Surgical treatment of hallux valgus: a review
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Purpose of review
The treatment of hallux valgus is dependent on multiple factors from clinical examination, patient considerations, radiographic assessment, and surgeon preference. Numerous techniques have been described to address this common disorder. The purpose of this paper is to provide an updated review of the surgical treatment of hallux valgus.

Recent findings
Operative management of hallux valgus involves a combination of both soft tissue and bony procedures. Various osteotomies, each demonstrating potential advantages and complications, may be selected based on the degree of deformity. Arthrodesis may be utilized to address severe deformities and first ray hypermobility. Minimally invasive techniques are now being employed with emphasis on cosmesis and reduced surgical exposure. Salvage techniques have also been recently described with improved clinical results.

Summary
While several well established surgical methods are available for hallux valgus, consensus regarding the best treatment has yet to be established. Ultimately, this decision-making process is multifactorial, and further investigation into more novel approaches may be warranted prior to their broad application. Appropriate surgical selection and proper technique will usually result in good to excellent outcomes.

Keywords
arthrodesis, arthroscopic, hallux valgus, hypermobility, osteotomy, percutaneous, salvage

Introduction
The treatment of hallux valgus is dependent on numerous factors from clinical examination, patient considerations, radiographic assessment, and surgeon preference. The multitude of established procedures and technique modifications in the literature underscores the fact that no single approach universally addresses this common disorder. Here we present an updated review of the surgical treatment for hallux valgus.

Etiology and pathogenesis
Both intrinsic and extrinsic factors have been implicated in the development of hallux valgus. Intrinsic factors may include pes planus, metatarsus primus varus, rheumatoid arthritis, collagen and neuromuscular disorders, first tarsometatarsal (TMT) hypermobility, and hereditary predisposition. Coughlin and Roger [1] reported, in a series of 31, that 94% of mothers whose children had hallux valgus also were affected.

Constrictive shoes and high-heel wear play an extrinsic role in hallux valgus. Sim-Fook and Hodgson [2] compared the incidence of hallux valgus in shoe-wearing versus nonshoe-wearing populations, 33% and 1.9% respectively. A predilection in the female population for hallux valgus has been reported to be anywhere from 3:1 by Hewitt et al. [3] to 15:1 by Hardy and Clapham [4].

Ultimately, an imbalance develops around the first metatarsophalangeal (MTP) joint leading to a progressive hallux valgus deformity and often, patient complaints of pain and cosmetic dissatisfaction. Repetitive valgus stress to the great toe, such as occurs with narrow shoes, may lead to medial sided soft tissue attenuation. Valgus drift of the proximal phalanx and varus drift of the metatarsal head can lead to a painful bursitis over the medial eminence. Lateral subluxation of the sesamoids with metatarsosesamoid (MTS) degenerative changes can develop. The deformity progresses as the extensor and flexor hallucis longus tendons shift to act as adductors and lateral capsular and soft tissue contractures develop. Pronation of the great toe can result from the pull of the abductor hallucis tendon on the proximal phalanx. Insufficiency of the first ray and resultant metatarsalgia can develop from this sequence of events.

Clinical evaluation
Clinical evaluation takes into account patient symptoms and physical exam findings. A family history of bunions
and the specific location of pain should be noted. A ‘deep’ ache or plantar pain is associated with sesamoid involvement whereas medial pain can be from bursal inflammation. Pain that occurs while being barefoot can also indicate more joint (MTP or MTS joint) involvement than pressure over the medial eminence. Problems with shoewear, painful bunion, cosmetic dissatisfaction, and metatarsalgia of the lesser toes are common presenting complaints.

Physical exam should be conducted with the patient seated and standing. Exam findings may reveal associated planovalgus deformity, tight heel cord, rigid or correctable hallux valgus, great toe pronation, corns or calluses of the lesser toes, second MTP joint synovitis, interdigital neuromas, or first TMT joint hypermobility.

Radiographic evaluation
Standard preoperative radiographic assessment of hallux valgus includes anterior–posterior, oblique, and lateral weightbearing views of the foot. In addition, a sesamoid view can be obtained to assess subluxation of the sesamoids as well as degenerative changes. Specific measurements include the hallux valgus angle (HVA), intermetatarsal angle (IMA), and distal metatarsal articular angle (DMAA). In addition, first MTP joint congruency should be noted as well as the position of the sesamoids [5]. Severity of the deformity may be classified according to these measurements [6] (Table 1).

Nonoperative management
Footwear modification is the mainstay of nonoperative treatment for hallux valgus. Orthotics have not been shown to prevent progression of the deformity. Torkki et al. [7] performed a randomized controlled trial of 209 patients comparing immediate operation versus 1 year of waiting with or without orthoses. The authors concluded that the surgical group had better outcomes with regards to foot pain, cosmetic disturbance, functional status, treatment satisfaction, footwear problems, and patient-derived global assessments. The orthosis group showed only short-term, symptomatic relief, with pain returning to previous levels after 12 months.

Operative management
Surgery for hallux valgus is indicated for pain not adequately controlled by nonoperative measures. Historically, some techniques, such as the Keller procedure, were once widely used but are now seldom seen. Other procedures, such as the Mitchell and Wilson osteotomies, are performed more regularly in Europe [8]. Here we discuss well established techniques that are frequently used in addition to more recent surgical approaches.

Distal soft tissue procedure
In 1923, Silver discussed the correction of hallux valgus by performing a medial exostectomy and release of contracted lateral structures (adductor hallucis, lateral joint capsule, transverse metatarsal ligament) along the first MTP joint. Further modifications were made by McBride and DuVries. Today, this technique is almost always combined with a bony procedure. In addition, a medial eminence resection and capsular plication are often performed. This procedure is contraindicated if there is a congruent joint present with a large DMAA.

At a recent meeting, Conti et al. [9] reported on the degree of sesamoid correction and the extent of metatarsosesamoid arthritis affecting surgical outcomes. This was a retrospective study looking at 96 patients: group 1 (41 patients) underwent distal chevron osteotomy alone and group 2 (55 patients) underwent distal chevron osteotomy with a modified distal soft tissue release (DSTR) through a medial incision to incise the lateral metatarsosesamoid ligament. There were no significant differences between the groups in regards to demographics or preoperative radiographic measurements. They reported a significantly greater preoperative to postoperative change in sesamoid position when the modified DSTR was combined with the chevron osteotomy versus osteotomy alone. In group 1, 81% of the patients had sesamoid subluxation of grade 2 or higher preoperatively, while 51% had persistent subluxation of grade 2 or higher postoperatively. In group 2, 76% of the patients had sesamoid subluxation of grade 2 or higher preoperatively, while only 9% had persistent subluxation of grade 2 or higher postoperatively. Significant differences were seen in patients under and over the age of 50 years. In patients under age 50 years, the degree of observed intraoperative eburnated bone was 5% at the MTP joint and 32% at the metatarsosesamoid joint. In patients over the age of 50 years, these numbers were 15.5% at the MTP joint and 74% at the metatarsosesamoid joint. Mean postoperative American Orthopaedic Foot and Ankle Society (AOFAS) scores were also higher for the modified DSTR group (91 versus 85). The authors concluded that early surgical intervention emphasizing proper sesamoid alignment and before significant arthrosis becomes present, may improve outcomes following bunion surgery.

Osteotomies
The choice and level of osteotomy (proximal, diaphyseal, or distal) depends largely on the degree of deformity and
amount of correction needed. Greater correction can be achieved with more proximal-based osteotomies, while distal procedures are usually reserved for smaller deformities and require less exposure and shorter recovery times.

**Distal osteotomies**

Distal osteotomies are used for mild/moderate deformities and contraindicated in severe deformities.

**Distal chevron**

The features of the distal chevron osteotomy are as follows: a V-shaped osteotomy through metatarsal head/neck with lateral displacement of head (5–6 mm) [10]; advantages include minimal shortening and intrinsic stability; it can be used for mild/moderate deformity of a congruent joint with normal DMAA; if DMAA exceeds 15°–20°, planar osteotomy is indicated [11]; patient satisfaction decreases after age 60 years (increased pain and stiffness around MTP joint) [12]; it is contraindicated in moderate/severe deformity (HVA >35° and IMA >15°).

Hattrup and Johnson [12] reported 1 year follow-up results on 154 patients who underwent 225 chevron osteotomies for hallux valgus between 1976 and 1982. Interviewed patients expressed 79.1% complete satisfaction, 12.9% partial satisfaction, and 8% dissatisfaction. Factors producing incomplete satisfaction included failure to achieve correction and technical errors. No cases of avascular necrosis, osteotomy nonunion, or hallux varus were reported.

**Akin**

The Akin osteotomy can often be used in conjunction with a distal chevron osteotomy to correct residual valgus. It can be used with many bunion procedures where valgus remains. It is most useful for hallux interphalangeus or increased DMAA. The Akin is a closing wedge osteotomy of proximal phalanx. It is contraindicated as a primary procedure for an incongruent joint.

**Percutaneous**

Percutaneous osteotomy is indicated for mild to moderate hallux valgus with HVA 40° or under and IMA 10–20°. It is indicated for juvenile hallux valgus with increased DMAA and contraindicated in severe hallux rigidus or previous Keller procedure. A Kirschner wire helps guide and stabilize the correction. The osteotomy is performed through a 3–5 mm incision using a corticotomy technique. No associated soft tissue procedure is performed. Advantages include minimal invasiveness, shorter operation time, and reduced surgical exposure complications.

Magnan et al. [13] described a percutaneous subcapital distal osteotomy technique for the treatment of mild to moderate hallux valgus in 82 patients (118 consecutive procedures). Follow-up averaged 35.9 months. Magnan reported 91% patient satisfaction with a mean American Orthopaedic Foot and Ankle Society (AOFAS) score of 88.2 ± 12.9 points. Significant postoperative improvements were seen in mean HVA, IMA, DMAA, and sesamoid position. Complications included three recurrent valgus deformities (2.5%), eight stiff first metatarsophalangeal joints (6.8%), and one deep infection that resolved with antibiotic therapy (0.8%). While the authors concluded the clinical results appear to be comparable with those of open techniques, further investigation may be warranted.

**Diaphyseal osteotomies**

Diaphyseal osteotomies are recommended for moderate hallux valgus and are usually performed with medial capsular plication and lateral soft tissue release.

**Scarf osteotomy**

The Scarf osteotomy is a Z-shaped step-cut osteotomy that allows translation of the head. It is highly stable biomechanically and indicated for moderate to severe deformities with IMA over 14°. It is technically demanding with extensive surgical exposure and risks stiffness.

Jones et al. [14] prospectively reviewed 24 patients (35 feet) treated by Scarf osteotomy and Akin closing-wedge osteotomy for hallux valgus. Follow-up averaged 20 months. Fifty percent of the patients were very satisfied, 42% were satisfied, and 8% were not satisfied. Mean AOFAS score improved significantly from 52 to 89 points. Mean IMA improved from 15° to 9° and mean HVA improved from 33° to 14°. DMAA did not change significantly. Mean pedobarographic measurements of the first and second metatarsals also did not change significantly and were within normal range at more than one year postoperatively. Complications included two wound infections, one intraoperative first metatarsal fracture, and one symptomatic screw requiring removal.

Smith et al. [15] reported six (6%) perioperative complications for their first 100 Scarf osteotomy procedures. Intraoperative complications included three cases of a split first metatarsal and one case of K-wire shearing. Two postoperative stress fractures were reported. These complications should be considered by those beginning to master the Scarf osteotomy procedure and by surgeons teaching surgical trainees.

**Proximal osteotomies**

Proximal osteotomies are used for moderate to severe deformities.

**Crescentic osteotomy**

The Crescentic osteotomy is made 1 cm distal to TMT joint with concavity facing proximally. It involves
minimal shortening. Risks include dorsal malunion and transfer metatarsalgia.

Veri et al. [16] reviewed short and long-term results of 25 patients (37 feet) treated with combined proximal crescentic osteotomy and DSTR. One year follow-up included 20 of 25 (31/37 feet) and long-term follow-up was 84% at an average of 12.2 years. Mean preoperative HVA and IMA were 37° and 16°, respectively. Mean long-term HVA correction was 24° and IMA correction was 10° with no tendency toward recurrence. Sesamoid position and first MTP subluxation was markedly improved postoperatively and long-term correction was maintained. Patients reported over 90% complete satisfaction with pain and motion and over 80% with appearance. AOFAS score improved from 37/100 to 92/100 at both follow-up periods, and 94% said they would have the operation again. Complications included two varus over-corrections, four undercorrections with asymptomatic recurrence (>10° increase HVA), two new transfer lesions, and one dorsiflexion malunion.

Brodsky et al. [17] looked at the effect of proximal crescentic osteotomy with a modified McBride procedure on plantar pressures under the first and second metatarsal heads in 32 patients (43 feet). Mean follow-up was 29 months. Average second metatarsal peak pressure increased postoperatively. First metatarsal elevation greater than 2 mm (12) occurred almost equally with depression (11) and resulted in five new second metatarsal transfer lesions. Postoperatively, nine feet had symptomatic second metatarsal transfer lesions. These results demonstrate potential difficulties in controlling the first metatarsal in the sagittal plane with this technique.

Coughlin et al. [18] performed a cadaveric study evaluating the change in first ray mobility after proximal crescentic osteotomy and DSTR. Significant reduction in mean sagittal first ray motion was found after correction. While this finding suggests that the stability of this technique may adequately address first ray hypermobility, its clinical efficacy remains less defined.

**Proximal chevron**

The proximal chevron is a proximal V-shaped osteotomy that is intrinsically stable. It leads to fewer transfer lesions and requires bone graft from excised medial eminence for stability.

Sammarco and Russo-Alesi [19] reviewed 88 consecutive cases of proximal chevron first metatarsal osteotomy combined with soft tissue procedure with mean follow-up of 41 months. HVA improved by an average of 15° (32.0° to 17.0°). IMA improved an average of 5.5° (15.3° to 9.0°). First metatarsal length decreased by 2.0 mm. Union occurred at an average of 2 months. Average sesamoid subluxation decreased from 80 to 29%. Subjective foot score profiles improved from 70.1/100 to 94.4/100, and 84% of patients stated they would undergo the procedure again without reservation. Complications included three delayed unions, two metatarsal stress fractures, one hallux varus, two hallux limitus, one progressive arthritis, one cellulitis, and one hallux elevatus.

Easley et al. [20] compared the crescentic and chevron proximal osteotomies for correction of adult hallux valgus (IMA >13°) in a prospective, randomized study. Follow-up included 29 patients (41 feet) in the crescentic group and 37 patients (43 feet) in the chevron group at an average of 24 and 20 months, respectively. They had good results with both procedures and found no significant difference in IMA correction or functional outcome. The chevron group had statistically significant shorter healing time, however. Easley concluded that a chevron osteotomy may have additional benefits over a crescentic osteotomy, including less first metatarsal dorsiflexion and shortening, more medial distribution of tibial sesamoids, and reduced potential for transfer lesions.

**Modified Ludloff**

The modified Ludloff osteotomy is used for moderate to severe deformities without associated instability and involves rotation of the shaft through 30° with an oblique cut 2 mm distal to the TMT joint and minimal shortening. It is more stable biomechanically than proximal osteotomies with a lower incidence of dorsal malunion and transfer metatarsalgia compared with other proximal osteotomies, such as the crescentic or chevron.

Chiodo et al. [21] reviewed 70 of 82 consecutive cases of moderate to severe hallux valgus corrected with the Ludloff osteotomy combined with a distal soft tissue procedure and medial eminence resection. With an average follow-up of 30 months, mean HVA improved from 31° to 11° and IMA improved from 16° to 7°. No symptomatic transfer lesions developed. Mean AOFAS hindfoot score improved from 54 to 91 points. Complications included prominent hardware requiring removal (five), hallux varus (four), delayed union (three), superficial infection (three), and neuralgia (three).

**Proximal wedge osteotomy**

The proximal wedge osteotomy involves an opening or closing wedge. The opening wedge elongates, stretches soft tissues and requires bone graft. Risks include stiffness and nonunion with the opening wedge. The closing wedge causes shortening, and is inherently unstable. Risks include dorsal malunion and transfer lesions with the closing wedge.
Shurnas and Sanders [22] presented their results on 21 proximal opening wedge osteotomies using a low profile plate and screw system. They reported 20 excellent or good results and one fair result with a 6-month minimum follow-up. They concluded that reliable healing and predictable correction can be achieved with this technique but ongoing functional scores and follow up are needed.

**Arthrodensis**

A first MTP joint arthrodensis is used for rheumatoid arthritis, severe deformities, degenerative changes of MTP joint, neuromuscular diseases and salvage following failed surgery.

Coughlin et al. [23] evaluated his results of first MTP joint arthrodensis as treatment for moderate to severe hallux valgus deformities over a 22-year period (1979–2001). Successful fusion with the primary procedure occurred for 18 of 21 (86%) at an average follow-up of 8.2 years. Time to union averaged 10 weeks. Three nonunions occurred and one required revision. Average corrections in HVA and IMA were 21° and 6°, respectively. Subjective satisfaction was rated as excellent in 80% and good in 20%. Postoperative pain improved significantly, and AOFAS scores averaged 84 at follow-up. All patients were able to wear conventional or comfort shoes. Interphalangeal joint arthritis progressed in seven (33%).

**Lapidus**

The Lapidus procedure involves fusion of the first TMT joint and is indicated for severe deformities, a hypermobile first ray and degenerative changes of first MTP. It is contraindicated in adolescents with open physes and degenerative changes of first MTP. It is technically demanding with a prolonged recovery period and leads to shortening.

Hypermobility of the first ray continues to be a focus of research. Good results have been reported for the Lapidus procedure as treatment for hallux valgus with associated first TMT hypermobility. Kopp et al. [24] retrospectively reviewed 29 patients (35 procedures) with this condition using preoperative and postoperative questionnaires, physical examination, and radiographs. They reported 90% (26 of 29) satisfaction with foot function and 86% (25 of 29) satisfaction with cosmetic appearance.

Coetzee and Wickum [25] prospectively looked at the functional outcome of patients with moderate and severe hallux valgus deformities (IMA >14° and HVA >30°) after the Lapidus procedure. AOFAS score, Visual Analog Pain Scale, clinical examination, weightbearing radiographs, and a patient satisfaction questionnaire were used preoperatively, 6 weeks after surgery, 6 months after surgery, and then yearly. One hundred and five feet (91 patients, mean age 41 years) were followed for an average of 3.7 years. AOFAS scores improved significantly from 52 to 87. IMA improved from 18° to 8.2° and increased by only 0.3° between 1-year and 3.7-year follow-up. HVA improved from 37° to 16° and increased by less than 1° between 1-year and 3.7-year follow-up. Complications included TMT nonunion requiring revision (seven), necessary hardware removal (eight), minor wound problems (two), superficial neuroma (two), and transfer metatarsalgia (four).

**Endoscopic/arthroscopic techniques**

Lui et al. [26] describe their experience with endoscopic distal soft tissue procedures to address hallux valgus with emphasis on improved cosmesis. They also describe an arthroscopic approach to the Lapidus arthrodensis, reporting several advantages over the open technique. Some of these included more thorough preparation of the fusion site with minimal bone removal, better positioning control, reduced malunion risk, improved cosmetic result, and minimal postoperative wound pain [27]. The procedures described are technically demanding and learning curves for small joint arthroscopy may limit their application.

**Complications and salvage procedures**

Lehman [28] reviews some of the more common complications that are seen following hallux valgus surgery. He discusses both nonsurgical and surgical options for treatment to assist in the management of these complications. Among those he addresses (and reported incidence) are deformity recurrence (16%), avascular necrosis (0–76%), hallux varus (10–12%), metatarsal osteotomy nonunion and malunion. For symptomatic recurrence, revision surgery should follow the same principles of primary hallux valgus correction after scrutiny of the initial failure. Hallux varus may be addressed with soft tissue releases, tendon transfers, or extensor hallucis brevis tendonectomy. Nonunions may require debridement and bone grafting, with use of tricortical iliac crest graft for significant bone erosion.

In addition to those complications mentioned above, Radl et al. [29] showed a 4% rate of venous thrombosis in 100 patients (mean age 48.9 years) 4 weeks after chevron bunionectomy using phlebography. The mean age of these four patients was 61.7 years, suggesting advanced age as a risk factor for deep venous thrombosis. They concluded that prophylactic anticoagulation for hallux valgus surgery may be justified for patients over age 60 years.

Machacek et al. [30] compared first MTP arthrodensis with repeat Keller or isolated soft tissue release as salvage technique following failed Keller procedure. Arthrodensis (group A) was performed in 28 patients (29 feet), and either a repeat Keller procedure or isolated soft-tissue release (group B) was performed in 18 patients (21 feet).
In group A, average follow-up was 36 months and fusion was achieved in 26 of 29 (90%). Satisfaction was excellent or good in 23, and postoperative score averaged 76 of 90 points. Repeat arthrodesis was necessary in five feet due to malposition or pseudarthrosis. In group B, average follow-up was 74 months. Satisfaction was excellent or good in six. Postoperative score averaged 48 of 90 points, with valgus deviation and cock-up deformity recurring in the majority of feet at follow-up. They concluded that, although more technically demanding, first MTP joint arthrodesis resulted in higher patient satisfaction and better clinical results.

**Conclusion**

Hallux valgus is the most common pathologic condition affecting the great toe. There are several surgical techniques available but no consensus as to the best treatment method. Patient expectations, clinical findings, radiographs, and surgeon preference are important factors in deciding what type of procedure to perform. Selecting an appropriate procedure, using good technique, and patient compliance will usually result in good to excellent outcomes.

**References and recommended reading**

Papers of particular interest, published within the annual period of review, have been highlighted as: • of special interest •• of outstanding interest

Additional references related to this topic can also be found in the Current Literature section in this issue (pp. 188–190).