Review Article

Operative Approach to Adult Hallux Valgus Deformity: Principles and Techniques

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Abstract

Hallux valgus deformity is a progressive forefoot deformity consisting of a prominence derived from a medially deviated first metatarsal and laterally displaced great toe, with or without pronation. Although there is agreement that the deformity is likely caused by multifactorial intrinsic and extrinsic factors, the best method of operative management is debated despite the creation of basic algorithms. Our understanding of the deformity and the development of newer techniques is continuously evolving. Here, we review the general orthopaedic principles of operative decision-making and management of hallux valgus deformity.

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Hallux valgus deformity occurs because of medial deviation of the first metatarsal and lateral deviation of the great toe, with or without coexisting pronation and subluxation of the metatarsophalangeal joint (MTPJ). The etiology of the deformity is both complex and multifactorial, consisting of intrinsic and extrinsic risk factors. This condition affects 23% of the adult cohort.[1]

For those who fail nonsurgical management, surgical treatment options are diverse with varying reported outcomes. Patients' pathoanatomy, expectations, and radiographic characteristics, and surgeons' familiarity and preferences for specific techniques determine the surgical selection. Surgery is reserved for those who fail nonsurgical management. For this group of patients, our review examines the general orthopaedic principles of operative decision-making and management, including both osteotomies and arthrodesis operations.

Anatomy and Pathophysiology

The normal first MTPJ is an imperfect ball-and-socket joint that allows extension and flexion with limited rotation. Medial, lateral collateral ligaments and the plantar plate converge with the capsule to stabilize the joint for controlled motion during gait. Genetic predisposition with hypermobility, constrictive shoe wear, and female sex have been identified as risk factors for the development of hallux valgus.[2] The development of deformity has been described to proceed in sequential steps, but it may be a concurrent and interdependent process that affects alignment and stability of the first MTPJ such as a congruent MTPJ, abnormal distal metatarsal articular angle (DMAA), unbalanced ligamentous and tendinous constraints, and first tarsometatarsal joint (TMTJ) instability. The medial capsule and collateral ligament attenuate because the first metatarsal head deviates medially, moving away from the second metatarsal and translating medially over the sesamoid mechanism. The proximal phalanx is restrained by the adductor hallucis and plantar support structures. Extensor and flexor hallucis longus tendons become deforming forces on the great toe because they bowstring lateral to the MTPJ. The abductor hallucis may subluxate plantar to the metatarsal head and become an ineffective antagonist to the valgus deforming forces.

Diagnosis and Clinical Evaluation

History

Patients often present to the physician when they become symptomatic, with pain commonly located over their medial eminence associated with footwear. Patients may describe symptoms of transfer metatarsalgia and hammertoe deformity with weight-bearing. In those patients presenting with recurrent deformity after previous surgical correction, an effort must be made to determine why the deformity had returned. Medical history of spasticity, neurologic injury, and inflammatory arthropathy can affect decision-making in patients with hallux valgus.

Clinical Examination

Clinical evaluation begins with a standing examination, looking specifically for evidence of flatfoot deformity, instability of the medial column, pronation of the hallux, and alignment of the lesser toes. The sitting examination focuses on the range of motion in the ankle and hindfoot and evidence of equinus contracture. Forefoot evaluation begins at the skin overlying the medial eminence and then location of tenderness, range of motion tenderness (arthritis of the first MTPJ), passive correctability to neutral alignment, and the coexistent hallux valgus interphalangeus component. The range of motion of the MTPJ should be measured with a goniometer, recording the dorsi- and plantarflexion of the proximal phalanx relative to the plantar foot.

Controversy exists in the ability of physicians to quantitate the degree of TMTJ motion, not only varus and valgus but also the sagittal plane motion. Because typical values of motion in the TMTJ have not been clearly presented in the literature, its clinical utility may be limited. One can compare the motion with the contralateral side to see whether there is gross discrepancy.

Hallux valgus deformities can be associated with lesser toe deformities or pain. This may include hammertoe, claw toe, plantar callosity, previous second toe amputation, and second metatarsalgia.[2] Patients may be symptomatic enough to undergo corrective lesser toe deformities during the hallux valgus correction. A neurovascular examination should be performed because abnormalities such as severe neuropathy (lack of protective sensation) or vasculopathy (poor pulses, capillary refill) may affect surgical decision-making. Multidisciplinary collaboration may be needed with appropriate consultation from neurology, vascular surgery, or rheumatology. A prominent bunion can also irritate the dorsomedial cutaneous nerve, producing numbness around the dorsomedial border of the great toe.

Imaging

Complete evaluation of patients with hallux valgus deformity requires weight-bearing AP and lateral foot radiography, which would also reveal evidence of osteoarthritis of the first MTPJ, hallux valgus interphalangeus, flatfoot, metatarsus adductus, and lesser toe deformities.

Measurements

The hallux valgus angle (HVA) is defined as the intersecting angle measured on the weight-bearing AP foot radiograph from longitudinal lines that bisect the proximal phalanx and first metatarsal (Figure 1A). The intermetatarsal angle (IMA) is the angular measurement of the intersection from the longitudinal lines that represent the longitudinal axes of the first and second metatarsals (Figure 1B).[3]

There is some debate on the measurement, reliability, and importance of the DMAA (Figure 1C). It has been commonly accepted that DMAA measurements >10° are abnormal. The reliability of DMAA on the weight-bearing AP foot radiograph can be affected by pronation and rotational changes of the first metatarsal shaft.[4]

A change in the sesamoid position in relation to the metatarsal head occurs from medial displacement of the first metatarsal because the hallux valgus deformity progresses. The lateral sesamoid does not translate and remains stable. Therefore, lateral sesamoid position can be used as a static marker for surgeons to evaluate the degree of medial displacement of the metatarsal head.[5]

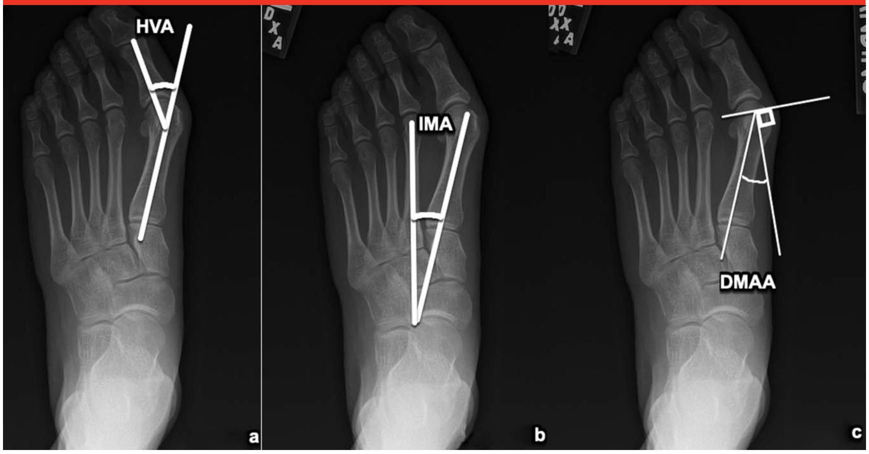
Although our understanding of the hallux valgus deformity is not yet complete, a classification system based on the angular measurements and general principles has been proposed (Table 1).

Management

Nonsurgical

Evidence shows that nonsurgical management neither corrects nor slows the progression of hallux valgus deformities, although it may reduce the symptoms that are secondary to the deformity, such as medial eminence irritation and second metatarsal transfer lesion. Shoes with wider toe

Figure 1



Radiographs illustrating the measurements of (**A**) HVA, (**B**) IMA, and (**C**) DMAA. DMAA = distal metatarsal articular angle, HVA = hallux valgus angle, and IMA = intermetatarsal angle

boxes to accommodate the deformity are recommended for those with medial eminence pain. A metatarsal pad or orthotic can alleviate pain from transfer metatarsalgia. Toe spacers or sleeves can reduce the symptoms associated with painful interdigital corns. Hallux valgus–specific braces, orthotics, or toe spacers can help with symptoms but do not reverse the course of the condition.

Operative

When nonsurgical management fails to reduce pain, operative treatment may reduce the deformity and underlying deforming forces to recreate a more balanced MTPJ. Although the severity of the deformity based on radiographic measurements often guides principles of treatment, there are patient factors to consider. Furthermore, the surgeons' training and experience can influence their interpretation of the importance of each deformity and selection of procedure.

No single procedure can be universally applied to all patients with hallux valgus. The guidelines will likely continue to evolve as we gain clarity in our understanding of hallux valgus deformity. Generally, the operations featuring soft-tissue reconstruction are rarely applicable, operations such as osteotomies preserving joint function are desirable, and more severe deformities benefit from surgical treatment at a more proximal level.

Options

Mild (Hallux Valgus Angle < 20, Intermetatarsal Angle < 13)

Indications for simple medial eminence resection, medial capsulorrhaphy, with or without distal soft-tissue release are limited. Resection is an acceptable treatment in which the goal is to address the irritation over the medial eminence rather than realignment. This can be combined with either lateral capsulotomy alone or a modified McBride soft-tissue procedure, releasing the deforming adductor-conjoined tendon without lateral sesamoidectomy to rebalance the proximal phalanx. This operation was widely used until the early 1990s when evidence of its limitations in patients with hallux valgus emerged with progression of the deformity and significant patient dissatisfaction.[6]

Mild hallux valgus deformities are often corrected with distal osteotomies, laterally displacing the center of the metatarsal head. This translational corrective osteotomy does not, however, address rotational deformities. A distal chevron osteotomy is popular among orthopaedic foot and ankle surgeons for correction of mild deformities, partially because of its biomechanically stable design.[7] This osteotomy was originally described as translating no more than 50% of the metatarsal head, allowing for the correction of mild deformities (Figure 2A). Distal chevron osteotomy has been modified in many ways, such as performing the bony cuts at a more acute angle, a longer plantar arm, internal fixation, combination with Akin osteotomy, biplanar ability, and much greater osteotomy displacement. The degree of lateral displacement of the metatarsal head may be increased, the "extended chevron" with the initial results comparable with that of more proximal osteotomies.[8] The distal metatarsal osteotomy has been successfully applied for the correction of moderate deformities. Repositioning of the metatarsal head over the sesamoids may or may not correlate with the radiographic hallux valgus recurrence in the short term.[9] However, the preoperative severity of the deformity measured in IMA, HVA, and DMAA correlates with recurrence.[10] Distal soft-tissue release can be used as an adjunct procedure to distal osteotomies, improving radiographic alignment but not patient satisfaction.[11]

When hallux valgus interphalangeus is present, a closing wedge osteotomy of the proximal phalangeal osteotomy (Akin) can be performed (Figure 2E). As an isolated procedure, it is not advisable for the correction of hallux valgus. Vander Griend[12] reported success in using Akin osteotomy concurrently with other forefoot procedures in both primary and revision cases, with acceptable radiographic outcomes and low adverse event rates. When combined with the

Table 1

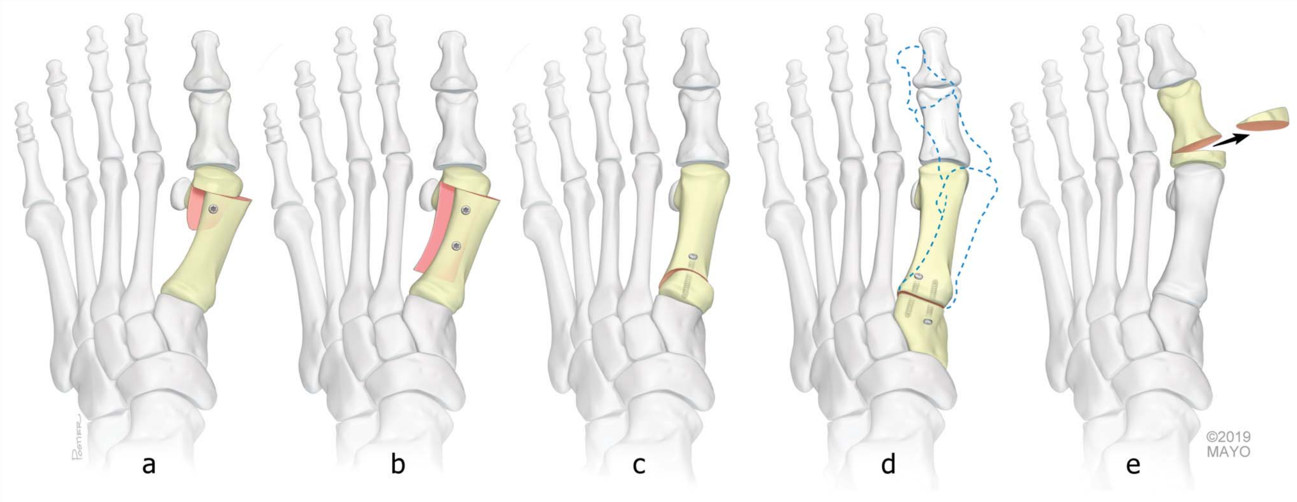
Severity of Deformity, Procedure, and Adverse Events

Deformity	Corrective Procedure	Potential Complications	Pearls
Any	Arthrodesis ± osteotomies	Malunion, nonunion, hallux varus, transfer metatarsalgia	• To avoid malunion and nonunion, surgeons apply stable internal fixation with good bony contact. Confirm correct osteotomy and arthrodesis position intraoperatively. • To prevent hallux varus, avoid negative postoperative IMA and aggressive lateral release, and excessive removal of medial eminence. • Transfer metatarsalgia can occur with incomplete correction, elevation of the metatarsal head, or shortening
Mild (HVA < 20, IMA < 13)	Distal osteotomy (ie, chevron), with or without distal soft-tissue release	Osteonecrosis	• Limit plantar and lateral periosteal stripping and extensive lateral release • Meticulous technique with good osteotomy bony contact.
Moderate (HVA 20–40, IMA 13–16)	Proximal osteotomy, with or without distal soft-tissue release	Troughing (scarf), hallux varus, transfer metatarsalgia	• Extend scarf osteotomy to metatarsal head for greater cancellous bone contact • Avoid negative postoperative IMA • Avoid unintentional elevation or depression of the distal fragment to reduce risk of transfer metatarsalgia • Add lateral soft-tissue release if the deformity is incongruent
Severe (HVA > 40, IMA > 16)	Proximal osteotomy, modified Lapidus, with or without distal soft-tissue release First MTPJ arthrodesis	Malunion, nonunion, hallux varus, transfer metatarsalgia	• In arthrodesis, ensure neutral rotation, extension such that the fat pad of the great toe rests on the platform simulating weight-bearing, and 10–15 degrees of valgus. Adjustments are necessary in a simulated plantigrade position which is achieved using a platform such as a sterile surgical tray cover. Consider lateral soft-tissue release if the deformity is incongruent
DMAA (>10)	Biplanar closing wedge osteotomy, with or without distal soft-tissue release	Nonunion, transfer metatarsalgia	• Avoid removing excessively large wedge during joint preparation.
MTPJ arthritis	First MTPJ arthrodesis	Nonunion, malpositioning	• Arthrodesis should be considered in patients with spasticity and uncontrolled inflammatory arthropathy.
TMTJ arthritis	Modified Lapidus, with or without distal soft-tissue release	Nonunion, transfer metatarsalgia	• Consider when there is gross TMTJ instability
HV interphalangeus	Akin phalangeal osteotomy		

DMAA = distal metatarsal articular angle, HV = hallux valgus, HVA = hallux valgus angle, IMA = intermetatarsal angle, MTPJ = metatarsophalangeal joint, TMTJ = tarsometatarsal joint

first metatarsal osteotomy, Akin osteotomy also reduces the deforming pull of the extensor and flexor hallucis longus.[8] Correction has been demonstrated to be effective in pain reduction, radiographic HVA and IMA, and American Orthopaedic Foot and Ankle Society Hallux Metatarsophalangeal-Interphalangeal Rating System and Short Form-36 scores in both open and percutaneous techniques.[13]

Figure 2



Illustrations showing the (**A**) distal chevron osteotomy, (**B**) scarf osteotomy, (**C**) proximal osteotomy, (**D**) modified Lapidus, and (**E**) Akin osteotomy.

Moderate (Hallux Valgus Angle 20-40, Intermetatarsal Angle 13-16)

Proximal osteotomy of the first metatarsal has greater potential of reducing the IMA. A variety of osteotomies have been described, each with their own unique characteristics and shortcomings.[4,14,15] Given that the sesamoid position on weight-bearing AP radiography does not change, reduction of the metatarsal head after proximal osteotomy has been shown to be an important factor in determining adequate intraoperative reduction and is associated with lower risk of recurrence.[5] Patients with increased DMAA, if not concurrently corrected, are at risk for a high recurrence rate after proximal osteotomy.[16]

Mau and Ludloff osteotomies are variations of the long proximal-oblique osteotomy, rotating the distal metatarsal laterally, reducing the IMA, and these are usually fixed with compression screws (Figure 2C).[17] Proximal opening wedge osteotomy is a single-plane osteotomy that has gained favor in recent years for moderate and severe deformities because of its easy-to-understand concept and stable fixation with procedure-specific plates.[18] The scarf osteotomy is an anatomically stable metatarsal shaft z-osteotomy with both corrective and first metatarsal lengthening powers that can be used in both primary and revision cases (Figure 2B).[19] Choi et al[20] evaluated functional and radiographic parameters of patients who underwent scarf osteotomy, demonstrating a reduction in Visual Analog Scale pain scores from 5.8 to 1.1 and an improvement in IMA from 13.6° to 5.6°. Bock et al[21] evaluated the long-term outcomes of scarf osteotomy, reporting a 30% radiographic recurrence rate at 124 months. Jeuken et al[7] compared the long-term outcomes of distal chevron and scarf osteotomies, reporting that no significant difference existed in recurrence rate and Visual Analog Scale pain score or subjective scores, including SF-36 and Manchester-Oxford Foot Questionnaire. Although radiographic recurrence can occur after both distal chevron and scarf osteotomies (73% and 78%), pain was not found to correlate with deformity recurrence at a mean of 14 years.[7]

Severe (Hallux Valgus Angle > 40, Intermetatarsal Angle > 16)

In patients with severe deformities, proximal osteotomy can be effective in reducing the deformity.[22] Some severe deformities are due to combined deformities, such as those with both increased IMA and DMAA. Braito et al[23] demonstrated that these severe deformities can be corrected with a double osteotomy, which has the potential for more correction, but with a 30% adverse event rate. In cases of severe hallux valgus deformity, especially those associated with first TMTJ instability or arthritis, a modified Lapidus procedure can be used (Figure 2D). Controversy regarding TMTJ hypermobility diagnosis and treatment exists in the literature.[2]

Ellington et al[24] found the modified Lapidus procedure to be a viable MTP joint-preserving option in revision surgical treatment after recurrence, with improved HVA, IMA, and DMAA from 36.2°, 13.6°, and 18.6° to 15.2°, 7.5°, and 11.7°, respectively. Similarly, Coetzee et al[25] reported short-term improvements at 24 months in radiographic HVA and

IMA from 37.1° and 18° to 18° and 8.6°, with a patient satisfaction rate of 81%.

Recent long-term follow-up of a prospective randomized trial of distal osteotomy versus modified Lapidus showed no differences in radiographic outcomes, regardless of the clinical findings of preoperative hypermobility.[26]

Although some advocate that the improved implants and techniques allow for early weight-bearing in postoperative shoe, this is not universally accepted.[27-29]

Arthritis

MTPJ arthrodesis is applicable in the setting of arthritis, joint hypermobility, spasticity, previously failed operations, and severe hallux valgus deformities to reduce pain and recurrence. Pydah et al[30] examined 69 feet (13 bilateral feet) that underwent primary arthrodesis of the first MTPJ, demonstrating not only correction of the HVA and IMA but also improvement of the sesamoid position on AP radiography. McKean et al[31] reported a series of 19 first MTPJ arthrodesis procedures in 17 patients, showing improvements in IMA from 19.2° to 10.8° and HVA from 48.5° to 12.3°. Arthrodesis may also be used after failed osteotomies, osteonecrosis, progressive neurologic hallux valgus deformity, salvage of failed great toe implant arthroplasty, and salvage of failed resection arthroplasty. It is not always necessary in well-controlled inflammatory arthropathy with a functional joint.[32] When applied in the setting of hallux valgus versus hallux rigidus deformities, the hallux valgus group had a markedly higher nonunion rate, 14.3% versus 0%.[33] Extra-articular deforming forces and contractures may need to be balanced intraoperatively, and choice of implant maximizing stability should be considered to reduce the risk of nonunion in patients with hallux valgus deformity. In the past, MTPJ implant arthroplasty was successfully applied to rheumatoid arthritis patients with hallux valgus, but today it has a limited role in patients with hallux valgus.

Future Directions

Three-plane Correction

Recent literature indicated that a first metatarsal rotational deformity, such with increased DMAAs on AP radiography, may not be because of an anatomic finding, but rather pronation of the hallux. This finding suggests possible inaccuracy of the AP foot radiograph to evaluate the DMAA.[34] Surgical techniques have been described to address not only the translational but also the rotational component of the deformity through a metatarsal osteotomy and modified Lapidus procedure, in hopes of achieving a more anatomic correction.[35] Osteotomy guides and surgical techniques with intramedullary nails and orthogonal plating had recently been used to improve fixation. No long-term studies are available to demonstrate superior improvement in pain relief, reduction in recurrence, or nonunion rate. The role of triplane correction in the treatment algorithm is being defined.

Minimally Invasive Techniques

Minimally invasive techniques are gaining popularity in the hallux valgus correction because they are in general orthopaedics. Short-term outcomes demonstrate a trend for equivalent radiographic deformity correction over traditional open procedures.[36] Iannò et al[37] cautioned against using minimally invasive techniques in patients with severe subluxation of the MTPJ or sesamoid because the recurrence rate is high, contributing to an overall adverse event rate of 29.4%. There is considerable interest in defining the role of minimally invasive techniques in the hallux valgus correction.[38]

Adverse Events

Common adverse events after hallux valgus correction include transfer metatarsalgia and recurrence of the deformity at rates of 6.3% and 4.9%, respectively (Table 1).[39] Although many risk factors have been identified, late recurrence may actually be a natural progression of the deformity. Early recurrence has been linked to the incomplete initial correction from an inadequate translation or "underpowered" osteotomy technique, as evidenced by incomplete reduction of the metatarsal head about the sesamoids. Other factors may contribute to recurrence such as hypermobile joints, metatarsal head shape, severe preoperative deformity, and metatarsus adductus.[40] Inadequate corrective procedures result in higher recurrence rates. Although obesity has been identified as a risk factor for revision surgery, Visual Analog Scale and American Orthopaedic Foot and Ankle Society Hallux Metatarsophalangeal-Interphalangeal Rating System scores were comparable between obsess and nonobese patients.[41] A recent review of pooled data from 16,273 hallux valgus corrective procedures reported the rate of metatarsalgia up to 17.4%, recurrence up to 4.9%, unresolved pain up to 4.6%, and nonunion up to 3.7%. The review also noted nonunion to be highest in first TMTJ arthrodesis, whereas hallux varus deformity was more frequent with proximal osteotomies. Patient satisfaction negatively correlated with large preoperative first-second IMA.[39] Chong et al[42] reviewed 118 patients, reporting that 25.9% were dissatisfied 5.2 years after hallux

Figure 3

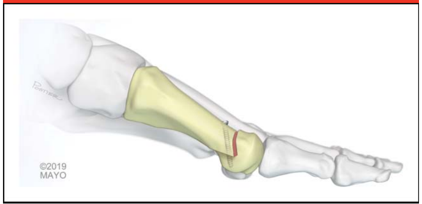


Illustration showing the medial approach to distal chevron osteotomy.

Figure 4

Illustration showing the medial approach to scarf osteotomy.

valgus operative management, regardless of severity of the initial deformity and type of surgical correction. Osteonecrosis of the metatarsal head has been implied to be a risk after distal osteotomies because of the disturbance of blood flow. Clinical and radiographic studies that followed question the application of this knowledge given that distal osteotomies with or without soft-tissue release had been demonstrated to be safe with very low rate of osteonecrosis.[9,43-45]

Most of the operations for the correction of hallux valgus have good clinical results based on the short-term outcomes. More critical analysis of the results with longer-term follow-up has improved our understanding of which operations will provide lasting relief of the pain and impairment associated with hallux valgus. As a consequence of more critical approach to examining patient outcomes, many of the operations which were considered standard practice in the past are no longer recommended. There is a need for well-designed prospective clinical studies and long-term follow-up results.

Authors' Preferred Approach and Technique

No single operation can be universally applied to all patients with hallux valgus. It first must be determined whether the patient has significant pain, impairment, understanding of the proposed operation, appropriate expectations, and ability to comply with postoperative care. Once it is determined whether a patient is a candidate for operative management, the choice is dependent on the condition of the MTPJ, degree of the deformity, associated conditions, and other patient factors. For patients with severe MTPJ arthritis or failed hallux valgus operations, arthrodesis is applicable.

In symptomatic patients without arthritis, with mild deformities without a rotational component, we recommend distal chevron osteotomy transfixed with a single screw or 2-mm absorbable pin, with the release of only the lateral capsular tissue and not adductor hallucis. For elderly patients with very low demands with symptoms primarily because of a prominent medial eminence who cannot tolerate the recovery and weight-bearing limitations of an osteotomy, a simple bunionectomy is applicable.

For distal chevron osteotomy, a standard medial longitudinal incision is made around the MTPJ. Subcutaneous dissection is performed carefully to protect the dorsomedial cutaneous nerve branch. Longitudinal or inverted L-shaped capsulotomy is performed, developing a thick periosteal flap and exposing the joint. Medial eminence resection is performed 1 mm medial to the sulcus in line with the medial border of the metatarsal shaft. With distraction of the joint, the lateral capsule may be released under direct visualization. A Kirschner wire is placed at the center of the metatarsal head to guide the microsagittal saw, preventing unintended elevation or depression of the metatarsal head and converging or diverging osteotomy cuts. The osteotomy angle is cut between 55° and 60° (Figure 3). Stripping of the plantar and lateral periosteum is avoided to limit the risk of osteonecrosis and nonunion. With traction of the great toe, translation of the distal fragment can be performed from 33% to 50% of the width of the metatarsal head. Controlled gentle axial compression along the hallux allows for mild impaction of the osteotomy. The osteotomy should be stable with both valgus and rotational positions of the improved toe. The osteotomy is temporarily pinned in place with a guide wire for a 2.0-mm cannulated compression screw, and then drilling and placement of the screw are performed. A 2.0 mm absorbable may be used instead, oriented from proximal to distal. The remaining metatarsal neck fragment is removed in plane parallel with the medial border of the foot. A small portion of the redundant capsular tissue can be excised with a tight medial capsular closure with 2 to 0 absorbable suture. We do not rely on aggressive lateral soft-tissue release or excessively tight medial capsular closure to compensate for an incomplete bony correction. Compressive forefoot soft dressing is applied. Patients are instructed to bear weight through the heel in postsurgical shoes, as tolerated, for 6 weeks. In some instances, a Robert Jones compressive dressing with splint is applied initially, followed by a short leg cast for 3 weeks.

Moderate deformities may be addressed with either proximal osteotomy such as scarf although distal ostetotomies may also be applied successfully. A lateral soft-tissue release may be performed. In some instances, it is helpful to judge the adequacy of the correction intraoperatively with capsular closure and removal of the tourniquet to see whether the great toe has been rebalanced and derotated. This may be performed by visual inspection with simulated weight-bearing and fluoroscopy.

The scarf osteotomy is performed through a medial incision around the forefoot over the MTPJ and longitudinal capsulotomy. A proximal extension of the capsulotomy is performed to expose the midshaft of the first metatarsal (Figure 4). The distal fragment is translated laterally. In some instances, the osteotomy is translated laterally and rotated medially to achieve correction. A two-screw fixation technique is used to stabilize the osteotomy. Our postoperative protocol is similar to that after distal osteotomies.

In patients with first TMTJ arthritis, a modified Lapidus procedure can be used to address both the hallux valgus correction and the TMTJ arthritis. We do not primarily use the modified Lapidus procedure as the first TMTJ hypermobility, which is difficult to define. A dorsal incision is made over the first TMTJ. The extensor hallucis longus tendon is retracted laterally, and the joint capsule is then incised. With joint distraction by pin distractors, the joint is prepared using a combination of microsagittal saw, curettes, and rongeurs, and the subchondral sclerotic bone is punctured with a 2.5-mm drill. The metatarsal head is reduced over the sesamoid complex because the microsagittal saw is passed through the TMTJ to remove any imperfections in joint preparation. The TMTJ is pinned provisionally, and screw and plate fixation is used. A distal lateral soft-tissue release may be needed through a smaller but separate incision. After a modified Lapidus procedure, we routinely cast the patient for 4 to 6 weeks before full weight-bearing.

Congruent hallux valgus deformities with a dysplastic metatarsal head may require a more complex double metatarsal osteotomy technique to correct the DMAA. A closing wedge biplanar distal chevron osteotomy is recommended for most patients.

After correction of the hallux valgus, if there is significant residual interphalangeus deformity, an Akin osteotomy may be performed. An incision is typically extended to the midshaft of the proximal phalanx. A medial closing wedge osteotomy is performed using a microsagittal saw at the base of the phalanx, and a cannulated 2.0-mm compression screw is used to transfix the osteotomy.

In severe deformities with arthritic changes, revision hallux valgus deformity, and selected neurologic conditions, or inflammatory arthropathies, the first MTPJ arthrodesis should be considered. A medial or dorsal longitudinal incision is made over the MTPJ, and care is take to avoid trauma to the extensor hallucis longus tendon and dorsomedial cutaneous nerve. Gentle pressure on the conical reamers is a reliable method joint surface preparation. A flat surface platform can be used to simulate a weight-bearing foot to guide hallux valgus correction to 5° to 10° valgus, neutral rotation, and 5° to 10° dorsiflexion relative to the plantar foot. Either two cross screws or a cannulated compression screw in addition to a dorsal MTPJ plate fixation may be used for fixation. Forefoot dressings are applied, and patients are instructed to bear weight in a post-surgical shoe for 6 weeks before transitioning to a tennis shoe. In some instances, a Robert Jones dressing is applied followed by a cast.

Summary

Successful operative management of hallux valgus deformity may be achieved with an understanding of the pathophysiology and application of appropriate procedure. Future research would be beneficial such as large clinical trials, long-term follow-up studies, and multicenter investigations using foot specific registry data.

References

References printed in **bold type** are those published within the past 5 years.

1. Saragas NP, Becker PJ: Comparative radiographic analysis of parameters in feet with and without hallux valgus. *Foot Ankle Int* 1995;16:139-143.
2. Easley ME, Trnka HJ: Current concepts review: Hallux valgus part 1: Pathomechanics, clinical assessment, and nonoperative management. *Foot Ankle Int* 2007;28:654-659.
3. Coughlin MJ, Jones CP: Hallux valgus: Demographics, etiology, and radiographic assessment. *Foot Ankle Int* 2007;28: 759-777.
4. Wagner E, Ortiz C, Gould JS, et al: Proximal oblique sliding closing wedge osteotomy for hallux valgus. *Foot Ankle Int* 2013;34:1493-1500.
5. Huang EH, Charlton TP, Ajayi S, Thordarson DB: Effect of various hallux valgus reconstruction on sesamoid location: A radiographic study. *Foot Ankle Int* 2013; 34:99-103.
6. Kitaoka HB, Franco MG, Weaver AL, Ilstrup DM: Simple bunionectomy with medial capsulorrhaphy. *Foot Ankle* 1991; 12:86-91.
7. **Jeuken RM, Schotanus MG, Kort NP, Deenik A, Jong B, Hendrickx RP: Long-term follow-up of a randomized controlled trial comparing scarf to chevron osteotomy in hallux valgus correction. *Foot Ankle Int* 2016;37:687-695.**
8. Al-Nammari SS, Christofi T, Clark C: Double first metatarsal and akin osteotomy for severe hallux valgus. *Foot Ankle Int* 2015;36:1215-1222.
9. **Shi GG, Henning P, Marks RM: Correlation of postoperative position of the sesamoids after chevron osteotomy with outcome. *Foot Ankle Int* 2016;37: 274-280.**
10. **Kaufmann G, Sinz S, Giesinger JM, Braito M, Biedermann R, Dammerer D: Loss of correction after chevron osteotomy for hallux valgus as a function of preoperative deformity. *Foot Ankle Int* 2019;40: 287-296.**
11. Resch S, Stenstrom A, Reynisson K, Jonsson K: Chevron osteotomy for hallux valgus not improved by additional adductor tenotomy. A prospective, randomized study of 84 patients. *Acta Orthop Scand* 1994;65: 541-544.

12. **Vander Griend R: Correction of hallux valgus interphalangeus with an osteotomy of the distal end of the proximal phalanx (distal akin osteotomy).** ***Foot Ankle Int*** **2017;38:153-158.**

13. **Lai MC, Rikhraj IS, Woo YL, Yeo W, Ng YCS, Koo K: Clinical and radiological outcomes comparing percutaneous chevron-akin osteotomies vs open scarf-akin osteotomies for hallux valgus.** ***Foot Ankle Int*** **2018;39:311-317.**

14. Adam SP, Choung SC, Gu Y, O'Malley MJ: Outcomes after scarf osteotomy for treatment of adult hallux valgus deformity. *Clin Orthop Relat Res* 2011;469:854-859.

15. **Braito M, Dammerer D, Hofer-Picout P, Kaufmann G: Proximal opening wedge osteotomy with distal chevron osteotomy of the first metatarsal for the treatment of moderate to severe hallux valgus.** ***Foot Ankle Int*** **2019;40:89-97.**

16. Iyer S, Demetracopoulos CA, Sofka CM, Ellis SJ: High rate of recurrence following proximal medial opening wedge osteotomy for correction of moderate hallux valgus. *Foot Ankle Int* 2015;36:756-763.

17. Sammarco VJ: Surgical strategies: Mau osteotomy for correction of moderate and severe hallux valgus deformity. *Foot Ankle Int* 2007;28:857-864.

18. Glazebrook M, Copithorne P, Boyd G, et al: Proximal opening wedge osteotomy with wedge-plate fixation compared with proximal chevron osteotomy for the treatment of hallux valgus: A prospective, randomized study. *J Bone Joint Surg Am* 2014;96:1585-1592.

19. Bock P, Lanz U, Kröner A, Grabmeier G, Engel A: The scarf osteotomy: A salvage procedure for recurrent hallux valgus in selected cases. *Clin Orthop Relat Res* 2010; 468:2177-2187.

20. Choi JH, Zide JR, Coleman SC, Brodsky JW: Prospective study of the treatment of adult primary hallux valgus with scarf osteotomy and soft tissue realignment. *Foot Ankle Int* 2013;34:684-690.

21. Bock P, Kluger R, Kristen KH, Mittlböck M, Schuh R, Trnka HJ: The scarf osteotomy with minimally invasive lateral release for treatment of hallux valgus deformity: Intermediate and long-term results. *J Bone Joint Surg Am* 2015;97: 1238-1245.

22. Coughlin MJ, Smith BW: Hallux valgus and first ray mobility. Surgical technique. *J Bone Joint Surg Am* 2008;90:153-170.

23. **Braito M, Dammerer D, Hofer-Picout P, Kaufmann G: Proximal opening wedge osteotomy with distal chevron osteotomy of the first metatarsal for the treatment of moderate to severe hallux valgus.** ***Foot Ankle Int*** **2019;40:89-97.**

24. Ellington JK, Myerson MS, Coetzee JC, Stone RM: The use of the Lapidus procedure for recurrent hallux valgus. *Foot Ankle Int* 2011;32:674-680.

25. Coetzee JC, Resig SG, Kuskowski M, Saleh KJ: The Lapidus procedure as salvage after failed surgical treatment of hallux valgus: A prospective cohort study. *J Bone Joint Surg Am* 2003;85:60-65.

26. Faber FW, van Kampen PM, Bloembergen MW: Long-term results of the Hohmann and Lapidus procedure for the correction of hallux valgus: A prospective, randomised trial with eight- to 11-year follow-up involving 101 feet. *Bone Joint J* 2013;95-B: 1222-1226.

27. **Crowell A, Van JC, Meyr AJ: Early weightbearing after arthrodesis of the first metatarsal-medial cuneiform joint: A systematic review of the incidence of nonunion.** ***J Foot Ankle Surg*** **2018;57: 1204-1206.**

28. Coetzee JC, Wickum D: The Lapidus procedure: A prospective cohort outcome study. *Foot Ankle Int* 2004;25:526-531.

29. Kopp FJ, Patel MM, Levine DS, Deland JT: The modified Lapidus procedure for hallux valgus: A clinical and radiographic analysis. *Foot Ankle Int* 2005;26:913-917.

30. Pydah SKV, Toh EM, Sirikonda SP, Walker CR: Intermetatarsal angular change following fusion of the first metatarsophalangeal joint. *Foot Ankle Int* 2009;30:415-418.

31. **McKean RM, Bergin PF, Watson G, Mehta SK, Tarquinio TA: Radiographic evaluation of intermetatarsal angle correction following first MTP joint arthrodesis for severe hallux valgus.** ***Foot Ankle Int*** **2016;37:1183-1186.**

32. Chao JC, Charlick D, Tocci S, Brodsky JW: Radiographic and clinical outcomes of joint-preserving procedures for hallux valgus in rheumatoid arthritis. *Foot Ankle Int* 2013;34:1638-1644.

33. Korim MT, Allen PE: Effect of pathology on union of first metatarsophalangeal joint arthrodesis. *Foot Ankle Int* 2015;36:51-54.

34. Kim Y, Kim JS, Young KW, Naraghi R, Cho HK, Lee SY: A new measure of tibial sesamoid position in hallux valgus in relation to the coronal rotation of the first metatarsal in CT scans. *Foot Ankle Int* 2015;36:944-952.

35. **Santrock RD, Smith B: Hallux valgus deformity and treatment: A three-dimensional approach: Modified technique for Lapidus procedure.** ***Foot Ankle Clin*** **2018;23:281-295.**

36. Giannini S, Faldini C, Nanni M, Di Martino A, Luciani D, Vannini F: A minimally invasive technique for surgical treatment of hallux valgus: Simple, effective, rapid, inexpensive (SERI). *Int Orthop* 2013;37:1805-1813.

37. Iannò B, Familiari F, De Gori M, Galasso O, Ranuccio F, Gasparini G: Midterm results and complications after minimally invasive distal metatarsal osteotomy for treatment of hallux valgus. *Foot Ankle Int* 2013;34:969-977.

38. **Kaipel M, Reissig L, Albrecht L, Quadlbauer S, Klikovics J, Weninger WJ: Risk of damaging anatomical structures during minimally invasive hallux valgus correction (Bösch technique): An anatomical study.** ***Foot Ankle Int*** **2018;39: 1355-1359.**

39. **Barg A, Harmer JR, Presson AP, Zhang C, Lackey M, Saltzman CL: Unfavorable outcomes following surgical treatment of hallux valgus deformity: A systematic literature review.** ***J Bone Joint Surg Am*** **2018;100:1563-1573.**

40. Okuda R, Kinoshita M, Yasuda T, Jotoku T, Kitano N, Shima H: Postoperative incomplete reduction of the sesamoids as a risk factor for recurrence of hallux valgus. *J Bone Joint Surg Am* 2009;91:1637-1645.

41. Chen JY, Lee MJ, Rikhraj K, et al: Effect of obesity on outcome of hallux valgus surgery. *Foot Ankle Int* 2015;36: 1078-1083.

42. Chong A, Nazarian N, Chandrananth J, Tacey M, Shepherd D, Tran P: Surgery for the correction of hallux valgus: Minimum five-year results with a validated patient-reported outcome tool and regression analysis. *Bone Joint J* 2015;97-B:208-214.

43. Kuhn MA, Lippert FG, Phipps MJ, Williams C: Blood flow to the metatarsal head after chevron bunionectomy. *Foot Ankle Int* 2005;26:526-529.

44. Lee HJ, Chung JW, Chu IT, Kim YC: Comparison of distal chevron osteotomy with and without lateral soft tissue release for the treatment of hallux valgus. *Foot Ankle Int* 2010;31:291-295.

45. Klein C, Zembsch A, Dorn U: Radiographic evaluation for AVN following distal metatarsal stoffella bunion osteotomy. *Foot Ankle Int* 2009;30:39-43.