

< Evolving Techniques >

Modified Minimal Incision Subcapital Osteotomy for Hallux Valgus Correction

Andrea Scala, MD, and
Domenico Vendettuoli, MD

Abstract: *The potential advantages of minimal incision surgery for hallux valgus (HV) correction are the following: reduced surgical exposure, diminished soft-tissue stripping, and less blood supply impairment. These advantages imply fewer complications. We retrospectively reviewed patients who were consecutively treated with a modified minimally invasive osteotomy from January 2006 until December 2009 for HV deformity. We radiographically assessed the HV angle, 1-2 intermetatarsal (IM) angle, and tibial sesamoid position. Clinical outcomes were determined using the American Orthopaedic Foot and Ankle Society Hallux Metatarsophalangeal Interphalangeal (AOFAS HMI) Clinical Rating Scale. A paired Student's t test was used to determine significance, with $P < .01$. There were 126 patients (146 feet) with an average age of 52.6 years and an average postoperative follow-up of 29.1 months. Preoperatively, the average HV angle was 32.3° , and postoperatively, it was 4.5° ($P < .01$). The preoperative average IM angle was 14.4° , whereas postoperatively, it was 4.8° ($P < .01$). The average tibial sesamoid position was 6.3 postoperatively and 2.5 postoperatively ($P < .01$). The average AOFAS HMI score was 54.6 preoperatively and*

85.3 postoperatively ($P < .01$). There were 15 postoperative complications (10.3%) that included hallux varus, painful hardware, and delayed union. The results are comparable with those of traditional open techniques, with the additional advantages of a minimally invasive procedure.

Level of Evidence: *Therapeutic, Level IV: Retrospective case series*

Keywords: hallux valgus; minimal incision; percutaneous metatarsal osteotomy; minimally invasive; foot surgery

Introduction

Hallux valgus (HV) is a common foot deformity of the first metatarsophalangeal (MTP) joint (Figure 1).^{1,2} Although there are more than 130 operative procedures to address this deformity,³ there is a current trend toward minimally invasive techniques.⁴⁻⁶ The potential advantages of minimal incision surgery are the reduction in operating time, minimal surgical exposure, fewer complications, and early weight bearing.^{4,5,7,8}

The Bosch osteotomy⁵ is a single-tract, subcapital osteotomy of the first metatarsal bone for the correction of HV deformity (Figure 2). Some authors have^{4,5,7,9} published their case series of this subcapital linear osteotomy and reported effective correction of the HV deformity. However, Kadakia et al¹⁰ found a high rate of complications that included osteonecrosis, nonunion, malunion, and recur-

“ The potential advantages of minimal incision surgery are the reduction in operating time, minimal surgical exposure, fewer complications, and early weight bearing.”

rence (Figure 3). Huang et al⁶ found a lower rate of complications but insisted that the operative procedure be limited to deformities with less than 30° of HV angle.

Having reviewed the literature, the lead author modified the traditional minimally invasive procedure for HV repair^{5,7,11} (Figure 4). The rationale behind the modification of the Bosch osteotomy was to

DOI: 10.1177/1938640012470716. From The Clinic (AS) and “ARS Medica” Clinic (DV), Rome, Italy. Address correspondence to Andrea Scala, The Clinic, 29, Via Cesare Ferrero Di Cambiano, Rome 0091, Italy; e-mail: dott.andreascala@alice.it.

For reprints and permissions queries, please visit SAGE's Web site at <http://www.sagepub.com/journalsPermissions.nav>.

Copyright © 2012 The Author(s)

Figure 1.

The Drawing Shows the Typical Appearance of the Hallux Valgus Deformity.

**Figure 2.**

The Drawing Shows the Bosch Procedure and the Percutaneous Fixation Technique.



achieve a simple but stable fixation of the first metatarsal osteotomy, to avoid hallux immobilization, and to preserve the range of motion of the operated MTP joint.

Figure 3.

The Postoperative X Rays Show a Poor Outcome of a Bosch Procedure: The Arthritic Changes and the Recurrent Hallux Valgus Are Apparent.

**Figure 4.**

The Drawing Shows the Modification of the Procedure. After the Osteotomy the First Metatarsal (MT) Head Is Laterally Displaced and Replaced on the Sesamoid Bones. The k-Wire, Used for Fixation, Is Angled and Oriented Toward the First MT Head. The Hallux Is Not Immobilized.



Because of these modifications, physical rehabilitation was performed on the same day of operation, and immediate weight bearing in protective shoes was allowed. The indications for the operative procedure were consistent with those of Magnan et al.⁴

Patients and Methods

We retrospectively looked at 126 patients (146 feet) consecutively treated from January 2006 until December 2009 for HV deformity. All patients were treated operatively with a modified minimal-incision subcapital osteotomy and followed postoperatively at least 12 months or more. All patients were treated, assessed, and followed by 1 surgeon. Of these patients, 20 had concurrent bilateral surgeries. Nonoperative care, that included modification of footwear and use of insoles and nonsteroidal anti-inflammatory drugs had previously failed after 6 or more months of treatment for all patients.

Clinical outcomes were determined comparing preoperative and postoperative results for the American Orthopaedic Foot and Ankle Society Hallux Metatarsophalangeal Interphalangeal (AOFAS HMI) Clinical Rating Scale.¹² A 12-item health-related survey (SF-12 [Short Form-12])¹³ was given to patients at final follow-up. Patient satisfaction was also recorded at final follow-up.

Radiographic Evaluation

Radiographs were routinely taken preoperatively and 1 month, 3 months, and 1 year postoperatively. Standard weight-bearing anterior-posterior, lateral, and oblique radiographic views were taken of the operative foot. We assessed the HV,¹⁴ 1-2 intermetatarsal (IM) angle,¹⁴ tibial sesamoid position,¹⁵ and consolidation of the osteotomy. We used the center of the articular surface of the metatarsal head and the proximal articulation as reference points to draw the first metatarsal axis. All measurements were done by the lead author to decrease potential bias. We considered inadequate reduction of the tibial sesamoid position as a risk factor for recurrence.¹⁶ Radiographic nonunion and malunion were recorded. All patients

Figure 5.

A 6-mm Longitudinal Skin Incision Is Made Directly Over the Medial Metatarsophalangeal Joint.

**Figure 6.**

The Picture Shows the First Metatarsal Medial Eminence Excision.



were available for follow-up radiographic review, and follow-up HV and IM angles and tibial sesamoid position were recorded. Recurrence was defined as a radiographic result of a HV angle of 20° or greater at final follow-up.⁶

Surgical Procedure

A 6-mm longitudinal skin incision was made directly over the medial MTP joint (Figure 5). Subcutaneous tissues were dissected with small tenotomy scissors, and the inflamed bursa was removed if necessary. With gentle retraction, the capsule over the medial aspect of the first metatarsal bone was exposed, undermining the skin incision. The capsule was incised and the sagittal groove of first metatarsal head found. The medial eminence excision began from the lateral edge of the sagittal groove and ended at the neck of the first metatarsal. A microsagittal saw or a burr was used (Figure 6). The medial

Figure 7.

The Picture Shows the First Metatarsal Neck Osteotomy, Perpendicular to the Long Axis of the Metatarsal Bone.



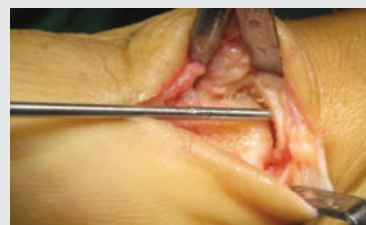
eminence was removed and the cancellous bone of the first metatarsal head exposed. The periosteum from the neck of the first metatarsal was detached. The osteotomy of the first metatarsal neck began on the cortical aspect of the first metatarsal, 3 mm proximal to the cancellous bone previously exposed by the resection of the medial eminence. This 3-mm cortical bony bridge is of crucial importance and must always be preserved. The plantar vascular bundle of the first metatarsal head was spared because the osteotomy was placed proximal to it (Figure 7).

An image intensifier was used to check the appropriate location for the osteotomy. A microsagittal saw was used to perform the osteotomy of the first metatarsal neck perpendicular to the long axis of the metatarsal. A burr may also be used, but bone loss should be considered. As the osteotomy is completed, the first metatarsal head is mobile and can be displaced laterally. Also, a small hook medially retracted the first metatarsal shaft. Under the image intensifier, the IM and HV angles were dramatically reduced. The first metatarsal head was easily reduced on the sesamoid bones, and whether the amount of reduction was adequate was checked visually through the capsular breach and by means of the fluoroscopic imager. Because the osteotomy was not within the cancellous bone of the first metatarsal head, any undue shortening was avoided.

Once we achieved adequate alignment and cortical contact was obtained at the

Figure 8.

The Picture Shows the 1.8-mm k-Wire Introduced Into the Proximal Metatarsal Shaft, Through the Capsular Breach and the Osteotomy Site.



osteotomy site, a 1.8-mm k-wire was introduced into the proximal metatarsal shaft from distal to proximal, through the capsular breach and the osteotomy site (Figure 8). While being inserted, the k-wire was carefully aligned along the long axis of the metatarsal shaft, following the dorsoplantar midline on the sagittal plane.

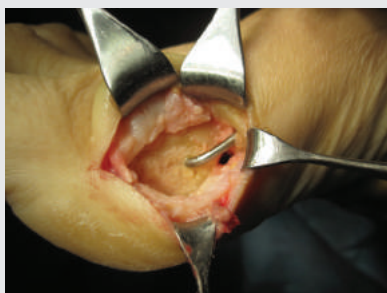
The k-wire is advanced into the medial cuneiform to achieve more stability. An image intensifier is used to assess the position of the k-wire. Proximally, the k-wire is bent to a 90° angle at the level of the first metatarsal head center. The k-wire is then cut, leaving a very short arm 2 to 3 mm in length. The short arm of the angled k-wire is turned laterally and put in contact with the cancellous bone surface of the center of the first metatarsal head. The tip of the angled k-wire is thrust in the cancellous bone. In this way, the motion of the metatarsal head is restricted and the osteotomy fixed (Figure 9).

The collar of the cortical bone around the first metatarsal head ensures the stability of the k-wire fixation and prevents secondary displacements. The tip of the angled k-wire must be situated above the cortical bone bridge between the osteotomy of the metatarsal neck and the cancellous bone of the metatarsal head (Figure 10).

The first MTP joint capsular incision is repaired using a resorbable 2.0 woven suture. The capsular repair separates the first metatarsal head and the angled k-wire from the overlying skin. Two stitches are normally sufficient because of

Figure 9.

The Picture Shows the k-Wire Turned Toward the First Metatarsal Head to Stabilize the Subcapital Osteotomy After Correction.

**Figure 10.**

The X Ray Shows the k-Wire Used to Stabilize the Osteotomy. It Is To Be Noted That the Amount of Lateral Displacement of the First Metatarsal Head Depends on the Repositioning of the Head Over the Sesamoid Bones.



the minimal exposure. The suture is performed in a "double-breasted" fashion. While suturing the capsule, the suture passes near the tibial sesamoid, thus

Figure 11.

The Picture Shows the 15-Blade Incision to Approach the Lateral Aspect of the First Metatarsophalangeal Joint.



ensuring a supplementary stabilization of the first MTP joint.

First MTP Joint Lateral Release (Percutaneous Technique)

When the osteotomy is fixed, the proper correction of the varus deformity of the first metatarsal is checked by the image intensifier (IM angle must be reduced). The alignment of the hallux is then evaluated. Because there is no percutaneous k-wire through it, the hallux is free to move.

If the hallux is deviated in the valgus because of the retraction of the lateral aspect of the first MTP capsule and the tension of the abductor hallucis conjoined tendon, the release of the lateral aspect of the first MTP joint is performed.

A punctiform incision is placed between the hallux and the second toe. By means of a 15 blade, the phalangeal head of the abductor hallucis tendon is gently severed. The existing adhesences between the lateral sesamoid bone and the plantar side of the lateral capsule are also released. As the tension of these structures is decreased, the alignment of the hallux appears to be improve, as also the range of motion (Figures 11 and 12).

Figure 12.

The X Ray Shows the 15-Blade While Severing the Lateral Aspect of the First Metatarsophalangeal Joint and the Abductor Hallucis Tendon.



Akin Osteotomy

As the first metatarsal subcapital osteotomy is fixed and the percutaneous lateral release is performed, the HV angle is evaluated. We used the Akin osteotomy of the first phalanx of the hallux to reduce the HV angle, when increased.

In the present series, we performed the Akin osteotomy in 129 (88.35%) out of the 146 procedures performed totally. In the first 48 cases, a small skin incision was used to fix the osteotomy with a 8-mm square angle staple. The subsequent consecutive 81 cases underwent a percutaneous osteotomy without hardware fixation. Through a 15-blade stab incision, a Shannon 44 burr (short or long) was put in contact with the medial cortex of the first phalanx of the hallux. The osteotomy was performed while viewing through the image intensifier (Figures 13 and 14; a 3.1 (or 4.1) wedge burr X-Mas tree was used in a few cases to enlarge the base of the Akin osteotomy when a larger Distal Articular Set Angle (D.A.S.A.) angle is involved.

Figure 13.

The X Ray Shows the Position of the Burr While Performing the Percutaneous Akin Osteotomy.

**Figure 14.**

The X Ray Shows the Correct Alignment of the Hallux After the Akin Osteotomy Was Performed.

**Figure 15.**

The Postoperative Bandage: The Hallux Is Not Immobilized.

**Figure 16.**

The Picture Shows a Case of Hallux Valgus Before the Operation.



Postoperative Protocol

Postoperatively, the hallux is bandaged but is not splinted in previous varus-like descriptions.^{7,11} The hallux remains free to move, and the range of motion is not restricted (Figure 15). The patient is allowed to bear weight immediately after the operation in a surgical shoe and is advised to walk several times during the day (Figure 16).

Limb elevation on the operated foot is advisable. After prolonged walking,

rest with the limb elevated as well as ice application are recommended. The postoperative bandage is removed 1 week after the operation, and a contrast bath (cold water 1 minute, warm water 30 s) is prescribed. The edema and swelling decrease, and patients are able to wear comfortable shoes and sneakers. Driving the car is generally possible 2 weeks after the operation. After a month, patients usually wear regular shoes.

Statistical Analysis

A paired Student *t* test was used to determine the significance between preoperative and postoperative measurements, with $P < .01$. A χ^2 test was used to compare the complication rates of this study with those of previous studies of minimally invasive osteotomies for hallux valgus deformity.^{4,6,10}

Results

The average age of the patients was 52.6 years (range = 16-87 years). There were 115 women and 11 men, and the average follow-up was 29.1 months (range = 12-54 months). Preoperatively, the average HV angle was measured as 32.3° (range = 12°-52°; standard deviation

Table 1.

Preoperative and Postoperative Parameters

	Preoperative	Postoperative	P Value
IM angle	14.4°	4.8°	<.01
HV angle	32.3°	4.5°	<.01
Tibial sesamoid	6.3	2.5	<.01
AOFAS HMI score	54.6	85.3	<.01
SF-12 PCS		47.1	
SF-12 MCS		56.1	

Abbreviations: IM, intermetatarsal; HV, hallux valgus; AOFAS HMI, American Orthopaedic Foot and Ankle Society Hallux Metatarsophalangeal Interphalangeal Scale; SF-12, Short Form-12; PCS = physical component score; MCS = mental component score

[SD] = 7.6°; 95% confidence interval [CI] = 31.1°-33.5°), and postoperatively, it was 4.5° (range = 20° to -4°; SD = 5.0°; 95% CI = 3.7°-5.3°). This was found to be significant ($P < .01$; Table 1). The preoperative average 1-2 IM angle was 14.4° (range = 9°-22°, SD = 3.5°, 95% CI = 13.8°-15.0°), whereas postoperatively, it was 4.8° (range = 0°-16°; SD = 3.4°; 95% CI = 4.2°-5.4°). This was found to be significant ($P < .01$). The average tibial sesamoid position (from 1 to 7) preoperatively was determined to be 6.3 (SD = 1.4; 95% CI = 6.1-6.5). Postoperatively, the average tibial sesamoid position was 2.5 (SD = 1.9; 95% CI = 2.2-2.8). This radiographic measurement was also found to be significantly different ($P < .01$).

The average AOFAS HMI score (out of 100) was 54.6 (range = 12-77; SD = 9.6; 95% CI = 53-56.2) preoperatively, and postoperatively, it was found to be 85.3 (range = 23-100; SD = 18.4; 95% CI = 82.3-88.3). This was found to be significant ($P < .01$). The postoperative physical component score for the SF-12 averaged 47.1 (SD = 11.3; 95% CI = 45.2-49.0), whereas the mental component score was 56.1 (SD = 10.3; 95% CI = 54.4-57.8).

There were 15 postoperative complications during the follow-up period, comparable to previous studies with similar complications^{4,6,10} (Table 2). Six feet (4.2%) had developed an

asymptomatic varus deformity, and the patients did not elect to undergo further treatment. Four patients (2.8%) complained of painful hardware, and all 4 had their k-wires removed. Two feet had a delayed union (1.4%) but eventually healed after an extended period of non-weight bearing of 3 months. Two feet presented with broken hardware without malunion (1.4%) but did not have their hardware removed. One foot developed a skin infection that resolved after treatment with local wound care (0.7%). There were no cases of recurrence.

Discussion

Early studies of minimally invasive transverse osteotomy for HV deformity have demonstrated good clinical results.^{4,5,7} They established the benefits of this minimally invasive technique, including smaller incision, decreased operative time, and lower morbidity rates. However, other studies have demonstrated higher morbidity rates,^{6,10} and 1 study had to stop using the technique altogether because of the higher than expected complication rate.¹⁰

Magnan et al⁴ reported average postoperative AOFAS HMI clinical outcome scores of 88.2, with significant radiographic changes. Although they

reported few complications, they noted that 8 feet (6.8%) of 7 patients (6.5%) had less than 30° of first MTP joint total range of motion, and 3 (2.5%) developed recurrence of their HV deformity. Magnan et al⁴ stated that the lack of soft-tissue surgery does not affect the recurrence of HV deformity; Huang et al⁶ reported recurrence rates of 6.7% (6 of 89) in feet that had mild HV preoperatively and 63.9% (23 of 36) in feet that had moderate HV preoperatively. Moreover, Kadakia et al¹⁰ reported recurrence of HV deformity in 5 of 13 patients (38%).

Maffulli et al⁸ performed a systematic review on minimally invasive procedures for HV repair. The authors found that most data are of case series and lower evidence studies, lacking definitive conclusions on the use of these techniques for routine management of patients with HV. The authors could not determine clear recommendations regarding the systematic use of minimally invasive surgery for HV correction, even though preliminary results are encouraging. Studies with higher levels of evidence, concentrating on large, adequately powered randomized trials, should be conducted to help answer these questions.

In our series, our modified technique with an internal k-wire had a recurrence rate of 0% and a significantly lower complication rate compared with those of previous studies.^{4,6,10} Although we did not experience any recurrence in HV deformity, we encountered 6 out of 146 cases (4.2%) of hallux varus deformity postoperatively, and this has not been previously reported, to our knowledge, when using minimally invasive techniques. We believe that our adoption of the splinting technique by Magnan et al⁴ may have been overaggressive and have since modified it to better suit our technique.

The peculiar feature of the original Bosch subcapital osteotomies is the restriction of first MTP joint range of motion for 4 weeks or more as the hallux is splinted in varus.⁵ Prolonged immobilization of articular surfaces causes cartilage damage as a result of

Table 2.

Complications

	Current Study, n (%)	Huang et al, ⁶ n (%): χ^2 P Value	Kadakia et al, ¹⁰ n (%): χ^2 P Value	Magnan et al, ⁴ n (%): χ^2 P Value
Total	15 (10.4)	42 (33.6): $P < .001$	21 (>100): N/A	15 (12.7): $P = .45$
Varus	6 (4.2)			
Painful hardware	4 (2.8)	1 (0.8): $P = .010$	4 (31): $P < .001$	2 (1.7): $P = .30$
Delayed/Nonunion	2 (1.4)		1 (8): $P = .004$	
Broken hardware	2 (1.4)			
Infection	1 (0.7)	11 (8.8): $P < .001$	1 (8): $P = .001$	2 (1.7): $P = .36$
Malunion	0 (0)	1 (0.8)	9 (63)	3 (2.5)
Recurrence	0 (0)	29 (23.2)	5 (38)	1 (0.8)
Stiffness (<30° ROM)	0 (0)			8 (6.8)
Osteonecrosis	0 (0)		1 (8)	

Abbreviation: ROM, range of motion.

Figure 17.

The Picture Shows the Appearance of the Same Patient After the Surgical Treatment.



the altered metabolism of cartilaginous tissue.⁵ The modified osteotomy allows early mobilization and resumption of joint range of motion that is optimal after articular repair or realignment procedures.

This study showed that our modified, minimal-incision subcapital

Figure 18.

Preoperative 15° Dorsoplantar X Ray of the Forefoot.



osteotomy enables the surgeon to achieve good correction of a mild to moderate HV deformity. Each postoperative outcome measurement showed a significant positive change compared with the preoperative status. Our results reflect positive clinical outcomes as found in other studies,^{4,5,8,17} except that our

Figure 19.

Routine 1-Month Postoperative 15° Dorsoplantar, Weight-Bearing X Ray of the Forefoot of the Same Patient.



patients did not experience stiffness or recurrence (Figures 16-23).

Conclusions

The suggested modification has been shown to be reliable and predictable in treating mild-to-moderate HV deformity. The following features should be outlined:

Figure 20.

Routine 3-Year Postoperative 15° Dorsoplantar, Weight-Bearing X Ray of the Forefoot of the Same Patient: The Osteotomy Consolidated Perfectly. The Newly Formed Bone Is Evident on the Lateral Aspect of the First Metatarsal Diaphysis.

**Figure 21.**

X Ray Showing a Preoperative Lateral Weight-Bearing View.



Dramatic correction of IM and HV angles

Immediate normal range of motion of the hallux

Good stability of the correction, maintained over time

Immediate postoperative weight bearing

Absence of recurrence

Absence of first MTP articular remodeling

Absence of postoperative hallux rigidus and joint stiffness

Figure 22.

The Lateral Weight-Bearing X-Ray View, Taken After 3 Years From the Operation Shows That the Alignment of the First Metatarsal Head Is Maintained.

**Figure 23.**

An X Ray of the Weight-Bearing Lateral View Was Taken While the Patient Wore a High-Heeled Shoe. The Range of Motion of the Operated First Metatarsophalangeal Joint Appears to Be Normal, 3 Years After the Operation.



The outcomes were similar to those of traditional open techniques,¹⁸ with the additional advantages of a minimally invasive procedure.⁸ However, studies providing higher levels of evidence, concentrating on large, adequately powered randomized trials, should be conducted to further determine the usefulness of this procedure. **FAS**

References

- Coughlin MJ, Jones CP. Hallux valgus: demographics, etiology, and radiographic assessment. *Foot Ankle Int.* 2007;28:759-777.
- Mann RA, Coughlin MJ. Hallux valgus: etiology, anatomy, treatment and surgical considerations. *Clin Orthop Relat Res.* 1981;157:31-41.
- G. B. Pfeffer. Hallux Valgus Correction with Modified Chevron Osteotomy G.B. Pfeffer, M.E. Easley, C. Frey, B. Hintermann, A. K. Sands eds. *Foot and Ankle Surgery Operative Techniques* Section 1, Procedure 1, pp. 3-20. Philadelphia PA: Saunders Elsevier, 2010
- Magnan B, Pezze L, Rossi N, et al. Percutaneous distal metatarsal osteotomy for correction of hallux valgus. *J Bone Joint Surg Am.* 2005;87:1191-1199.
- Bosch P, Wanke S, Legenstein R. Hallux valgus correction by the method of Bosch: a new technique with a seven-to-ten-year follow-up. *Foot Ankle Clin.* 2000;5:485-498, v-vi.
- Huang P-J, Lin Y-C, Fu Y-C, et al. Radiographic evaluation of minimally invasive distal metatarsal osteotomy for hallux valgus. *Foot Ankle Int.* 2011;32:503-507.
- Giannini S, Ceccarelli F, Bevoni R, et al. Hallux valgus surgery: the minimally invasive bunion correction (SERI). *Tech Foot Ankle Surg.* 2003;2:11-20.
- Maffulli N, Longo UG, Marinozzi A, et al. Hallux valgus: effectiveness and safety of minimally invasive surgery: a systematic review. *Br Med Bull.* 2011;97:149-167.
- Kramer J. Die Kramer-Osteotomie zur behandlung des hallux valgus und des digitusquintus varus. *Operat Orthop Traumatol.* 1990;2:29-38.
- Kadakia A, Smerek J, Myerson M. Radiographic results after percutaneous distal metatarsal osteotomy for correction of hallux valgus deformity. *Foot Ankle Int.* 2007;28:355-360.
- Magnan B, Bortolazzi R, Samaila E, et al. Percutaneous distal metatarsal osteotomy for correction of hallux valgus: surgical technique. *J Bone Joint Surg Am.* 2006;88(suppl 1, pt 1):135-148.
- Kitaoka HB, Alexander IJ, Adelaar RS, et al. Clinical rating systems for the ankle-hindfoot, midfoot, hallux, and lesser toes. *Foot Ankle Int.* 1994;15:349-353.
- Ware J Jr, Kosinski M, Keller SD. A 12-item Short-Form Health Survey: construction of scales and preliminary tests of reliability and validity. *Med Care.* 1996;34:220-233.
- Coughlin MJ. Hallux valgus. *J Bone Joint Surg Am.* 1996;78:932-966.
- Hardy RH, Clapham JC. Observations on hallux valgus; based on a controlled series. *J Bone Joint Surg Br.* 1951;33B:376-391.
- Okuda R, Kinoshita M, Yasuda T, et al. Postoperative incomplete reduction of the sesamoids as a risk factor for recurrence of hallux valgus. *J Bone Joint Surg Am.* 2009;91:1637-1645.
- Portaluri M. Hallux valgus correction by the method of Bosch: a clinical evaluation. *Foot Ankle Clin.* 2000;5:499-511, vi.
- Thordarson D, Ebramzadeh E, Moorthy M, et al. Correlation of hallux valgus surgical outcome with AOFAS forefoot score and radiological parameters. *Foot Ankle Int.* 2005;26:122-127.