Treatment of Hallux Valgus with Three-dimensional Modification of Mitchell's Osteotomy

Technique and Results

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Mitchell's osteotomy gives very good results but there are still some cases where the original method, as well as its modification, cannot address all aspects of deformity. We modified the original Mitchell's method to address pronation and plantar displacement of the first metatarsal. Modification includes formation of lateral and plantar spur with metatarsal displacement and derotation of distal metatarsal fragment in the frontal and horizontal planes with stable screw fixation. We present midterm results of the first 60 patients compared to the original Mitchell method (30 patients). Differences between the groups postoperatively were in declination angle, postoperative metatarsalgia rate, and first metatarsal pronation angle. The technique described eliminated many of the disadvantages of Mitchell's method. (J Am Podiatr Med Assoc 99(2): 162-172, 2009)

Numerous operative techniques have been described for the treatment of hallux valgus over the past years. Selection of the technique is based on various factors including type and particular components of hallux valgus, patient's age, patient's expectations, and surgeon's preference. Surgeons usually develop an algorithm for hallux valgus treatment that includes a variety of techniques.[1] The Mitchell osteotomy, with its modifications,[2-5] is one of the commonly used distal osteotomy techniques showing good long-term results.[6, 7] It is a double step-cut osteotomy through the first metatarsal neck with lateral displacement of the distal fragment. The technique has its inherent disadvantages, such as shortening of the first metatarsal, lateral metatarsalgia, insufficient correction, and instability.[3, 4, 8-10] We describe a modification of the technique that enables deformity correction in all three planes and addresses some of the problems in Mitchell's technique such as pronation and plantar displacement of the first metatarsal. Midterm results of the new three-dimensional (3-D) technique compared to the results of Mitchell's osteotomy, as well as operative techniques, are presented.

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Materials and Methods

Patients

Ninety consecutive feet (90 female patients) that had been operated on by the first author (I.L.) in the period between January 1, 1997 and January 1, 2002 were selected for this prospective randomized study. We included all patients who were willing to participate in the study and who signed a written consent form, those with painful mild-to-moderate hallux valgus without degenerative changes in the first metatarsophalangeal joint, and those who had an intermetatarsal angle of less than 20°. We excluded all patients with any kind of neurologic deficit, post-traumatic foot disorders, chronic arthritis, previous or contralateral hallux valgus surgery, and all male patients. In the period between 1997 and 1998, all patients underwent Mitchell's osteotomy. From 1999 to 2000, every third patient underwent Mitchell's osteotomy (Mitchell's group); from 2001 to 2002, all patients underwent our new method (3-D group). In Mitchell's group, there were 30 female patients with a median age of 46 years (range, 18–61 years) at the time of surgery and with a median follow-up time of 81 months (range, 48–109 years). In the 3-D group, there were 60 female patients with a median age of 51 years at the time of surgery (range, 18–65 years) and with a median follow-up time of 54 months (range, 40–74 years). Both groups were comparable in respect to pain, deformity duration, and family history, which was positive in 73% of cases in Mitchell's group and in 76% in the 3-D group (Table 1). Patients in the 3-D group were older ($z = -2.73$; $P = .006$) at the time of surgery.

Assessment

All patients were assessed using standardized methods of data collection according to the hallux valgus assessment.[5] Clinical evaluation was performed using the American Orthopaedic Foot and Ankle Society's Hallux Metatarsophalangeal-Interphalangeal Scale (HMIS) to compare preoperative and postoperative pain, range of motion in the first metatarsophalangeal joint, shoe-wear comfort, activity levels, callus, and alignment.[11] On a 100-point scale, a score between 90 and 100 was considered excellent; 80 to 89, good; 70 to 79, fair; and less than 70, poor. Dorsoplantar, lateral, and axial weightbearing radiographs were taken preoperatively, 8 weeks after surgery, and at the final follow-up. Measurements from radiographs included the hallux valgus angle (HVA), intermetatarsal angle (IMA), distal metatarsal articular angle (DMAA), relative lengths of first and second metatarsal, metatarsal declination angle, tibial sesamoid position, first metatarsophalangeal joint congruence, and first metatarsal pronation. The pressure distribution under the feet was recorded preoperatively and at the final follow-up time using dynamic pedobarography (Mini Emed system; Novel GmbH, Munich, Germany), and the pedobarographic patterns were determined as described by Grace et al.[12] Measurements were taken during walking by mat system. Three gait cycles were used for the analysis.

Table 1. Patient Demographic and Preoperative Data

Characteristic	Group: Mitchell	Group: 3-D
No. of patients	30	60
Age at time of surgery (y)	41.8 ± 12.8 46 (18 61)	49.6 ± 12.5 51 (18 65)
Follow-up (mo)	77.3 ± 18.7 81 (48 109)	55.8 ± 10.1 54 (40 74)
Duration of pain (y)	3.9 ± 4.5 2 (0.5 20)	6.1 ± 5.9 5 (0.5 30)
Duration of deformity (y)	16.1 ± 10.1 15 (2 35)	21.6 ± 10.9 20 (4 40)
Family history	15 (mother's line) 7 (father's line)	30 (mother's line) 16 (father's line)
Foot side	14 left/16 right	30 left/30 right
Foot type I	9 planus 2 cavus	14 planus 4 cavus
Foot type II	17 Egyptian[a] 9 Greek[b] 4 square[c]	37 Egyptian[a] 15 Greek[b] 8 square[c]

Note: Values are given as means ± standard deviation, followed by median (range).

[a]Egyptian foot refers to having a great toe that is longer than the second toe.

[b]Greek foot refers to having a great toe that is shorter than the second toe.

[c]Square foot refers to having a great toe that is the same length as the second toe.

Evaluation

A Wilcoxon signed-rank test was used to compare pre- and postoperative results within each group. Differences in distributions between the groups were tested for significance by the Mann-Whitney *U* test. The presence of metatarsalgia within each group, pre- and postoperatively was compared using the McNemar test of proportion.

Preoperative planning was performed according to the Saraffian method for all patients.[13]

Operative Technique

3-D Method

All patients were operated on in the supine position with spinal anesthesia and tourniquet. In both techniques, a 6-cm medial longitudinal skin incision is made over the first metatarsophalangeal joint. The skin is elevated, and a distally based Y-shaped incision is made through the joint capsule and the periosteum of the metatarsal shaft. The V-shaped flap is formed and distally attached to the proximal phalanx. The first metatarsal neck is subperiosteally exposed and exostosis is removed. In our 3-D method, a transverse line is marked at the junction of the metatarsal head and shaft at the dorsal aspect of the metaphysis after minimal exostosis resection (Fig. 1A). The de-

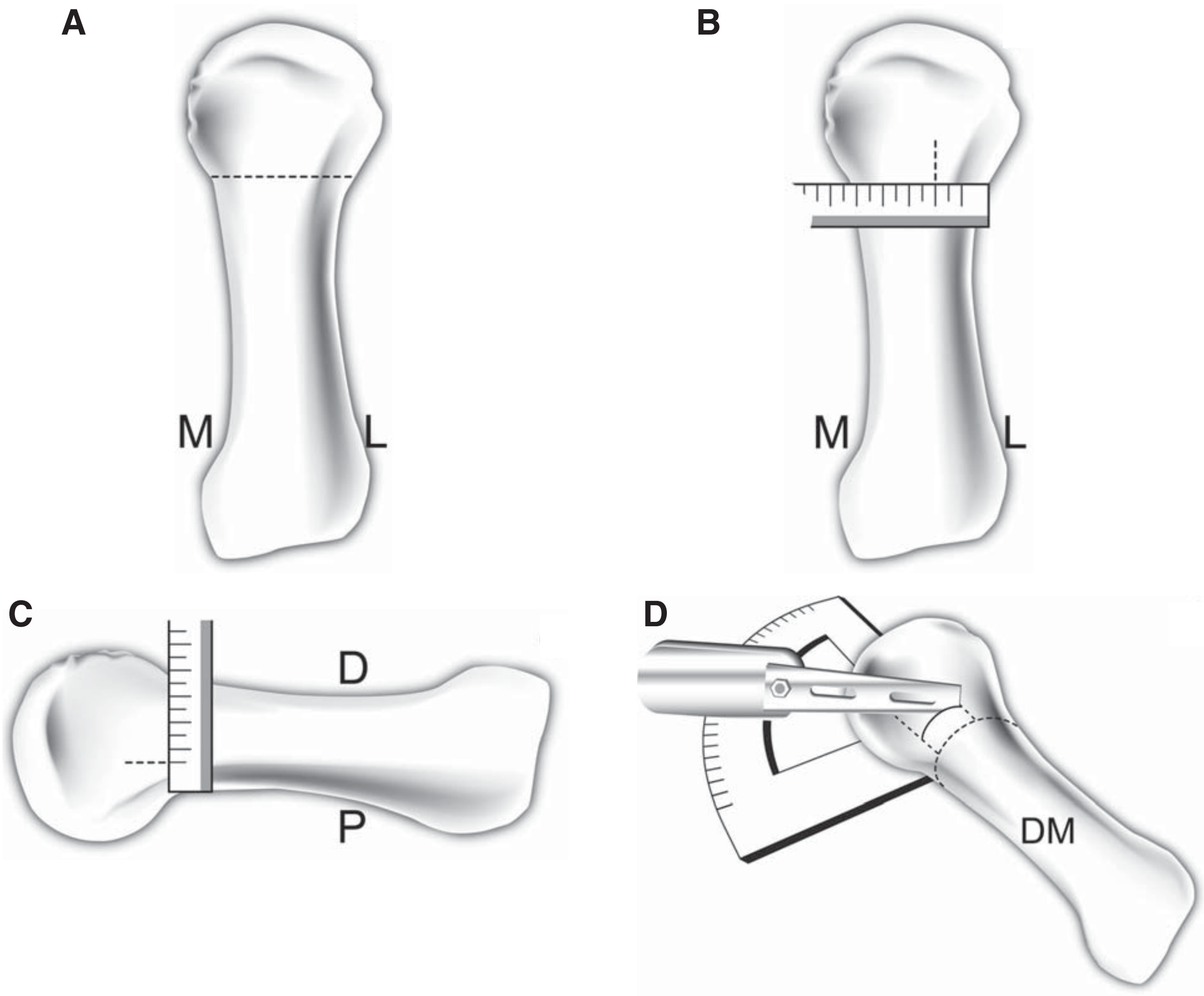

Figure 1 A–D. Three-dimensional osteotomy for hallux valgus of the right foot. A, A transverse line is marked at the junction of the metatarsal head and shaft. B, Measurement and marking of the lateral displacement. C, Measurement and marking of the plantar displacement. D, Distal subcapital osteotomy. M, represents medial; L, lateral; D, dorsal; P, plantar; DM, dorsomedial. *(Figure continues on next page.)*

sired lateral displacement of the distal fragment is marked on the dorsal side of the neck (Fig. 1B). On the medial side of the neck, a desired plantar displacement of the distal fragment is marked (Fig. 1C). A dorsal line is then marked as an inclination to the first line and corresponds in degrees to the DMAA. The distal cut is made beginning medially and dorsally up to the marks on the dorsal and medial side. An oscillating saw with a fine and narrow serrated blade is used. The lateral and plantar aspects of the first metatarsal are left uncut (Fig. 1D). The proximal cut is then made across the metatarsal shaft at the first marked line (Fig. 1E). Two cuts are shown on the dorsoplantar view (Fig. 1F) and on the medial view (Fig. 1G). Both transverse cuts are then connected, first on the dorsal side with a small osteotome at an inclination angle that corresponds to the pronation of the first metatarsal (Fig. 1H). Then two transverse cuts are connected on the medial side of the metatarsal neck with the osteotome directed horizontally. The bone (small wedge) between the two osteotomes is removed, leaving small spurs laterally and plantarly on the distal fragment (Fig. 1I). The inclination angle of the lateral spur corresponds in degrees to the metatarsal pronation. The distal fragment is then pushed laterally and plantarly and rotated medially in the horizontal plane to change the DMAA. Pronation of the first metatarsal is then corrected by supinating

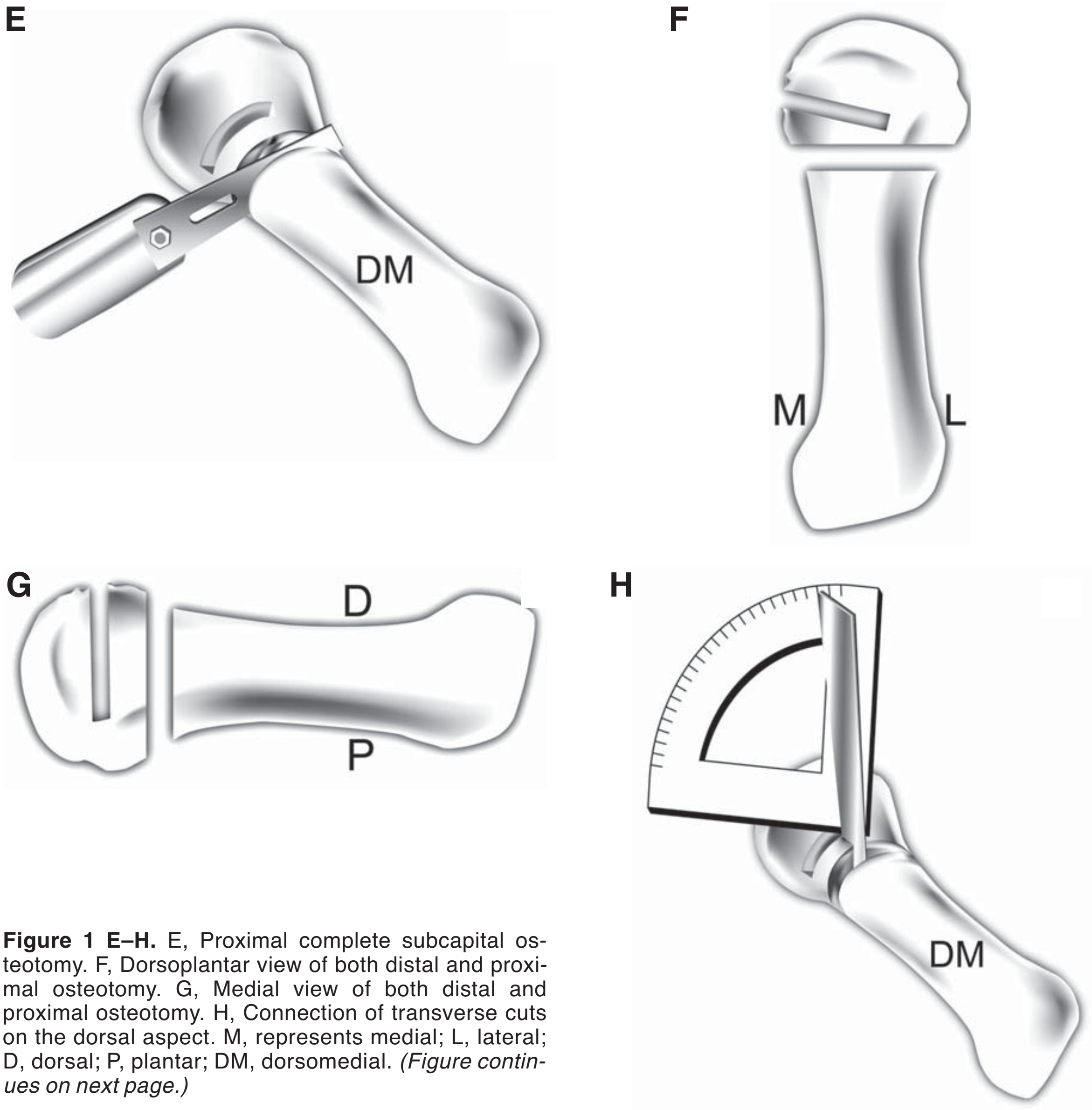

Figure 1 E–H. E, Proximal complete subcapital osteotomy. F, Dorsoplantar view of both distal and proximal osteotomy. G, Medial view of both distal and proximal osteotomy. H, Connection of transverse cuts on the dorsal aspect. M, represents medial; L, lateral; D, dorsal; P, plantar; DM, dorsomedial. *(Figure continues on next page.)*

the distal fragment. Two fragments are then secured in a corrected position with a partially threaded 4.0 mm cancelous screw (Synthes GmbH, Solothurn, Switzerland). The screw is inserted from the proximal-dorsomedial into the distal-plantar-lateral direction at an angle of about 45° across the osteotomy site (Fig. 1J and K). The screw is inserted approximately 10 to 12 mm proximally from the osteotomy site as a lag screw, and a counter-sink is used to improve head seating. The articular surface of the first metatarsal head is inspected to ensure that the end of the screw has not penetrated the articular surface. Excessive prominence of the proximal stump is removed. Lateral soft-tissue release is performed from inside the joint, if necessary. Medial tightening of the V-shaped flap is performed with 2-0 Vicryl (Ethicon, Inc, Somerville, New Jersey) interrupted sutures, with the toe held in a slightly overcorrected position. After skin closure with 4-0 nylon sutures, a sterile dressing is placed over the wound.

The Mitchell Technique

According to the Mitchell technique, two holes are drilled after exostosectomy. A distal incomplete cut and proximal complete cut of the metatarsal shaft are

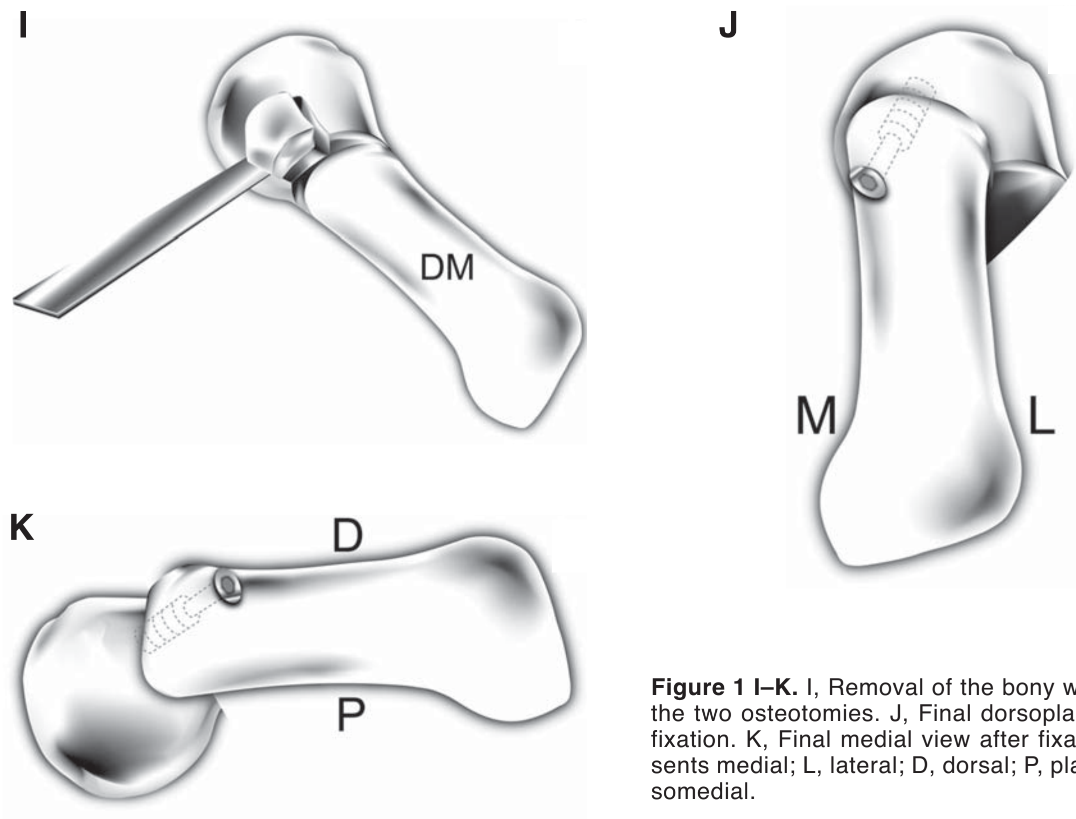

Figure 1 I–K. I, Removal of the bony wedge between the two osteotomies. J, Final dorsoplantar view after fixation. K, Final medial view after fixation. M, represents medial; L, lateral; D, dorsal; P, plantar; DM, dorsomedial.

performed. The bony wedge is removed, and the distal fragment is pushed laterally until it locks on the lateral spur. A suture is passed through the holes and a knot is tied. Wound closure is done in the same manner as in our 3-D method.

Postoperative Procedure

In both methods, folded gauze pads are inserted between the hallux and the second toe in a slightly overcorrected position and secured with an elastic bandage. Metamizol natrium, 1 gram every 6 hours, is given on the first postoperative day, and then on demand on the second and third days. The patient walks on the heel and on the lateral side of the foot from the first postoperative day for the next 4 to 6 weeks. Partial weightbearing is allowed. A special shoe with an open toe compartment is worn. Before discharge from the hospital, (between the third and fifth postoperative day) control radiographs are taken (Fig. 2A). On the second and fourth postoperative day, the wound is inspected and new bandages are applied. Skin sutures are removed after 2 weeks. Full weightbearing in all patients is recommended from the sixth week (Fig. 2B). Eight weeks after surgery, control weightbearing radiographs are taken. Four months after surgery, the screw is removed under local anesthesia to prevent possible discomfort and clavus formation. In the Mitchell osteotomy, a short walking cast is applied before discharge from the hospital and is usually removed after 6 to 8 weeks. Full weightbearing is allowed after 8 weeks.

Results

All preoperative and postoperative values are given in Table 2. Scores on the HMIS increased in both the Mitchell (from 45.1 to 87.7) and 3-D groups (from 42.8 to 91.4). The overall outcome was rated as excellent and good in 83.4% (2 fair, 3 poor) of patients in the Mitchell group and in 90% (3 fair, 3 poor) of patients in the 3-D group. Complications included recurrence of the bunion in three cases and asymptomatic hallux varus in one case, in each group. Preexisting metatarsalgia worsened in one case in each group. In one patient in the 3-D group, the second metatarsophalangeal dislocation caused deterioration of the preexisting metatarsalgia. In the Mitchell group, one patient de-

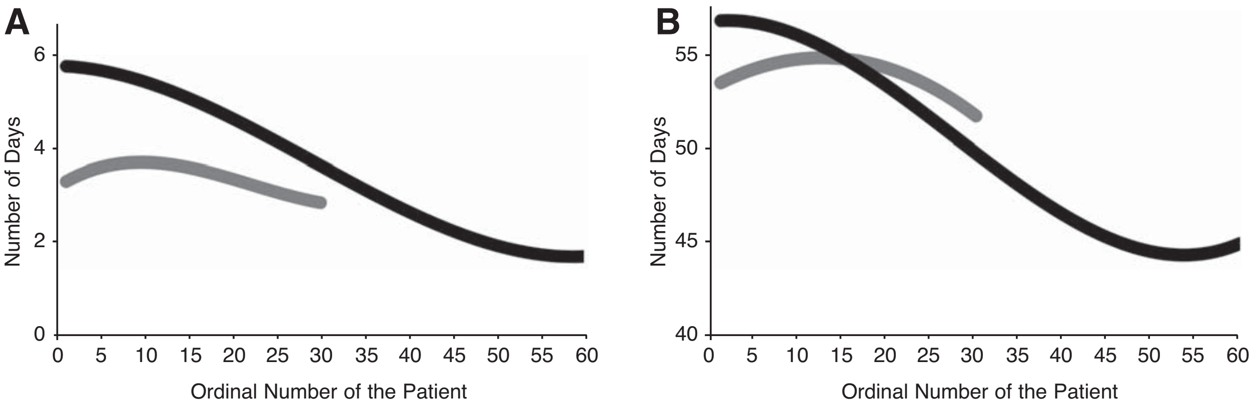

Figure 2. Trend graphs of postoperative management during (A) duration of hospital stay and (B) duration of postoperative partial weightbearing. Patients are labeled with ordinal numbers (higher number means later inclusion in the study). Black lines represent the 3-D group; gray lines, Mitchell's group.

veloped dorsal angulation of the distal fragment and one patient developed postoperative metatarsalgia (Table 3). Prolonged swelling was found in one case in each group, and slow wound healing occurred in one patient in the Mitchell group. Pedobarographic patterns (pressure distribution) were significantly improved by the 3-D method, by shifting pressure more medially from the second metatarsal to the head of the first metatarsal ($z = -3.51$; $P < .001$), while the pressure and the pressure area remained unchanged. Most patients in the 3-D group had maximal loading under the first and second, and second and third metatarsal heads (according to Grace et al)[12] (Table 4).

Discussion

The study design and data collection were carried out according to the guidelines of the American Orthopaedic Foot and Ankle Society (AOFAS).[5] Both the Mitchell and the 3-D groups were comparable with respect to family history, which was positive in one-half of the patients on the mother's side in both groups and in one-quarter of patients on the father's side. Similar results were reported by Hardy and Clapham[14] (63%) and Glynn et al[15] (68%). The data on duration of deformity and duration of the preoperative pain were unreliable but similar in both groups (Table 1). Foot structure and foot types were similar in both groups with predominantly Egyptian foot types. Pes planus was present in 30% in the Mitchell group and 24% in the 3-D group. These data correlate with the literature[16, 17] and confirm that feet with a longer first metatarsal are more likely to develop hallux valgus deformity.

Patients in the 3-D group were on average 5 years older ($z = -2.73$; $P = .006$) at the time of surgery, with a longer duration of preoperative pain but with comparable pain levels. Recent studies suggest that pain is increased in all patients with hallux valgus deformity regardless of age group.[18] Postoperative pain management was the same in both groups and similar to protocols described in the literature.[19] The hallux valgus angle decreased on average 20° in the Mitchell group and 22° in the 3-D group, and the intermetatarsal angle decreased 6.1° in the Mitchell group and 8.6° in the 3-D group. There was no significant postoperative difference between the two groups, but during the study, the duration of hospital stay and duration of partial weightbearing decreased in the 3-D group. This was because good initial results allowed more aggressive rehabilitation in the 3-D group. The idea of distal metatarsal osteotomy is to reduce the IMA to normal values (8° or less); this could be achieved with various techniques.[3, 4, 20-22] The average correction of 8.6° in the 3-D method required approximately the same amount of distal fragment lateralization in millimeters. This lateralization would be very unstable without the stable osteosynthesis and could lead to increased rates of nonunion and aseptic necrosis of the first metatarsal head. Frischhut et al[23] reported nine unstable osteosyntheses out of 118 feet. Wu[24] reported one unstable out of 100 osteosyntheses, and Kuo et al[4] reported 13 infections out of 161 fixations with a Kirschner wire. The distal metatarsal articular angle decreased 9.3° in the Mitchell group and 13.2° in the 3-D group. A similar correction of 13.8° could be achieved with Selner's Tricorrectional method.[25] Objective plantar displacement is indirectly measured with the first metatarsal declination angle. With

Table 2. Pre- and Postoperative Values Compared Between Groups

Radiographic Measurement	Values					
	Preoperative[a]		Postoperative[a]		Intergroup Significance[b]	
Hallux Valgus Angle (°)						
Mitchell	31.3 ± 7.7	30.5 (17 to 46)	11.6 ± 7.4	11.5 (3 to 31)	z = 4.78;	$P < .001$
3-D	32.9 ± 9.6	31 (16 to 58)	10 ± 6.9	10 (2 to 29)	z = 6.74;	$P < .001$
Intragroup significance[c]	z = 0.47; $P = .64$		z = 0.96; $P = .33$			
Intermetatarsal Angle (°)						
Mitchell	12.4 ± 2.6	12 (5 to 17)	6.3 ± 3.2	6 (0 to 12)	z = 4.79;	$P < .001$
3-D	14.3 ± 3.5	14 (8 to 23)	5.7 ± 3.2	6 (0 to 15)	z = 6.74;	$P < .001$
Intragroup significance[c]	z = 2.22; $P = .04$		z = 0.46; $P = .65$			
Distal Metatarsal Articular Angle (°)						
Mitchell	15.7 ± 7.7	14.5 (3 to 30)	6.4 ± 6.7	4 (4 to 18.5)	z = 4.15;	$P < .001$
3-D	16.1 ± 7	16 (0 to 33)	2.9 ± 4.9	3 (7 to 15)	z = 6.72;	$P < .001$
Intragroup significance[c]	z = 0.31; $P = .75$		z = 2.13; $P = .03$			
First Metatarsal Declination Angle (°)						
Mitchell	22.7 ± 3.7	23 (16 to 33)	23.9 ± 4	23 (16 to 32)	z = 2.25;	$P = .025$
3-D	21.8 ± 3.6	21 (16 to 32)	26.1 ± 3.5	26 (20 to 35)	z = 6.52;	$P < .001$
Intragroup significance[c]	z = 1.20 $P = .229$		z = 2.52 $P = .012$			
First Metatarsal Pronation Angle (°)						
Mitchell	6.5 ± 8.7	7.5 (17 to 20)	6 ± 6.4	5 (6 to 21)	z = 0.9	$P = .367$
3-D	6.9 ± 8.3	8 (16 to 25)	0.7 ± 2.9	0 (5 to 10)	z = 4.73;	$P < .001$
Intragroup significance[c]	z = 0.18; $P = .86$		z = 4.49; $P < .001$			
Relative Length of First Metatarsal to the Second (in mm)						
Mitchell	2.5 ± 3.9	3 (5 to 9)	3.5 ± 4	4 (10 to 6)	z = 4.79;	$P < .001$
3-D	2.4 ± 2.6	2.3 (3 to 9)	(4.3) ± 3.1	5 (12 to 4)	z = 6.75;	$P < .001$
Intragroup significance[c]	z = 0.29; $P = .77$		z = 0.74; $P = .46$			
Range of Motion in the First Metatarsophalangeal Joint (°)						
Mitchell	82.4 ± 18.0	86 (40 to 108)	68.9 ± 15.7	74 (32 to 90)	z = 3.87;	$P < .001$
3-D	80.4 ± 14.1	80.5 (58 to 110)	75.5 ± 14.5	76.5 (40 to 105)	z = 2.45;	$P = .014$
Intragroup significance[c]	z = 1.84; $P = .066$		z = 2.69; $P = .007$			
Hallux Metatarsophalangeal-Interphalangeal Scale						
Mitchell	45.1 ± 13.6	45.5 (20 to 64)	87.7 ± 11.8	90 (57 to 100)	z = 4.78;	$P < .001$
3-D	42.8 ± 12.2	44.5 (20 to 67)	91.4 ± 9.7	95 (62 to 100)	z = 6.72;	$P < .001$
Intragroup significance[c]	z = 0.77; $P = .44$		z = 1.53; $P = .125$			

[a]Pre- and postoperative values are given as mean ± SD, followed by median (range).
[b]Intergroup significance determined by Wilcoxon signed-rank test.
[c]Intragroup significance determined by Mann-Whitney *U* test.

Table 3. Pre- and Postoperative Metatarsalgia Comparison

Group	Total[a]	Preoperative: No Metatarsalgia	Preoperative: With Metatarsalgia	Postoperative: No Metatarsalgia	Postoperative: With Metatarsalgia	Postoperative: New Metatarsalgia	*P* Value[b]
Mitchell's	30	15 (50%)	15 (50%)	21 (70%)	8 (27%)	1 (3%)	$P = .07$
3-D	60	28 (47%)	32 (53%)	52 (87%)	8 (13%)	0	$P < .001$

[a]Total refers to the total number of feet included in each group.
[b]Significance determined by McNemar test.

Table 4. Comparison of Pedobarographic Patterns Between the Groups, According to Grace et al[12]

	Values				
Pedobarographic Patterns	Preoperative[a]		Postoperative[a]		Significance[b]
Pressure distribution					
Mitchell	2.5 ± 0.8	2.5 (1 4)	2.0 ± 0.9	2 (1 4)	z = 1.67; *P* = .096
3-D	2.6 ± 1	3 (1 4)	1.8 ± 0.8	2 (1 4)	z = 3.51; *P* < .001
Area (10^{-4} m^2)					
Mitchell	128 ± 12.9	128 (111 153)	129 ± 13.3	127 (114 159)	
3-D	131 ± 14.5	132 (105 159)	133 ± 11.3	136 (109 154)	
Pressure (10^{-4} Pa)					
Mitchell	87 ± 24.3	92 (54 159)	89 ± 21.4	88 (48 118)	
3-D	84 ± 18	83 (40 120)	84 ± 22.7	81 (42 120)	

[a]Pre- and postoperative values are given as mean ± SD, followed by median (range).
[b]Intergroup significance determined by Wilcoxon signed-rank test.

Mitchell's method, the angle increased 1.2°, and with the 3-D method, 4.3°. A greater increase in declination angle in the 3-D group (*P* < .001) indirectly confirms greater plantar displacement of the distal fragment. Piper et al,[26] with the modification of the Hohmann bunionectomy, showed a 6.8° increase of the declination angle. With Mitchell's method, the first metatarsal pronation angle decreased only 0.5°, whereas with the 3-D method, pronation was corrected on average 6.2° (*P* < .001). The importance of pronation correction was described by Scranton and Rutkowski[27] and Chang et al.[28] One of the key elements in hallux valgus surgery is shortening of the first metatarsal, because when the first metatarsal is too short it does not ensure proper loading and leads to metatarsalgia. This problem is well documented and described.[29-31] Shortening of the first metatarsal is desired by some authors[32-35] because it relaxes lateral structures and it allows valgus deformity correction. In the present study, the first metatarsal was shortened 6 mm with Mitchell's method and 6.7 mm with the 3-D method. Although the shortening was greater in the 3-D group, it was well compensated with greater plantarization of the distal fragment (an increase in first metatarsal declination angle). This plantarization allowed for a 75% reduction of metatarsalgia in the 3-D group and only 47% in the Mitchell group (Table 3) (*P* < .001). In one patient in the Mitchell group (3%), a new metatarsalgia developed postoperatively. Greater plantarization also allowed for better pressure distribution patterns in the 3-D group (Table 4) (*P* < .001).

Scores on the HMIS significantly increased in both groups; thus 83% of patients were rated as excellent and good in Mitchell's, and 90% in the 3-D group. Mitchell et al[2] reported good results (85%) in their 1958 paper, and Madjarevic et al[7] reported 97% good results. The oldest 3-D method is Hohmann's. With the modification of Hohmann's method, Christensen and Hansen[33] and Piper et al[26] achieved 88%. Using Magerle's 3-D method, Frischhut[23] achieved only 75% good results. With his 3-D modification of Mitchell's method, Kuo et al[4] achieved 92% of good results. Similar results were reported by Terzis et al[36] and Wagdy et al.[37] Blum[3] reported 91% of excellent or good results. Recurrence of hallux valgus deformity accounts for two-thirds of poor results in both groups, while similar results were reported in the literature.[3, 15, 31] In spite of the fact that one patient in each group was overcorrected and hallux varus developed, both patients were asymptomatic. This low percentage of overcorrection was most probably attributable to the fact that lateral soft-tissue release was rarely performed.

Conclusions

Successful results can be achieved in more than 90% of patients with Mitchell's method or with its modifications. The method is rather simple and provides satisfactory correction of hallux valgus (Fig. 3). Using the hereby described modification, we tried to address some of the disadvantages of the original method. By sufficient plantar displacement, negative effects of the first metatarsal shortening are avoided, and metatarsalgia is eluded in the majority of cases. Shortening of the first ray is used because great amounts of shortening relax the lateral structures and remove the necessity of performing lateral soft-tissue release (thus avoiding possible complications). The method also corrects excessive pronation, which attributes to some of the poor results. Other overall results are comparable both with Mitchell's original method and its recent modifications. Most of the differences between

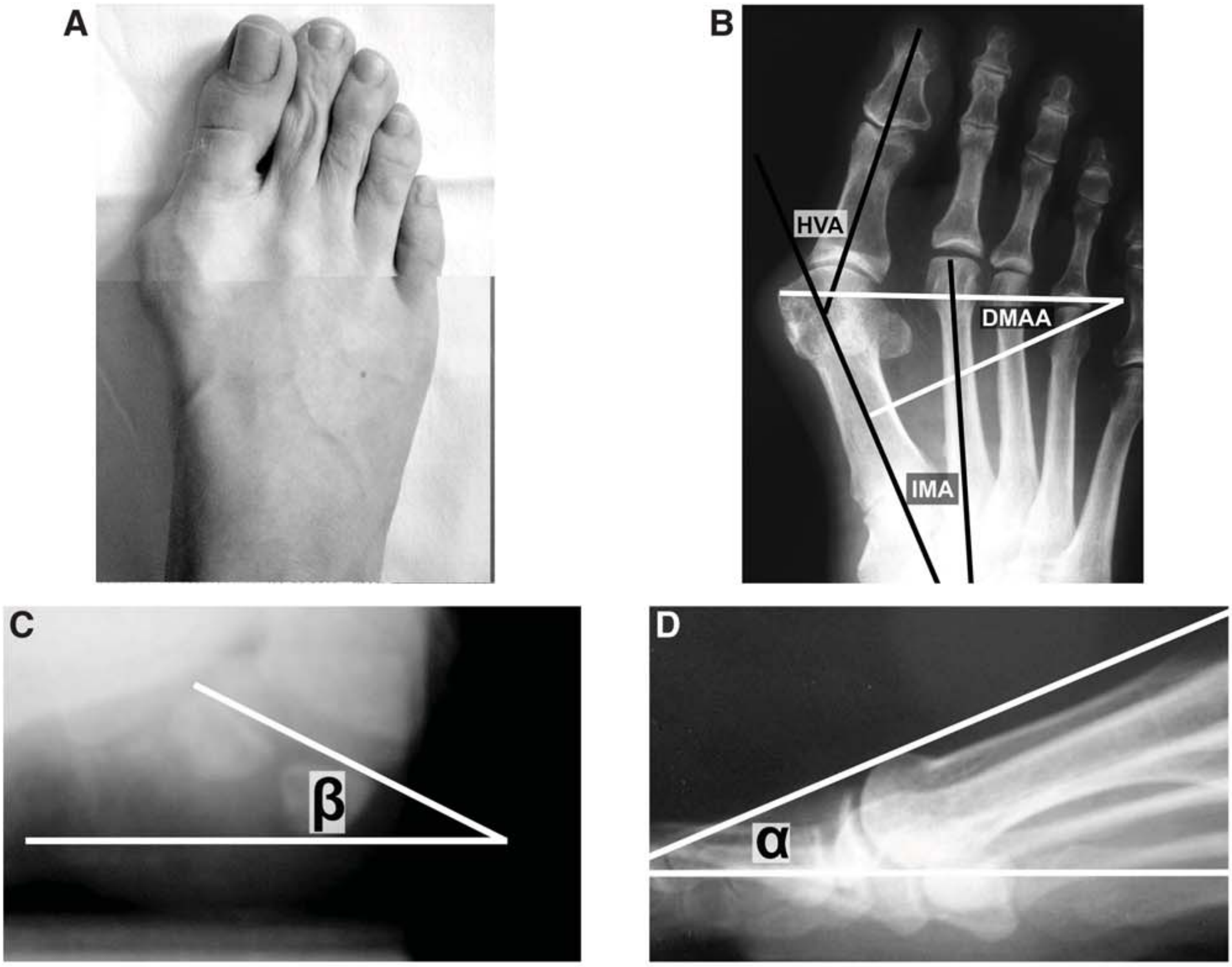

Figure 3 A–D. Native preoperative photograph (A), preoperative anteroposterior radiograph (B), preoperative axial radiograph (C), preoperative lateral radiograph (D) of patient's right foot operated on with the 3-D method. HVA, hallux valgus angle; IMA, intermetatarsal angle; DMAA, distal metatarsal articular angle; α, first metatarsal declination angle; β, first metatarsal pronation angle. *(Figure continues on next page.)*

the methods come from different types of fixation and are accounted for in this report. The main disadvantage of the 3-D method is relative complexity of preoperative planning and necessity of exact intraoperative measurement. The method could also raise some concerns regarding shortening of the first metatarsal, but we believe that shortening could be a useful outcome, not always a complication. Nevertheless, we believe that the 3-D method will be useful for orthopedic surgeons who are willing to take into account all components of hallux valgus—shortening and pronation of the first metatarsal, plantar displacement of the distal fragment, and necessity of distal metatarsal articular angle correction—and for those who are searching to decrease postoperative complications and long-term failures.

Financial Disclosure: None reported
Conflict of Interest: None reported.

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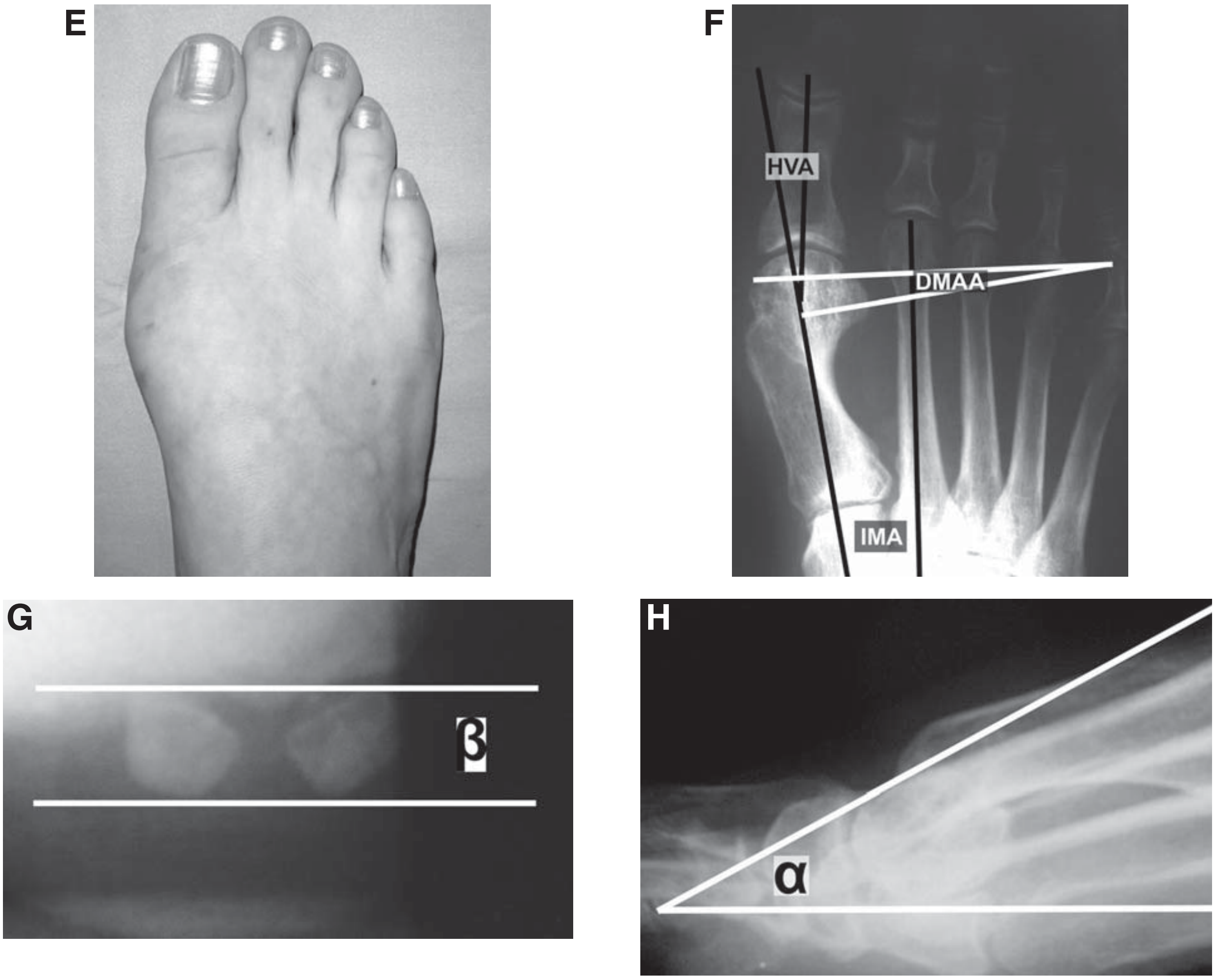

Figure 3 E–H. Native postoperative photograph (E), postoperative anteroposterior radiograph (F), postoperative axial radiograph (G), postoperative lateral radiograph (H) of patient's right foot operated on with the 3-D method. HVA, hallux valgus angle; IMA, intermetatarsal angle; DMAA, distal metatarsal articular angle; α, first metatarsal declination angle; β, first metatarsal pronation angle.

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