Percutaneous Distal Metatarsal Osteotomy for Correction of Hallux Valgus

By Bruno Magnan, MD, Lorenzo Pezzè, MD, Nicola Rossi, MD, and Pietro Bartolozzi, MD

Investigation performed at the Department of Orthopaedics, University of Verona, Verona, Italy

Background: Distal osteotomy of the first metatarsal is indicated for the surgical treatment of mild-to-moderate hallux valgus deformity. The aim of this study was to evaluate the results of a subcapital distal osteotomy of the first metatarsal with use of a percutaneous technique.

Methods: From 1996 to 2001, 118 consecutive percutaneous distal osteotomies of the first metatarsal were performed for the treatment of painful mild-to-moderate hallux valgus in eighty-two patients. The patients were assessed with a clinical and radiographic protocol at a mean of 35.9 months postoperatively. The American Orthopaedic Foot and Ankle Society (AOFAS) hallux-metatarsophalangeal-interphalangeal scale was used for the clinical assessment.

Results: The patients were satisfied following 107 (91%) of the 118 procedures. The mean score on the AOFAS scale was 88.2 ± 12.9 points. The postoperative radiographic assessments showed a significant change ($p < 0.05$), compared with the preoperative values, in the mean hallux valgus angle, first intermetatarsal angle, distal metatarsal articular angle, and sesamoid position. The valgus deformity recurred after three procedures (2.5%), the first metatarsophalangeal joint was stiff but not painful after eight (6.8%), and a deep infection developed after one (0.8%). The infection resolved with antibiotic therapy.

Conclusions: The percutaneous technique proved to be reliable for the correct execution of a distal linear osteotomy of the first metatarsal for the correction of a painful mild-to-moderate hallux valgus deformity. The clinical results appear to be comparable with those obtainable with traditional open techniques, with the additional advantages of a minimally invasive procedure, a substantially shorter operating time, and a reduced risk of complications related to surgical exposure.

Level of Evidence: Therapeutic Level IV. See Instructions to Authors for a complete description of levels of evidence.

Hallux valgus is a frequent deformity of the first metatarsophalangeal joint, particularly in women. The two fundamental elements in this condition are abduction and pronation of the hallux and abduction and pronation of the first metatarsal. The indication for surgical correction of hallux valgus with a distal osteotomy of the first metatarsal is pain associated with a mild-to-moderate hallux valgus deformity[1-9] and a first intermetatarsal angle[10] of 13° to 18°[3,5-7].

A number of osteotomies that correct the deformity simply by realigning the osseous segments have been proposed[1,4,11-16]. Currently, a simple linear osteotomy can be performed with use of a minimally invasive percutaneous approach[2,16-20], provided that technically correct execution is ensured and secure stabilization of the osteotomy site is achieved.

The potential advantages of a minimally invasive percutaneous approach are a reduction in the operating time and the surgical exposure, the possibility of performing the procedure bilaterally with fewer complications, the use of distal ankle-block anesthetic techniques, and early weight-bearing[2,17-20].

Our indication for performing a percutaneous distal osteotomy is the same as that for performing a distal osteotomy with an open technique and lateral soft-tissue release. An intermetatarsal angle of up to 20° is not regarded as a contraindication.

The percutaneous procedure has evolved from the traditional open techniques that depend on stabilization with a Kirschner wire[4,14,15,21] and was standardized by Bösch et al.[16,17].

The aim of the present study was to analyze a series of patients who had undergone a percutaneous distal metatarsal osteotomy and had been followed for more than two years.

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Materials and Methods

From May 1996 to February 2001, 118 consecutive percutaneous distal osteotomies of the first metatarsal were performed

in eighty-two patients (seventy-seven female and five male). Conservative treatment (wearing comfortable or modified shoes, use of insoles, and skin care) for at least one year had failed for all patients. The procedure was performed bilaterally in the same session in thirty-one patients and bilaterally in two separate sessions, with an interval of about a year between the operations, in another five patients. The mean age of the patients at the time of the operation was 56.3 ± 13.1 years (range, seventeen to seventy-nine years). No previous surgery had been performed on any of the feet. All patients complained of pain in the area of the first metatarsal head, mainly due to pressure of footwear. One patient had an ulcerated bunion, and there was pain under the lesser metatarsals in sixty-four (54%) of the 118 feet.

Clinical Assessment

The hallux-metatarsophalangeal-interphalangeal scale proposed by the American Orthopaedic Foot and Ankle Society (AOFAS) was used for the clinical assessment[22]. This system, which has not yet been validated[23], provides a score ranging from 0 to 100 points, which takes into consideration both subjective and objective elements such as pain (maximum score, 40 points), functional capacity (maximum score, 45 points), and hallux alignment (maximum score, 15 points). Other factors that were evaluated in the clinical assessment were any limitation of daily and/or sports or recreational activity, the type of shoes that the patient could wear, the stability of the first metatarsophalangeal and interphalangeal joints, and the presence of calluses. The patient's satisfaction

Fig. 1-A

Fig. 1-B

Figs. 1-A through 1-F Operative photographs and fluoroscopic images demonstrating the surgical technique. **Figs. 1-A and 1-B** A 2-mm Kirschner wire is inserted from distal to proximal, and a 2 to 3-mm skin incision is made at the distal metaphysis of the first metatarsal medially.

Fig. 1-C

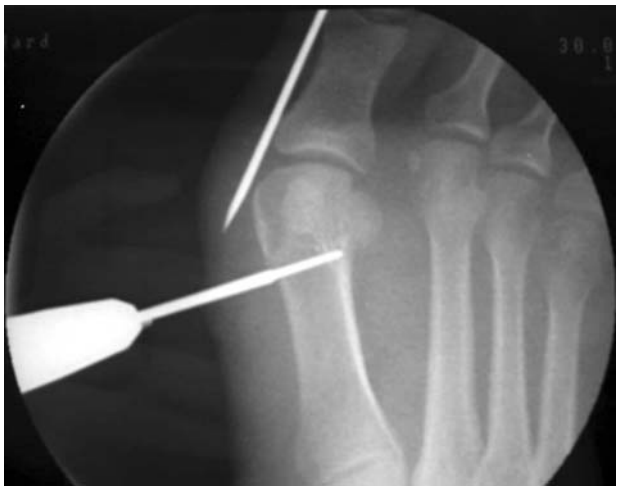

Fig. 1-D

Figs. 1-C and 1-D The osteotomy is performed with a micromotorized Lindemann bone-cutter.

with the outcome (satisfied or unsatisfied) was also elicited.

Radiographic Assessment

Anteroposterior and lateral weight-bearing radiographs of the foot were made preoperatively; at three months postoperatively to verify consolidation of the osteotomy site; and at the time of final follow-up to measure the hallux valgus angle, first intermetatarsal angle, and distal metatarsal articular angle, as recommended by the AOFAS[10]. The position of the sesamoids was assigned a grade of 0 to 4[10,24,25]. The position of the head of the first metatarsal in the sagittal plane in relation to the shaft of the first metatarsal was defined as plantar, neutral, or dorsal, and the extent of lateral displacement of the capital fragment was expressed as a percentage of the transverse diameter of the osteotomy line[20].

When there was evidence of incomplete consolidation of the osteotomy site at three months postoperatively, the radiographic assessment was repeated every three months until consolidation was confirmed.

Statistical Evaluation

The significance of the changes in the hallux valgus angle, the first intermetatarsal angle, the distal metatarsal articular angle, and the sesamoid position at the follow-up examination, as compared with the preoperative values, was determined with use of the Student t test, with 0.05 as the cut-off for significance.

Surgical Technique

The operation was performed with a minimally invasive technique and ankle block anesthesia[26]. The surgical procedure can be facilitated by the use of a fluoroscopic image intensifier to monitor the performance of some of the steps[2,17].

The technique involves two percutaneous approaches: the first is carried out approximately 2 to 3 mm from the medial corner of the nail of the great toe, and the second is carried out at the distal metaphysis of the first metatarsal on the medial side, which is the site of the osteotomy[2,16-20] (Figs. 1-A and 1-B). The periosteum around the osteotomy site is detached first, with use of small scissors inserted through the percutaneous approach dorsally and then plantarly. In this way, the structures surrounding the metatarsal shaft can be kept far from the bone-cutter. The osteotomy is then performed through the subcapital region of the first metatarsal with use of a thin 2.33-mm-diameter micromotorized Lindemann bone-cutter (Aesculap, Tuttlingen, Germany) (Figs. 1-C and 1-D). The cut is made in a single plane, perpendicular to the axis of the shaft of the first metatarsal in the sagittal plane. The mediolateral obliquity of the osteotomy in the frontal plane makes it possible to lengthen or shorten the metatarsal with lateral displacement of the head fragment. A slight lengthening obliquity enables the surgeon to recover the 2 to 3 mm lost as a result of the action of the burr.

The osteotomy enables the surgeon to achieve an appreciable degree of lateral displacement and slight plantar displacement of the hallux and the metatarsal head. Furthermore, the metatarsal head can be rotated in the axial plane to correct the rotational components of the deformity.

The percutaneous displacement of the first metatarsal head is best achieved with the use of the Bösch device[16,17] (Figs. 1-E and 1-F), which is a bent grooved probe, manufactured from a stainless-steel cylindrical rod, measuring 7 mm in diameter. The distal edge of the device is smooth and is bent over a distance of about 4 cm (Tecres, Verona, Italy).

The osteotomy site is then stabilized by means of a 2-mm Kirschner wire, which is inserted from distal to proximal

Fig. 1-E

Fig. 1-F

Figs. 1-E and 1-F The lateral displacement of the metatarsal head is obtained with a grooved Bösch device, and the realignment is stabilized by the insertion of the 2-mm Kirschner wire into the medullary canal; the wire is firmly driven as far as the base of the first metatarsal.

Fig. 2-A

Fig. 2-B

Figs. 2-A and 2-B Postoperative taping. **Fig. 2-A** The dressing is maintained for six weeks and is changed every week. **Fig. 2-B** The taping includes use of a plantar kidney-shaped pad in order to reduce the local weight-bearing pressure beneath the first metatarsal head, preventing dorsiflexion of the capital fragment.

in a parosteal position in relation to the hallux and the head of the first metatarsal and then into the medullary canal of the first metatarsal; it is firmly driven as far as the base of the first metatarsal in order to improve stabilization (Fig. 1-F). The wire is kept in that site for four weeks.

No associated soft-tissue procedures are performed. In particular, lateral release with dissection of the soft tissues is never done.

Postoperatively, functional taping is of fundamental importance. The tape, which is kept in situ for six weeks and is replaced every week (Fig. 2-A), is used with a plantar kidney-shaped pad, with its concavity surrounding the plantar aspect of the head of the first metatarsal in order to reduce the local weight-bearing pressure beneath the capital fragment and prevent dorsiflexion of the capital fragment (Fig. 2-B). The tape maintains a slight hypercorrection of the hallux in order to counter any recurrence of pronation.

Patients are allowed to walk on the day after the operation with the use of appropriate postoperative footwear with a flat, rigid sole (Figs. 3-A through 3-F). After the tape is removed, patients are encouraged to exercise the first metatarsophalangeal joint, taking particular care to obtain full dorsiflexion within four to six weeks.

Results

The subjects in the study gave informed consent, and the study was approved by our institutional review board.

All patients were seen at the time of follow-up, at an average of 35.9 ± 10.9 months (range, twenty-four to seventy-eight months), and all reported the disappearance or reduction of the pain that they had experienced prior to the operation, both in the area of the first metatarsal head and under the lateral metatarsal heads. Fifty-six patients (eighty-three feet; 70%) reported total disappearance of the pain, nineteen patients (twenty-six feet; 22%) had only occasional pain, seven patients (nine feet; 7.6%) had daily moderate pain, and no patient had severe or constant pain (Table I). The mean overall pain score was 36.3 ± 6.2 points of the 40-point maximum on the AOFAS hallux-

TABLE I AOFAS Scores for Pain at the Time of Final Follow-up

Pain	Score *(points)*	No. (%) of Feet (N = 118)	No. of Patients
None	40	83 (70)	56
Mild, occasional	30	26 (22)	19
Moderate	20	9 (7.6)	7
Severe, constant	0	0	0

Fig. 3-A

Fig. 3-B

Figs. 3-A through 3-F A woman treated with bilateral percutaneous distal osteotomy of the first metatarsal at the age of fifty-five years and followed for five years. **Figs. 3-A and 3-B** Clinical appearance and anteroposterior radiograph of the forefeet affected by painful moderate bilateral hallux valgus.

metatarsophalangeal-interphalangeal scale.

The functional capacity of the hallux, which was graded by summing the scores for the six different aspects of functional performance on the hallux-metatarsophalangeal-interphalangeal scale (Table II), averaged 38.1 ± 5.1 points (maximum score on the scale, 45 points). The maximum score for hallux alignment (15 points, indicating excellent or good alignment) on the hallux-metatarsophalangeal-interphalangeal scale was recorded for eighty-eight feet (75%) in sixty patients; mild, asymptomatic malalignment (a score of 8 points) was recorded for twenty-seven feet (23%) in nineteen patients; and true recurrence of the hallux valgus (a score of 0 points) was recorded for three feet (2.5%) in three patients (Table III). The overall mean score for hallux alignment was 13.8 ± 3.9 points. The mean total score for the AOFAS assessment was 88.2 ± 12.9 points, with a range of 40 to 100 points (Table IV).

Patients were satisfied with the results of 107 (91%) of the 118 procedures and dissatisfied with the results of eleven (9%).

With regard to the radiographic findings (Table V), the final first intermetatarsal angle averaged 7.3° ± 2.7° and the

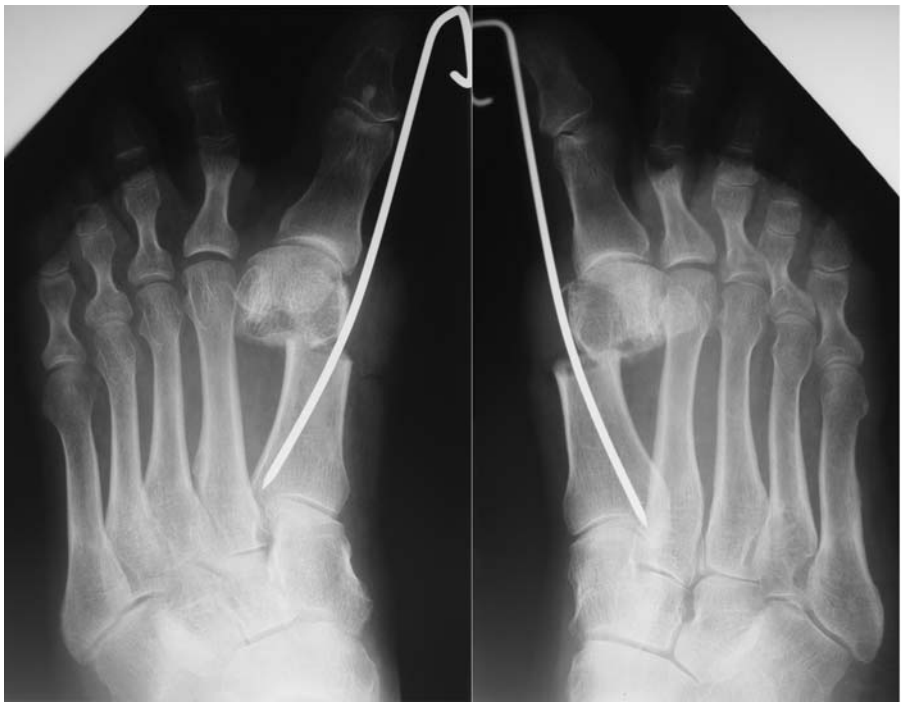

Fig. 3-C

Anteroposterior radiograph made after the surgical procedure.

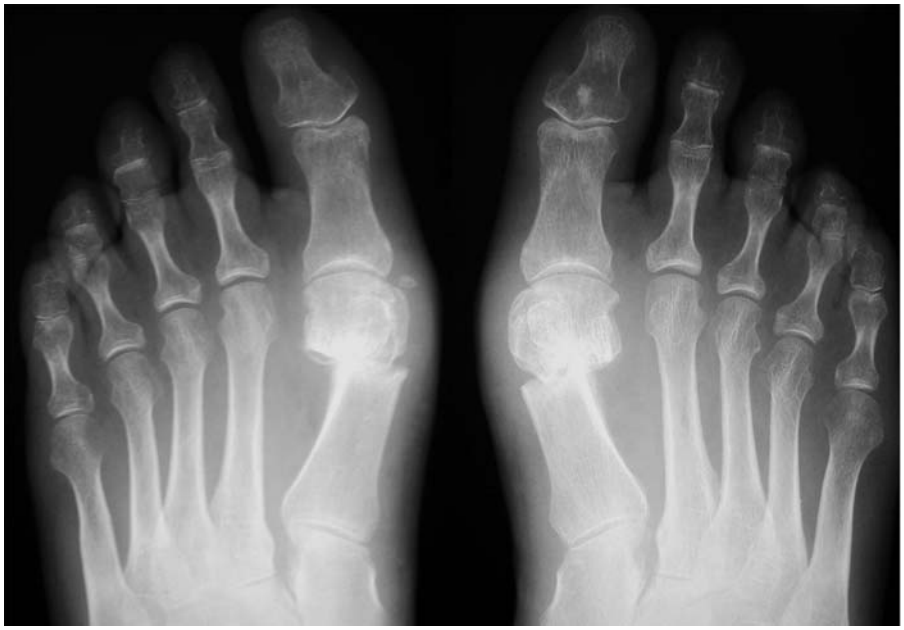

Fig. 3-D

Anteroposterior radiograph made at three months postoperatively, when full activity was allowed.

hallux valgus angle averaged 13.7° ± 6.7°. The mean distal metatarsal articular angle decreased from 14.2° ± 6.4° preoperatively to 6.7° ± 4.6° at the time of final follow-up. The mean sesamoid position was graded as 0.4 ± 0.6 at the time of final follow-up, compared with 2.0 ± 0.8 preoperatively.

Plantar displacement of the first metatarsal head (mainly a plantar translation, with some degree of plantar angulation in a few feet) was found at the time of follow-up in fifty-eight (49%) of the 118 feet, dorsiflexion of the head (mainly angular deformity) was seen in fourteen feet (12%), and a position that can be defined as neutral (essentially similar to the preoperative position) was observed in forty-six feet (39%).

The extent of lateral displacement of the first metatarsal head was 52.6% ± 20.6% of the diameter of the first metatarsal shaft in the immediate postoperative period and 32.8% ± 18.6% at the time of follow-up.

Fig. 3-E

Fig. 3-F

Figs. 3-E and 3-F Clinical appearance and anteroposterior radiograph of the forefeet five years after the surgery. The correction was well maintained, and the patient was pain-free while wearing any type of footwear.

TABLE II AOFAS Scores for Functional Capability at the Time of Follow-up

Functional Capability	Score *(points)*	No. (%) of Feet (N = 118)	No. of Patients
Activity limitation			
None	10	105 (89)	73
No limitation of daily activity, limitation of recreational activity	7	8 (7)	6
Limitation of daily and recreational activity	4	3 (3)	2
Severe limitation of all activity	0	2 (2)	1
Footwear			
Normal	10	82 (70)	57
Comfortable and/or insole	5	35 (30)	24
Orthopaedic	0	1 (1)	1
Metatarsophalangeal joint motion			
>75°	10	29 (25)	22
30°-74°	5	81 (69)	53
<30°	0	8 (7)	7
Interphalangeal joint motion			
Normal	5	116 (98)	80
<10°	0	2 (2)	2
Joint stability			
Stable	5	116 (98)	80
Unstable	0	2 (2)	2
Callus			
None or asymptomatic	5	108 (92)	75
Symptomatic	0	10 (9)	7

Complications

There was one early deep infection at the osteotomy site, which was treated with intravenous antibiotic therapy and resolved in about two weeks. There was no need to remove the Kirschner wire before the scheduled time. Superficial skin irritation by the Kirschner wire occurred in two feet (1.7%), and permanent numbness of the hallux occurred in three. There were no nonunions of the osteotomy site. One sixty-two-year-old man had progressive recurrence of the deformity with pain and severe limitation of his ability to walk.

Motion of the first metatarsophalangeal joint was limited to <30° in eight feet (6.8%) in seven patients. These patients included one woman who had presented with hallux valgus rigidus preoperatively. At thirty-five months postoperatively, the hallux appeared to be well aligned and was only occasionally painful. This patient's only limitation was the inability to wear high-heeled shoes. One case of rigidity resulted from the above-mentioned early infection, and the other cases were related to poor mobilization of the hallux following removal of the tape. However, these patients did not regard the joint motion deficit as disabling, and the rigidity did not cause pain during walking.

No cases of secondary hallux varus were observed despite the slight overcorrection that had been consistently achieved at the time of stabilization of the osteotomy site.

Discussion

This study showed that the percutaneous distal osteotomy enables the orthopaedic surgeon to achieve good correction of a moderate hallux valgus deformity, a finding that confirms previously reported results in the literature[2,16-18,20]. The positive changes in the radiographic parameters measured following consolidation of the osteotomy site fulfill the biomechanical requisites for distal osteotomies of the first metatarsal, and the clinical results, which were entirely comparable with the reported outcomes of distal osteotomies performed

TABLE III AOFAS Scores for Hallux Alignment at the Time of Final Follow-up

Alignment	Score *(points)*	No. (%) of Feet (N = 118)	No. of Patients
Excellent/good	15	88 (75)	60
Mild asymptomatic misalignment	8	27 (23)	19
Symptomatic misalignment	0	3 (2.5)	3

TABLE IV Overall AOFAS Scores at the Time of Follow-up

	Mean Score and Standard Deviation *(points)*
Pain (0-40 points)	36.3 ± 6.2
Functional capability (0-45 points)	38.1 ± 5.1
Activity limitation	9.5 ± 1.7
Footwear	8.5 ± 2.4
Metatarsophalangeal joint motion	5.8 ± 2.7
Interphalangeal joint motion	4.9 ± 0.4
Joint stability	4.9 ± 0.6
Callus	4.6 ± 1.4
Alignment (0-15 points)	13.8 ± 3.9
Total (0-100 points)	88.2 ± 12.9

with open techniques[1,3-7,14,15,21,27-32], were maintained at the time of follow-up.

The only true contraindication to this procedure is hallux rigidus with stiffness of the joint and periarticular osteophytes that cannot be fully treated by the percutaneous technique.

The type of fixation is an important element of the surgical technique[2,6-8,21]. The percutaneous Kirschner wire inserted parosteally in a distal-to-proximal direction at the level of the proximal phalanx and the first metatarsal and then coming to lie in an intramedullary position at the level of the diaphysis appears to be suitable for the stabilization of the osteotomy site. It should remain in place for four weeks.

Consolidation of the osteotomy site was confirmed radiographically in all patients within six months. Good angular correction, comparable with that reported following use of the more standard open techniques[3,5,7,14,15,21,28,31], was obtained despite the slight varus hypercorrection at the time of the operation.

The reported rate of deep infection has ranged from 0% to 3.5% in other series in which the percutaneous technique was used[16-18,20]. Our low rate of one of 118 was related both to the advantages afforded by the minimally invasive procedure and to the thorough standardization of a postoperative monitoring protocol that required a clinical examination with dressing changes and retaping at weekly intervals[2,16-20] until the Kirschner wire was removed. This was of fundamental importance for reducing pin-track problems.

Hallux varus hypercorrection was not observed in our series. The fact that, to our knowledge, this complication has never been reported in association with this technique[17,18,20] may be due to the avoidance of surgery on the soft tissues, including any type of lateral release of the first metatarsophalangeal joint. Such releases can be avoided because of the substantial lateral displacement of the first metatarsal head afforded by the particular type of Kirschner wire stabilization. The displacement may be as much as 75% to 90% of the transverse diameter of the osteotomy, which brings about a substantial relaxation of the tendon of the adductor hallucis. The lack of soft-tissue surgery does not appear to affect the prevalence of recurrent hallux valgus deformity, perhaps because reorientation of the metatarsal head and reduction of the head on the sesamoids were the consistently achieved primary surgical objectives[17].

The lateral displacement of the first metatarsal head achieved at surgery (mean, 52.6%) was not maintained by the time of full consolidation of the osteotomy site (mean, 32.8%). The action of the long extensor and long flexor tendons on the hallux during the plasticity phase of the healing callus probably offset the slight hypercorrection obtained at the time of surgical stabilization.

Stiffness of the first metatarsophalangeal joint is one of the most feared outcomes of hallux valgus surgery and one that affects the overall clinical result. Percutaneous distal osteotomy of the first metatarsal is an extra-articular operation and therefore should have a limited effect on the postoperative range of motion of the hallux. Reduction of the range of motion is therefore most likely due to pre-existing degenerative arthritis or a failure to implement the brief rehabilitation program following removal of the Kirschner wire and the bandage. The Kirschner wire stabilizes the first metatarsophalangeal joint for four weeks, which creates the risk of postoperative stiffness. In the present study, stiffness was by no means rare, with a rate of 6.8% (eight of 118). However, one case resulted from a postoperative infection, and we believe that the other cases were at least partly attributable to poor mobilization after removal of the Kirschner wire. While most of our patients had the same degree of joint motion at the time of follow-up as they had preoperatively, all patients should be informed that hallux valgus surgery may result in some loss of mobility of the first metatarsophalangeal joint[7].

The exposed corner of bone along the medial aspect of

TABLE V Radiographic Measurements

	Preop.*	Postop.*	Correction*	P Value
Intermetatarsal angle *(deg)*	12.3 ± 3 (10-20)	7.3 ± 2.7 (4-16)	5.1 ± 3	<0.05
Hallux valgus angle *(deg)*	31.5 ± 10.2 (18-42)	13.7 ± 6.7 (7-25)	17.8 ± 9.7	<0.05
Distal metatarsal articular angle *(deg)*	14.2 ± 6.4 (3-22)	6.7 ± 4.6 (0-15)		<0.05
Sesamoid position	2.0 ± 0.8 (1-3)	0.4 ± 0.6 (0-2)		<0.05

*The values are given as the mean and standard deviation with the range in parentheses.

the first metatarsal shaft usually remodels over time, but it can remain clinically evident for as long as four to six months. This exposed corner has been reported to cause symptoms, requiring percutaneous revision, in 1% to 2% of patients[15,16], but this problem was not observed in our series. Creating a slightly oblique osteotomy plane could have contributed to our achievement of a less prominent bone shelf.

The results of this study demonstrate that subcapital distal osteotomy of the first metatarsal with a percutaneous technique and Kirschner wire stabilization under fluoroscopic control, and without soft-tissue surgery, is an effective, reliable method of treating mild-to-moderate hallux valgus deformity. The results appear to be comparable with those reported following traditional open techniques[1,3,4,6,7,14,15,21,28-32], and the technique has all of the advantages of a minimally invasive procedure. These advantages include the simplicity of the procedure, the very short operative time, a reduced risk of complications, and the ability to perform the operation with ankle-block anesthesia and without a tourniquet. ■

Bruno Magnan, MD
Lorenzo Pezzè, MD
Nicola Rossi, MD
Pietro Bartolozzi, MD
Department of Orthopaedics, University of Verona, P.le L.A. Scuro 10, 37134 Verona, Italy

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