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Radiographic Outcomes of a Percutaneous, Reproducible Distal Metatarsal Osteotomy for Mild and Moderate Bunions: A Multicenter Study



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ABSTRACT

Hallux valgus is a prevalent condition. Many open surgical methods of correction have been described. We performed a percutaneous, extra-articular distal metatarsal osteotomy for mild to moderate bunion deformity. The minimally invasive technique was used in 217 feet (180 patients; age 49 ± 4.7 years, mean \pm standard deviation) at 4 centers in North America (Center 1: November 2012 to March 2017; Center 2: January 2010 to May 2016; Center 3: October 2013 to June 2016; Center 4: January 2015 to June 2017). The procedure was used in simultaneous bilateral cases in 28 patients (15.6%) and in nonsimultaneous bilateral cases in 9 patients (5.0%). Immediate postoperative weightbearing was used in all cases. The mean preoperative intermetatarsal angle, hallux abductus angle, and tibial sesamoid position were $14.6^\circ \pm 3.5^\circ$, $30.7^\circ \pm 7.8^\circ$, and 5.4 ± 1.4 , respectively. At final follow-up of 9.3 ± 6.1 months, the mean intermetatarsal angle, hallux abductus angle, and tibial sesamoid position were $4.7^\circ \pm 2.8^\circ$, $8.4^\circ \pm 6.1^\circ$, and 2.0 ± 1.0 , respectively ($p < .0001$ for all comparisons). No major complications were noted. All 217 osteotomies achieved union; 3 feet (1.4%) in 3 patients (1.7%) experienced asymptomatic malunion. Superficial pin-site infection was seen in 42 (19.4%) of the 217 feet (39 patients, 21.7%). The radiographic results of this percutaneous technique appear to be reproducible across multiple centers, and the technique is useful when correcting intermetatarsal and hallux abductus angles. This percutaneous osteotomy for realignment of the first ray allows immediate postoperative weightbearing and, in this initial review, appears to be safe and effective, even in simultaneous bilateral cases.

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Hallux abductovalgus (HAV) is a common condition managed by orthopedic and podiatric foot and ankle surgeons. Surgical treatment of hallux valgus may be necessary when conservative measures fail to provide relief of painful symptoms and shoe wear remains challenging (1–3). Historically, differing surgical treatments have been available,

selected by assessing joint congruency, the first intermetatarsal angle (IMA), and the hallux abductus angle (HAA).

Numerous reports have focused on clinical and radiographic alignment of the great toe and first metatarsophalangeal joint (MTPJ) (4–10), and satisfaction surveys have reported positive outcomes that range from 70.5% to 96% after bunionectomy (11–16). Traditionally, an open, extensile exposure is used to expose the structures of the first MTPJ for correction of HAV. After correction is achieved, radiographic measurements of the HAA, first IMA, and tibial sesamoid position (TSP) are commonly used to report the anatomic realignment of the great toe joint. Comparison of preoperative and postoperative radiographic measurements is often used to describe surgical success in radiographic terms (11–25). Common complications associated with hallux valgus

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surgery include recurrence, scarring, continued pain or first MTPJ arthritis, and decreased range of motion (ROM).

Hohmann (26,27) and Reverdin (28) were 2 of the first surgeons to describe a first metatarsal osteotomy for correction of HAV. Austin and Leventen (29) are credited with popularizing a distal chevron osteotomy for the correction of hallux valgus, and interestingly, although they did not describe fixation of the osteotomy in their initial report, subsequent articles have described the chevron osteotomy with and without fixation (18,19,21,30–34). The translational chevron osteotomy has become very popular because of its inherent stability (35). However, it is usually recommended for mild hallux valgus (IMA $<13^\circ$ and HAA $<30^\circ$), and translation of the distal metatarsal is limited to $\sim 50\%$ of the width of the distal metatarsal to avoid malalignment resulting from troughing (36).

In 1990, Bösch et al. (37) published a minimally invasive approach to hallux valgus correction, one that involved the use of an incision that was no more than 1 cm in length and did not use the typical soft tissue lateral first MTPJ release that has been described in association with other methods (31,32,38). Moreover, the procedure did not involve fixation beyond a temporary pin that was removed at 4 weeks (37). Bösch et al. (37) reported encouraging outcomes, and the method was then adapted by European surgeons and others, who have also reported similar positive outcomes (15,33,34,39,40). Despite these results, the foot and ankle surgical community in North America has been reluctant to broadly adopt this method of correction (36), even though the purported benefits of the technique include a precise, percutaneous, and cosmetic incision; immediate postoperative weightbearing, which facilitates bilateral surgery; extra-articular surgery without direct soft tissue maneuvers; no retained internal fixation after an initial temporary period of stabilization; early passive and active ROM of the first MTPJ; and consistently reproducible results.

In an effort to assess the outcomes of the percutaneous, extra-articular, distal first metatarsal transverse osteotomy for the treatment of HAV, we undertook a retrospective cohort study based on review of patients with mild or moderate bunion deformity who underwent this modified Bösch procedure.

The primary outcomes of interest were radiographic measurements, along with complications associated with the procedure. We hypothesized that statistically and clinically significant improvements would be observed between the preoperative and postoperative radiographic measurements. To the authors' knowledge, this article describes the first North American multicenter assessment of the results of this modified Bösch procedure.

Patients and Methods

The institutional review board (IRB) of each study site determined this retrospective study to warrant expedited review as long as protected health information was maintained in a secure fashion. Four surgeons at 4 separate centers performed the modified Bösch procedure. Medical records were reviewed, and consecutive patients were included who underwent the procedure between November 2012 and March 2017 for Center 1, January 2010 and May 2016 for Center 2, October 2013 and June 2016 for Center 3, and January 2015 and June 2017 for Center 4. At Center 1, potentially eligible patients were identified by searching an internal surgical database for the terms "bunion" or "bunionectomy." For Centers 2 and 3, patients were identified by searching the electronic medical record systems at each study site using the following *International Classification of Diseases, Ninth Revision* (ICD-9) (41), ICD-10 (42), and Current Procedural Terminology (43) codes: ICD-9 727.1, ICD-10 M21.611 and M21.612, and CPT 28296. At Center 4, all surgical procedures were reviewed that were listed as performing an osteotomy to treat hallux valgus, and the percutaneous cases were included in the study.

Patients were included in the study if they underwent the modified Bösch procedure and had at least 1 month of follow-up, which is the typical duration of time before pin removal. Patients were excluded if they had undergone ligamentous or tendinous procedures on the medial or lateral aspect of the first MTPJ to balance the capsule or if they did not have preoperative and final follow-up postoperative weightbearing anteroposterior (AP) and lateral view radiographs in the angle and base of gait. Data were abstracted from the medical records by the coauthors (Center 1: A.L.W., Center 2: G.L., Center 3: J.S.A., Center 4: S.B.), and radiographic measurements were also obtained by the coauthors (Center 1: N.A.S. and A.L.W., Center 2: G.L., Center 3: J.S.A., Center 4: M.G.). Age, sex, body

mass index, anatomic laterality, and duration of follow-up were noted for each case based on review of the medical records.

Complications were identified based on reviewing radiographs and documentation in the medical records. Superficial pin-site infections were considered present based on documentation of redness, drainage, or pain at the pin site. Nerve-related complications were considered present based on documentation of numbness, and hardware failures or revision of hardware was defined as premature loosening or backing out of the hardware. Sesamoiditis was considered present based on documentation of inflammation of the sesamoids. Malunion occurred when the capital fragment appeared malaligned with respect to the first metatarsal articular surface (44).

Delayed union of the capital fragment was considered present in cases wherein the radiographs failed to show cortical bridging involving at least 3 cortices along with medullary trabeculation crossing the osteotomy at 3 months postoperatively. Bunion recurrence was defined as a phalangeal deformity with the toe deviated laterally in valgus (not a metatarsal deformity) and the HAA $>12^\circ$ (44).

Each surgeon had minor modifications as to the slope of the osteotomy and the method of medullary wire placement (antegrade versus retrograde). However, the steps and principles of correction were the same. Indications included mild to moderate hallux valgus (with or without hypermobility) with little or no arthritis, HAA $\leq 50^\circ$, and first IMA $\leq 22^\circ$. Relative contraindications included a history of bony or soft tissue infection, significant arthritis of the first MTPJ, or peripheral arterial disease.

Surgical Procedure

The patient was placed on the operating table in the supine position with a bump under the ipsilateral hip to provide a foot-forward rotation. A well-padded bump was placed under the ipsilateral knee, which allowed it to be flexed at a 45° angle to provide ease in obtaining AP view radiographs. The foot was prepped and draped to the level of the knee in a standard aseptic manner. Local, regional, or general anesthesia was administered per the patient's medical needs. When possible, and when not contraindicated by the anesthesia service, the surgeons' preference was to use a regional ankle block with intravenous sedation. Prophylactic antibiotics were administered intravenously (2 g cefazolin; if allergic to cefazolin, 900 mg clindamycin HCl). No anticoagulant was used.

Step 1

One 2-mm Steinmann pin was placed medial and distal to the hallux interphalangeal joint of the great toe. The placement of this pin was 2 to 3 mm from the medial proximal corner of the toenail of the great toe (Fig. 1). The pin was inserted and advanced to the head of the first MTPJ. AP view fluoroscopic images confirmed close apposition of the bone and pin interface to avoid too much pressure on the skin superficial to the pin.

Step 2

A 1-cm or smaller incision was made on the medial aspect of the first metatarsal, at the level of the metatarsal neck (metaphyseal-diaphyseal junction). Blunt dissection was carried down to the metatarsal neck. Dorsal periosteal elevation was performed with an iris scissor or hemostat.

One of 2 techniques was then used to complete the osteotomy. For the first technique, a side-cutting burr (Lindemann burr, 2.3 mm) was used to pierce the cortex in the coronal plane. Then the side-cutting burr was used in the dorsal and plantar direction perpendicular to the axis of the shaft. The osteotomy was completed with a small osteotome. The second technique was a modification of the Bösch method and consisted of a multiple-drill hole

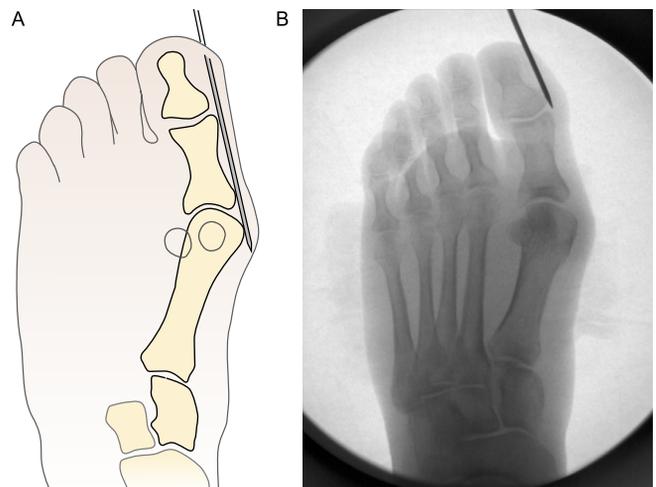


Fig. 1. (A, B) Insert pin from distal tip of great toe subperiosteally to metatarsal head. Used with permission, Rubin Institute for Advanced Orthopedics, Sinai Hospital of Baltimore.

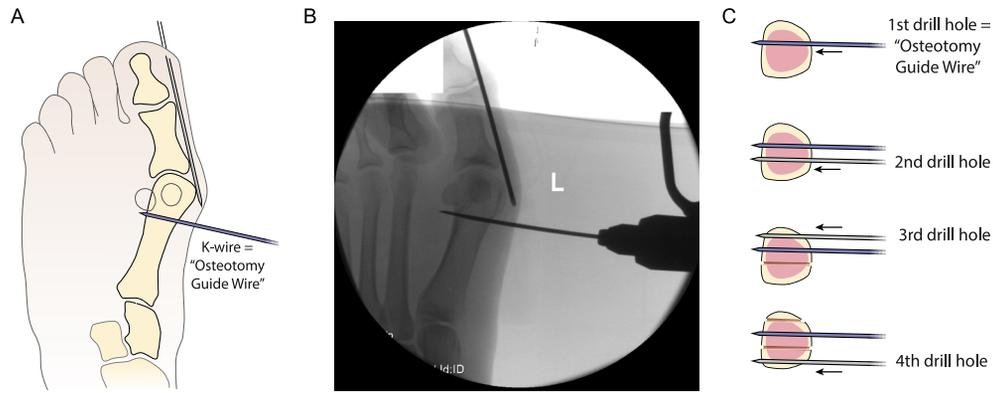


Fig. 2. (A, B) Place 1.8-mm axis guide wire at metatarsal neck. (C) Use additional wires to create multiple drill holes. K-wire, Kirschner wire. L, left. Used with permission, Rubin Institute for Advanced Orthopedics, Sinai Hospital of Baltimore.

osteotomy (Fig. 2). Multiple drill holes were made with a bayonet-tip 1.8-mm Ilizarov wire in a dorsal to plantar manner along the planned path of the osteotomy. The surgeon then angled the guidewire or burr to create an oblique osteotomy in the frontal plane to lengthen, shorten, or maintain neutral length (after translation of the distal fragment). The osteotomy was completed with a small osteotome or sagittal saw (Fig. 3).

Step 3

After the osteotomy was completed, a small hemostat or grooved device was used to translate the capital fragment laterally (Fig. 4). Simultaneous adduction maneuvers on

the hallux were performed to facilitate advancement of the 2.0-mm Steinmann pin to enter the medullary canal of the first metatarsal (Fig. 5). Alternatively, 1 surgeon (in 38 feet) placed the Steinmann pin through the incision and advanced it antegrade toward the distal aspect of the toe and then retrograde through the medullary canal.

No attempt was made to capture or fixate the capital fragment. The surgeons attempted to translate the capital fragment to achieve reduction over the stable sesamoid bones. The amount of this translation was allowed to be as great as 90% of the metaphyseal-diaphyseal metatarsal shaft width (Fig. 6). The goal was to maintain bony contact between the cortex of the medial, proximal aspect of the capital fragment and the cortex of the distal, lateral aspect of the osteotomized first metatarsal.

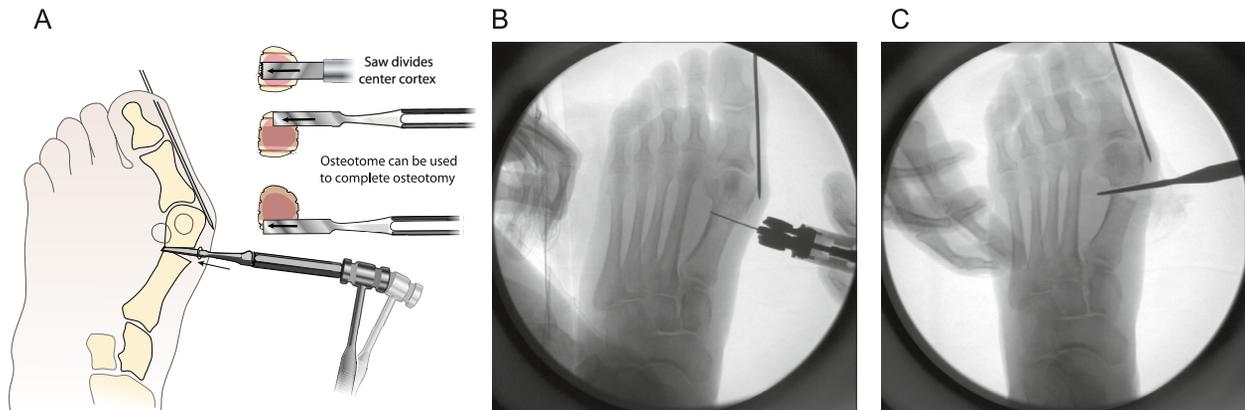


Fig. 3. Use osteotome (A, B) or mini-microsagittal blade (C) to complete osteotomy. Used with permission, Rubin Institute for Advanced Orthopedics, Sinai Hospital of Baltimore.

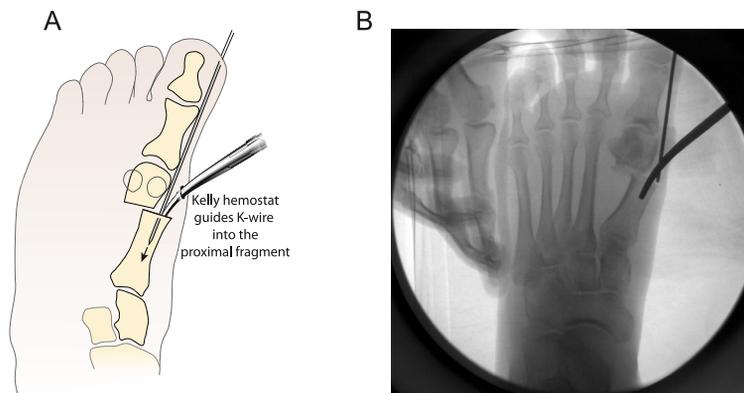


Fig. 4. (A, B) Kelly hemostat guides Kirschner wire (K-wire) into the proximal fragment. Used with permission, Rubin Institute for Advanced Orthopedics, Sinai Hospital of Baltimore.

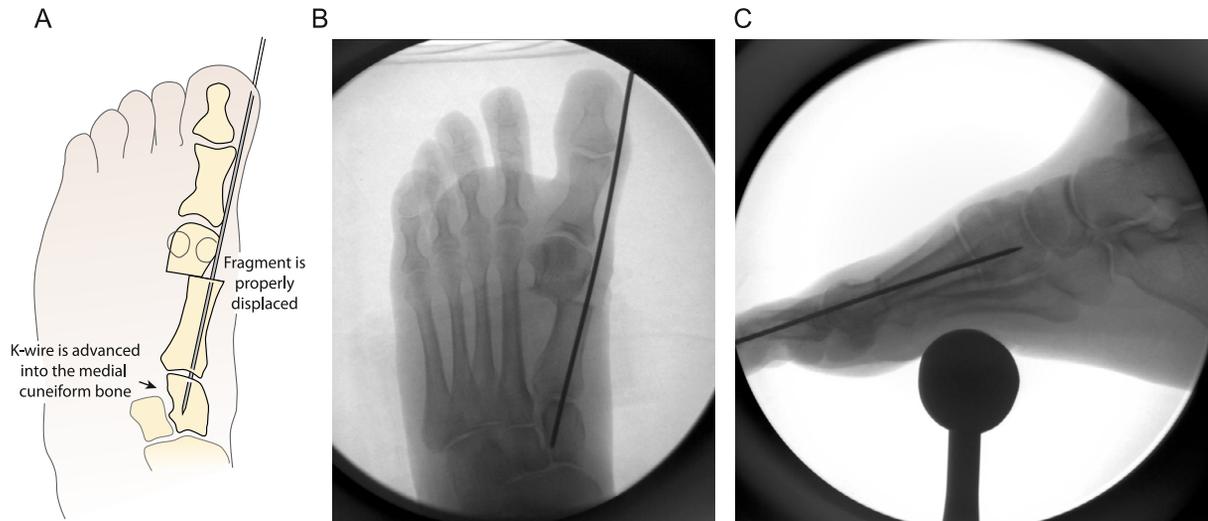


Fig. 5. (A) Kirschner wire (K-wire) advanced into the medial cuneiform bone. (B, C) Wire placement and reduction are confirmed on anteroposterior (B) and lateral (C) view fluoroscopic images. Used with permission, Rubin Institute for Advanced Orthopedics, Sinai Hospital of Baltimore.

Step 4

If the toe was pronated, the head of the first metatarsal was derotated (supinated) in the frontal and transverse planes based on the preoperative and intraoperative fluoroscopic evaluations. Dorsal and plantar translation of the capital fragment can be addressed as needed in patients with dorsiflexed or plantarflexed first ray. The goal was to obtain reduction of the sesamoid apparatus and to restore congruence of the articular surface in all planes. Once appropriate alignment was confirmed on AP and lateral view fluoroscopic images, the wire was advanced beyond the metatarsocuneiform joint for additional stability (Fig. 5). It was also important for the wire to be centered on the first ray in the lateral view fluoroscopic image (Fig. 5).

Step 5

If a bony protrusion of the proximal portion of the first metatarsal was palpable medially, it was removed using a rongeur or osteotome through the small medial incision.

Step 6

The incision was closed with 1 or 2 simple absorbable sutures. The pin was bent, cut, and capped; a standard postoperative hallux valgus bandage was applied. The purpose of the postoperative bunion dressing was to support the Steinmann pin with adduction of the first toe.

Postoperative Protocol

Patients were given a prescription for antibiotics, and they were instructed to start the antibiotics if they observed signs of pin-site infection. Patients were encouraged to begin immediate weightbearing in a flat, rigid postoperative shoe. The bandage was removed 1 week after surgery, after which time normal showering was allowed. Alternatively, the bandage was changed 1 week after surgery. This second bandage was maintained for 3 additional weeks until the wire was removed (4 weeks after surgery), and then showering was allowed. The postoperative shoe was maintained for 4 weeks, at which point the pin was removed in clinic. The patient transitioned to wearing a sturdy sneaker to start normal weightbearing activities. The patient was given first MTPJ ROM exercises that focused primarily on dorsiflexion and plantarflexion of the great toe joint. Radiographs were obtained during follow-up visits until consolidation was confirmed at the osteotomy site. Normal impact sports were usually permitted after the 3-month follow-up visit.

Radiographic Assessments

AP standing radiographs as well as lateral and medial oblique radiographs were obtained for both feet in all patients. Preoperative and postoperative AP view weightbearing radiographs were used by the 4 surgeons to assess HAA, first IMA, and TSP (position of the tibial sesamoid bone in relation to the mechanical axis of the first metatarsal) (4,44,45).

Statistical Plan

Excel (Microsoft, Redmond, WA) was used for data collection, and the Statistical Package for Social Sciences, version 17.0 (SPSS, Chicago, IL), was used to analyze the data. The computations were conducted by N.A.S. and Chukwuweike Uchenna Gwam, MD (Wake Forest Department of Orthopedic Surgery, Winston-Salem, North Carolina). Descriptive statistics were used to calculate the mean, standard deviation, and range for each estimate. Statistically significant differences between the preoperative and postoperative assessments were evaluated with paired-samples Student's *t* tests; statistical significance was defined at the 5% ($p \leq .05$) level.

Results

Our review identified 180 patients, including 159 females (88%) and 21 males (12%), in whom 217 feet, including 108 left (49.8%) and 109 right (50.2%) feet, underwent the modified Bösch procedure (Figs. 7 and 8). Thirty-seven patients (20.6%) underwent bilateral bunion surgery: 28 patients (15.6%) underwent simultaneous procedures, and 9 (0.05%) underwent nonsimultaneous bilateral procedures. The mean age of the patients was 49 ± 4.7 years (range 17 to 81), the mean body mass index was 26.6 ± 4.8 kg/m² (range 17.5 to 40.5), and the mean duration of follow-up was 9.3 ± 6.1 months (range 1 to 48).

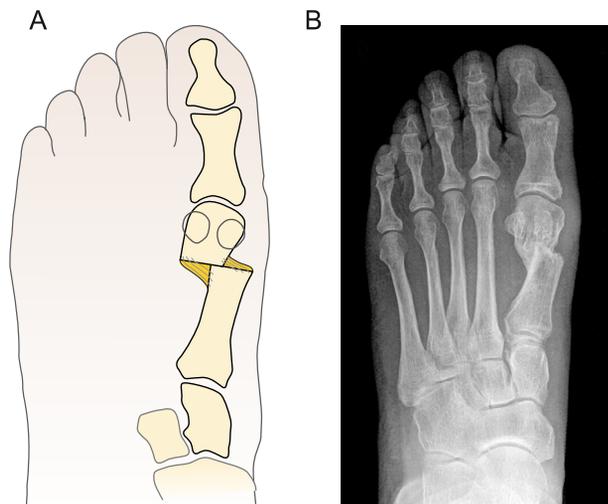


Fig. 6. Illustration (A) and radiograph (B) show bone after consolidation is achieved. Used with permission, Rubin Institute for Advanced Orthopedics, Sinai Hospital of Baltimore.

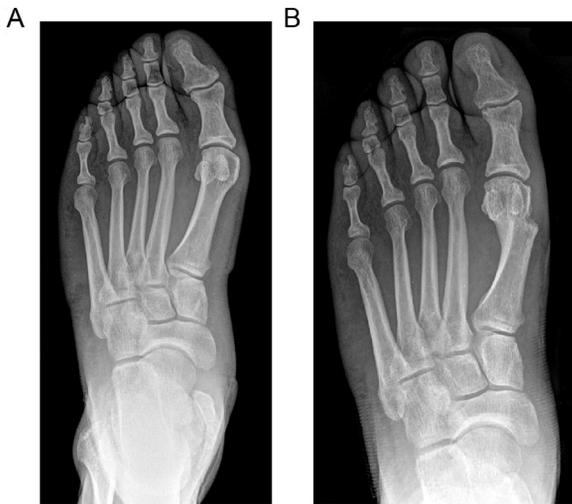


Fig. 7. (A) Preoperative radiograph shows mild hallux valgus. (B) Postoperative radiograph obtained at 2.5-year follow-up. Reduction has been maintained. Note the remodeling of the medial shelf. Used with permission, Rubin Institute for Advanced Orthopedics, Sinai Hospital of Baltimore.

A statistically significant reduction was noted in all measured radiographic values, specifically the first IMA, HAA, and TSP (Table 1). The mean IMA changed from $14.6^\circ \pm 3.5^\circ$ preoperatively to $4.7^\circ \pm 2.8^\circ$

postoperatively ($p < .0001$); the HAA changed from $30.7^\circ \pm 7.8^\circ$ preoperatively to $8.4^\circ \pm 6.1^\circ$ postoperatively ($p < .0001$); and the TSP changed from 5.4 ± 1.4 preoperatively to 2.0 ± 1.0 postoperatively ($p < .0001$). All of the metatarsals displayed radiographic union within the observation period.

Sixty-eight complications were observed in 59 feet (27.2%) of 55 patients (30.6%) (Tables 2 and 3). The most common complication was superficial pin-site infection, which was seen in 42 feet (19.4%) in the 39 patients (21.7%), and each of these resolved after treatment with broad-spectrum oral antibiotics (e.g., 500 mg cephalexin taken orally 4 times per day for a period of 10 days). Nerve-related numbness was observed in 8 feet (3.7%) in 8 patients (4.4%). Bunion recurrence was observed in 5 feet (2.3%) in 5 patients (2.8%). Four (2.2%) of the 5 feet underwent bunion revision surgery (i.e., the percutaneous procedure was performed a second time) and resolved. The 1 remaining foot (20%) had not undergone revision at the time of the most recent follow-up. Hardware failure or revision of hardware (premature loosening and/or backing out) occurred in 6 feet (2.8%) in 6 patients (3.3%); only 1 (16.7%) of the 6 feet required a return to the operating room. Asymptomatic malunion (i.e., patients did not report discomfort, pain, or limitations to activity) was seen in 3 feet (1.4%) in 3 patients (1.7%). Delayed union of the capital fragment (3 feet, 1.4%; 3 patients, 1.7%) was observed and resolved. Transient sesamoiditis was reported in 1 (0.5% of feet; 0.6% of patients), and resolved without treatment.

Twenty-eight patients (56 feet) underwent simultaneous bilateral surgery. Six patients (8 of 56 feet, 14.3%) who underwent simultaneous



Fig. 8. (A) Photograph obtained before treatment shows hallux valgus deformity. This is the same patient that is shown in Figs. 1–6. (B, C) Photographs obtained 6 months after surgery. The hyperpigmented skin on the lateral view photograph denotes the site of the incision. (D) Excellent range of motion was maintained at the first metatarsophalangeal joint. Used with permission, Rubin Institute for Advanced Orthopedics, Sinai Hospital of Baltimore.

Table 1
Comparison of preoperative and postoperative radiographic measurements for the modified Bösch procedure (N = 217 feet, 180 patients)

Measurement	Preoperative	Postoperative	p Value
Intermetatarsal angle (°)	14.6 ± 3.5	4.7 ± 2.8	<.0001*
Hallux abductus angle (°)	30.7 ± 7.8	8.4 ± 6.1	<.0001*
Tibial sesamoid position	5.4 ± 1.4	2.0 ± 1.0	<.0001*

Data are mean ± standard deviation.

* Significant at $p < .05$.

Table 2
Sixty-eight complications were observed in 59 feet (27.2%); 55 patients (30.6%)

Complication	Feet (N = 217)	Patients (N = 180)
Pin-site infection	42 (19.4)	39 (21.7)
Nerve-related complaints (numbness)	8 (3.7)	8 (4.4)
Hardware failure or hardware revision	6 (2.8)	6 (3.3)
Bunion recurrence	5 (2.3)	5 (2.8)
Asymptomatic malunion	3 (1.4)	3 (1.7)
Delayed union	3 (1.4)	3 (1.7)
Sesamoiditis	1 (0.5)	1 (0.6)

Data are n (%).

Table 3
Complications grouped according to how many feet/patients experienced 0, 1, 2, or 3 or more

No. of Complications	Feet (N = 217)	Patients (N = 180)
0	158	125
1	52	50
2	4	3
≥3	3	2

Data are n.

bilateral surgery experienced pin-site infections. Two of the 6 patients experienced bilateral pin-site infections, and 4 patients had unilateral pin-site infections. One of the 9 patients who underwent nonsimultaneous bilateral surgery experienced bilateral pin-site infections. No other complications were observed in the bilateral surgery groups.

Discussion

Distal metatarsal osteotomies have been used for bunion correction in mild to moderate deformities, with or without soft tissue release and capsular tightening (16,21,22,24,29,46–49). Classically, moderate deformity is treated with a more proximal osteotomy along with distal soft tissue procedures. In our study, 217 feet with mild to moderate deformities underwent percutaneous distal osteotomy to achieve deformity correction, union, and improvement in radiographic parameters. The bunionectomy was performed in 217 feet, and statistically significant reductions were observed in the first IMA, HAA, and TSP. The case series contained data from 4 North American surgeons who reported similar outcomes, despite surgeon variability in training and the surgeons' training biases toward more open techniques with internal fixation.

The most common complication was development of a superficial pin tract infection (42 feet, 19.4%) (Table 2). The superficial pin-site infection rate was lower than that described by other surgeons (50–52) when correcting bunion deformity using percutaneous methods or external fixation. None of the patients developed significant bony infection, and all soft tissue infections resolved with orally administered antibiotics.

Avascular necrosis and stress fracture have been reported after traditional bunion correction (53–58), but the authors were unable to find

reports of these complications after bunion correction using percutaneous or minimally invasive methods. Of the 217 feet in the study, 72.8% (158 feet) did not experience any form of observed complication. Based on our experience with this modified Bösch method, we believe that adherence to the techniques, principles, and postoperative follow-up is critical to avoiding complications with this form of bunionectomy.

Malunion and nonunion are a concern when performing a transverse osteotomy of the first ray (59,60). However, we did not observe any nonunions, although 3 malunions (1.4%) in 3 patients (1.7%) were observed. The malunions that we did observe were not clinically significant, in that none of the patients complained of discomfort or limitations of activity. In this regard, and again based on our experience with the modified Bösch procedure, we believe that it is critical to maintain appropriate dorsal and plantar translation relationships when the osteotomy is performed. Placement of the Steinmann pin is critical in this step, because dorsally based pins would promote plantar placement or translation of the capital fragment, whereas plantar-based pins would promote the opposite. Besides placement of the pin, it is important for the surgeon to place the capital fragment in the correct position before advancing the Steinmann pin into the medial cuneiform. This maneuver ensures that the correction will be maintained during the recovery period.

The amount of translation of the capital fragment in association with a distal metaphyseal osteotomy varies in the literature. Magnan et al (15) observed lateral displacement at the time of surgery to be 52% and only 30% at final follow-up. They did not have any cases of nonunion. Giannini et al. (61) aimed for at least 30% contact of the metatarsal and did not observe nonunion in their series of patients. Bösch et al. (36) reported >75% lateral displacement, but the incidence of nonunion was not clearly described in their report. In the present study, all 217 metatarsals achieved union despite the authors' attempting translation of the capital fragment up to 90% of the metaphyseal-diaphyseal metatarsal shaft width to achieve complete reduction of the sesamoid bones.

Bösch et al. (36) reported the results of 98 feet and found that radiographic measurements improved and that 81% of the patients were satisfied. Magnan et al (15) reviewed radiographic and satisfaction outcomes for 118 feet, reported improvement in all radiographic parameters, and observed that 91% of the patients were satisfied with the results (15). Giannini et al. (61) reported a procedure that they called a simple, effective, rapid, and inexpensive method that showed significant improvements in American Orthopaedic Foot & Ankle Society scores and radiographic measurements in 54 feet.

Kadokia et al. (50) reported poor outcomes with a modified distal transverse osteotomy similar to that described by Magnan et al. (15) in 13 patients, and their study was abandoned because of the observation of many complications. However, a review of the technique and methods they used revealed that numerous deviations were made to the tenets and principles proposed by Bösch et al. (37) and Magnan et al. (15). The senior author (N.A.S.) of the present study believes that the deviations from the percutaneous and minimal incision technique principles espoused by Bösch et al. (37) and Magnan et al. (15), could have led to the suboptimal results observed by Kadokia et al. (50) and, as such, considers that study to be a poor comparison relative to the technique described in the current report.

Stability of the medullary Steinmann pin is a source of concern for surgeons. The authors postulate that placement of the pin into the medial cuneiform along with adduction of the hallux splints the capital fragment against the medullary pin. By not performing any lateral capsular or tendon-balancing procedures, there is an increase in the soft tissue tension on those structures, which provides further stability to the capital fragment. Removal of the pin releases the tension at the first MTPJ, and the hallux is allowed to naturally glide back into its resting position (37). Although theoretical, the authors believe that this hypothesis explains why this method provides stability to an osteotomy that might not be inherently stable.

One limitation of this study is that the mean follow-up was 9.3 ± 6.1 months (range 1 to 48). Given that this technique is unique and challenges the conventional distal procedure that is associated with the ability to correct mild and moderate bunions, we believed that it was important to present short-term results. Moreover, the outcomes of interest were radiographic changes, which we believed had to at least be reported by the time that the osteotomy had healed. Of course, we understand that longer-term follow-up is required for us to better understand the effectiveness of the modified Bösch procedure, but some patients elected not to schedule follow-up visits despite being advised to do so. Yet another limitation is the fact that the surgeons collected, measured, and reported the study results, which could impart bias. Also, the method of correction was not precisely uniform and varied slightly at all 4 institutions based on individual surgeon preferences. However, all of the surgeon-authors followed the basic principles of ensuring minimal soft tissue dissection/stripping, performing the osteotomy at the metatarsal neck (distal metaphysis-diaphysis), translating the capital fragment up to 90%, stabilizing the fragment with a medullary Steinmann pin, avoiding periarticular soft tissue manipulations, and providing immediate weightbearing in a protected postoperative shoe for 4 weeks. Another limitation is that clinical outcomes with regard to patient-reported subjective outcomes, as well as joint ROM, were not presented. The authors focused primarily on radiographic measures to be able to compare preoperative to postoperative alignments. The association of risk factors with complications was not assessed, and no confounding or sensitivity analyses were undertaken with this cohort.

In the past, minimally invasive surgery for bunion correction has been looked upon negatively by many surgeons. This may be a result of training bias toward open surgery based on the perceived poor historical outcomes of the minimally invasive methods of the 1970s and 1980s. Kadakia et al. (50) blamed minimally invasive bunion techniques for high complication rates and poor outcomes. However, the authors contend that deviating from the proper technique caused these problems. It appears that poor outcomes after percutaneous or minimal incision techniques of bunions may be related to poor application of the principles of minimally invasive techniques.

In conclusion, although the modified Bösch procedure described in this report has been labeled as minimally invasive surgery, the authors believe that a more appropriate term for this type of procedure is precision incision surgery, because the incision and osteotomy are made at a precise anatomic location. This article is, to our knowledge, the first description of a North American multicenter cohort that focused on radiographic outcomes after this modified Bösch procedure. Our general understanding of the current literature leads us to believe that a comparison to prior published reports shows similar outcomes, despite the well-understood shortcomings of such biased comparisons. The percutaneous approach described in this report appears to be effective for hallux valgus correction, can be performed bilaterally, and allows for postoperative full weightbearing. It can also be combined with other common bony and soft tissue procedures, if the surgeon desires to do so. Our radiographic results show that this method of correction can be considered a viable alternative for correcting mild to moderate bunion deformities. Future studies should be conducted that examine long-term radiographic outcomes as well as patient satisfaction and compare this technique to other traditional surgical methods for the treatment of hallux valgus deformity.

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Supplementary Materials

Supplementary material associated with this article can be found in the online version at www.jfas.org doi:10.1053/j.jfas.2019.04.012.

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