteotomy is made in a similar manner although the osteotomies are oriented from a distal-medial to proximal-lateral direction. It is not the position of the osteotomy, but the location of the apex or hinge which determines correction. For example, a proximal hinge would produce the same correction as the transverse proximal method. Obviously, the size of wedge must vary according to degree of correction desired. The osteotomy may be fixated in a number of ways, including sutures, buried or percutaneous K-wires, monofilament wire with or without a tension band, or cortical screw fixation. Threaded K-wire fixation is employed as follows.

While holding the osteotomy closed, a 0.045" smooth K-wire is passed from the proximal cortex medially, across the osteotomy site, to the lateral cortex, maintaining a parallel trajectory to the weightbearing surface. This acts as a pilot hole. The exit point is felt laterally with a finger before it punctures the skin. The smooth wire is removed and a 0.062" threaded K-wire is placed in the same hole and drilled from distal to proximal (utilizing the pilot hole) until it can be felt laterally. It is then slowly reversed until it cannot be distinguished by touch, yet is still in the lateral cortex. The entire process is performed with compression at the osteotomy site. The interphalangeal joint is then taken through a full range of motion to ensure the K-wire is not in the joint. The threaded K-wire will maintain the manually delivered "static" compression and is cut flush with the medial cortex. This fixation is effective and simple but care must be taken not to enter the joint. If the hinge fractures, the osteotomy must be stabilized with another point of fixation in a different plane.

**Distal Akin Osteotomy**

As with the proximal Akin osteotomy, there are two techniques to perform a distal Akin procedure, transverse and oblique. However, exposure should include easy visualization of the proximal fibers of the interphalangeal joint capsule.

When performing a transverse distal Akin osteotomy, the first distal cut is made perpendicular to the bisection of the distal phalanx, with care taken to preserve the lateral cortex. The second (proximal) cut is made perpendicular to the bisection of the proximal phalanx, joining the distal osteotomy approximately three quarters the distance from the medial cortex. As in the proximal Akin, the wedge is removed and trial closure performed. The lateral cortical hinge is weakened and when the distal side of the osteotomy rests gently against the proximal side, it can be fixated with suture, monofilament wire, K-wires or internal screw fixation. In all cases, the fixation device should be placed from a distal (unstable) to proximal (stable) direction. This also eliminates the potential for entering the joint.

An oblique osteotomy courses from proximal-medial to distal-lateral, leaving the distal apex to correct the deformity at that level.
Derotational Akin Osteotomy

Dissection is carried to the proximal phalanx and a wedge osteotomy is made with its apex lateral and base medial. The osteotomy is angled from distal-dorsal to plantar-proximal. A vertical osteotomy will yield transverse plane correction. A more oblique or horizontal osteotomy will increase frontal plane correction. This procedure is versatile and by varying the angle of the osteotomy, correction may be tailored to the condition. The lateral cortical hinge is maintained intact and the osteotomy closed while applying a gentle varus force to the hallux. Fixation may be accomplished with sutures, monofilament wires, K wires, bone screws, or external splintage.

Typically, monofilament stainless steel wire is used both for its ease and reliability of fixation. A hole is drilled with a 0.045" smooth K-wire from a dorsal-proximal to plantar-distal direction, through the proximal aspect of the osteotomy site. Monofilament 26 gauge wire is passed through and twisted onto itself until the osteotomy is closed. The remaining tag of wire is placed within a drill hole in the bone, located at the point where the wire contacts the cortex. Fixation is located at the proximal aspect of the osteotomy where weight-bearing produces a tensile force. The distal aspect of the osteotomy will undergo compression upon weight-bearing. Schwartz employed this technique after analyzing fractures of the osteotomy site and devising a method to reduce distractive forces. If the lateral cortical hinge is fractured a second point of fixation, such as a snap-off threaded K-wire, is employed. A modification of this procedure is the linear or shortening osteotomy. In this case, the lateral cortical hinge is sacrificed and the capital fragment is slid proximally to shorten the hallux. The osteotomy must be fixated with two points of fixation since the lateral cortical hinge was violated. A simple and stable means of fixation is a threaded K-wire in combination with monofilament wire. Indications include a long hallux with or without valgus rotation. Care must be taken to avoid a prominent plantar-proximal or dorsal-distal ledge. This ledge will be proportional to the amount of shortening attained. If this ledge does exist, it should be resected.

Cylindrical Akin Osteotomy

A cylinder of bone is resected from the middle of the phalanx or a trapezoidal shaped portion of bone if a transverse plane deformity exists. The amount of shortening desired, minus two saw blade widths, is the usual size of the cylinder removed. The distal and proximal portions are brought together and inspected to insure a flush fit and absence of any undesired deviation in position. The osteotomy may be fixated with sutures, monofilament wires, bone screws or crossed K-wires. The wires lie in the transverse plane, one running from a proximal-medial to distal-lateral direction, the other from a distal-medial to proximal-lateral attitude. An alternative method is to resect an oblique cylinder to facilitate fixation with a bone screw. A parallelogram shaped portion of bone is removed with the long axis running from a distal-medial to proximal-lateral direction. The screw is placed from a proximal-medial to distal-lateral attitude.
Hallux Interphalangeal Joint Fusion

Several incisional approaches have been described for interphalangeal joint arthrodesis. The "best" approach may depend upon whether or not concomitant surgery is performed at the metatarso-phalangeal joint, such as an extensor hallucis longus lengthening, and the degree of deformity. The two most common incisional approaches are: a) two converging semi-elliptical incisions transverse to the long axis of the digit, and b) a longitudinal lazy-S incision crossing medial to lateral at the interphalangeal joint. Medial and lateral incisions at the level of the interphalangeal joint may yield a better cosmetic result. With a severe flexion deformity of the hallux, the first incision is recommended, as it removes redundant soft tissue after arthrodesis. If IPJ arthrodesis is performed in conjunction with metatarso-phalangeal joint surgery, the second incision can be incorporated into the standard dorso-medial approach for hallux abducto valgus correction.

Once the skin is incised, dissection is deepened to the extensor hallucis longus tendon. Care must be taken to avoid the dorso-medial and dorso-lateral neurovascular bundles. The long extensor tendon is incised transversely and reflected proximally-distally while the medial and lateral collateral ligaments are transected. This allows exposure of the head of the proximal phalanx and base of the distal phalanx. Utilizing a power saw, the head of the proximal phalanx is removed just proximal to the articular cartilage, and the base of the distal phalanx is removed just distal to its cartilage. In the presence of severe deformities, these bone cuts can be modified as necessary, such as slight angulation to plantarflex the hallux affording better purchase and cosmetic result. The surgeon must not create too much shortening since a degree of shortening is inherent to the procedure. Once desired correction is obtained, the fusion is then fixated. The extensor tendon is repaired with non-absorbable suture and the hallux immobilized externally for at least four weeks, with complete bone union occurring after six to eight weeks.

The methods of IPJ internal fixation must be discussed, not merely from the standpoint of technique, but more importantly as to the choices available and which is appropriate in most situations.

The following techniques are well known and include: single K-wire, double K-wire (parallel or crossed), tension band fixation, bone pegs, bone grafts, polypropylene pegs, manipulative fixation, external fixation, standard cortical and cancellous screw fixation, Reese R2 screws, Herbert R3 screws, and modifications of the bone cuts to accommodate any of the above. Each technique has advantages and disadvantages determined by concomitant procedures performed on the proximal first ray segment; including, re-sorbable poly-L lactic acid mini staples, or related devices.

For example, if implant arthroplasty is performed at the metatarso-phalangeal joint, the fixation used must avoid the stem of the implant. This would preclude cancellous screw fixation and some methods of K-wire fixation.
Severe osteoporosis should alert the surgeon to avoid stress to the cortical bone, as well as reaming the tenuous cancellous marrow. Although the rate of nonunion is low, the difficulty of primary bone healing at this fusion site is due to force being placed perpendicular to the arthrodesis. Resorbable poly-L lactic acid mini staples may also be considered.

Therefore, since dynamic compression is impossible, the best means of static compression should be applied. This is easily achieved with a 4.0 mm. cancellous screw applied with standard ASIF technique. In the event of adjunctive implant arthroplasty, two crossed K-wires suffice, or two parallel wires from proximal-dorsal to plantar-distal with tension band fixation, is another option. As long as the principals of rigid fixation are maintained the exact technique should be determined on an individual basis.

Aftercare:

Post-operative care depends on what other procedures were also performed. If an Akin osteotomy is the sole procedure, the patient may be full weight-bearing in a surgical shoe, eliminating the propulsive phase of gait. Sutures are removed at the surgeon’s discretion and the patient may return to normal shoe-gear when they feel comfortable.

**COMPPLICATIONS OF THE AKIN OSTEOTOMY**

**Long-term Complications:**

Complications not unique to the Akin osteotomy include infection, delayed wound healing, skin slough, painful scar formation, nerve entrapment, delayed union, mal-union, non-union, avascular necrosis and over or under correction

**Proximal Akin Osteotomy**

The most common complication of the proximal Akin osteotomy is interphalangeal and metatarso-phalangeal joint stiffness. However, other complications can occur since the hallux has a natural abduction tendency pushing a surgically induced rectus toe against the inner aspect of a shoe. This is important in women who desire to wear shoes with a narrow toe box, producing an increase in joint deviation between the distal and proximal phalanges, leading to joint degeneration and pain.

Another common occurrence for the Akin osteotomy, is a sclerotic line at the osteotomy site for up to one year. Although some may heal sooner, the surgeon should not be alarmed unless there is correlated pain.
Distal Akin Osteotomy

Complications are similar to those seen with the proximal Akin. Joint stiffness can occur at the interphalangeal joint. Failure of fixation can lead to a dorsiflexed distal fragment upon weightbearing and a resultant structural deformity represented as a prominence of the head of the proximal phalanx or a hallux hammertoe.

Derotational Akin Osteotomy

Complications of the derotational Akin osteotomy are relatively rare due to the inherent stability of the osteotomy and ease of fixation. Complications such as delayed healing can occur if there is inadequate fixation. Another problem may be irritation due to a prominent K-wire.

Cylindrical Akin Osteotomy

Hallux extensus distalis is the primary complication with this procedure. As far as cylindrical wedge removal from the midshaft is concerned, complications include tenosynovitis of the flexor hallucis longus tendon and adhesions at the operative site leading to impaired flexor tendon function.

Hallux Interphalangeal Joint Fusion

As with any arthrodesis, complications will include malunion, delayed union and nonunion. However, in many cases, these are avoidable mistakes. Pain may develop at the distal tip of the hallux secondary to a prominent screw head. This can occur in both young and elderly populations. It is seen in young people who are especially active or athletic and in the elderly with diminished subcutaneous tissue at the level of the screw head. An ulcer may develop at the tip of the toe. The etiology must be identified immediately and the screw removed. An ulcer in this area can lead to a soft tissue or bone infection requiring more aggressive treatment.

Intra-operative Complications:

Proximal and Distal Akin Osteotomies

The most obvious problem is fracture of the lateral cortical hinge. This should be stabilized with two points of fixation to prevent movement in all planes. There are several common mistakes that encourage hinge fracture. For example, if the proximal and distal osteotomies join too far laterally the hinge will be weakened prematurely. Another error is applying excessive pressure to the hallux while attempting closure. This should be done gently, while weakening the cortex through reciprocal planing. Finally, if the proximal and distal osteotomies do not properly converge, a "teardrop" effect will occur, leading to a delay in healing. This appears as a gap between the cortical hinge laterally, and the opposed osteotomy medially. Other complications include entering the joint with either the power saw blade or fixation device.
A rare, but possible occurrence is severing or partially cutting the flexor hallucis longus tendon with the saw. The defect should be repaired immediately. Finally, if the proximal and distal osteotomies are not parallel in the frontal plane, the hallux will dorsiflex or plantarflex with closure.

**Hallux Interphalangeal Joint Fusion**

Extreme shortening of the hallux is avoided by preoperative planning with templates in an effort to visualize the maximum correction available without sacrificing length. Flexion or Extension deformities are also possible if the bone cuts are not made parallel to one another in the coronal plane. This also applies to transverse and frontal plane deviations. Other complications are related to the methods of fixation, including fusion site distraction, cortical fracture, loose internal fixation and distal tuft fractures. If the extensor tendon is not adequately reapposed, contracture with cicatrix formation may yield loss of full dorsiflexion to the metatarso-phalangeal joint.

**Concluding Remarks**

When all aspects of the hallucal segment in an HAV deformity is respected, successful treatment is usually obtained. And, it is hoped that the material outlined in this review proves valuable to those who study for board certification examinations.

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