RESEARCH ARTICLE

Percutaneous Foot Surgery without Osteosynthesis in Hallux Valgus and Outcomes

Giuseppe Restuccia, MD, SD[1]; Alessandro Lippi, MD, SD[1]; Sheila Shytaj, MD[2]; Federico Sacchetti, MD[2]; Fabio Cosseddu, MD[2]

Research performed at Azienda Ospedaliera Universitaria Pisana, Italy

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Abstract

Background: Several procedures and types of osteotomies have been described for hallux valgus (HV) correction. Percutaneous techniques may lead to an early regain of function reducing morbidity and recovery time. In this study, we aimed to evaluate the clinical and radiographic outcomes of percutaneous hallux valgus (HV) correction.

Methods: One hundred and twenty-four feet treated with the percutaneous technique between May 2011 and December 2015 were included in our study. All patients underwent resection of the medial metatarsal exostosis, complete first metatarsal distal osteotomy, adductor hallucis tendon release and Akin osteotomy of the proximal phalanx. Pre- and postoperative X-rays were clinically assessed.

Results: The mean hallux valgus angle (HVA) and the intermetatarsal angle (IMA) decreased significantly from the preoperative assessment to the final follow-up. The AOFAS score improved from a mean preoperative value of 70.2 to 93.8 at the final follow-up.

Conclusion: Percutaneous complete distal osteotomy in hallux valgus correction is a safe, reliable and effective procedure for the correction of symptomatic mild hallux valgus. Nevertheless, it requires appropriate surgical experience and patient aftercare in order to achieve the best result.

Level of evidence: IV

Keywords: Hallux valgus, Osteosynthesis, Percutaneous foot surgery

Introduction

Hallux valgus (HV) is a frequent, complex and progressive deformity of the first toe with a multifactorial etiology. The deformity is characterized by progressive abduction and pronation of the proximal phalanx with adduction, pronation, and elevation of the first metatarsal, and lateral capsular retraction of the first metatarsophalangeal (MTP) joint (1). On X-rays, diagnosis can be confirmed by the presence of the first MTP angle that is greater than 15 degrees. When patients experience pain, discomfort, or difficulties while wearing shoes, a surgical correction may be advised. Hallux valgus deformity is classified as mild (up to 20 degrees), moderate (20-40 degrees), or severe (40 degrees or more). Various procedures have been introduced to correct the HV deformity, ranging from several techniques of corrective osteotomies, whether associated with soft tissue releases or not, to arthrodesis of the first metatarsal-cuneiform joint (2-5). In recent years, percutaneous forefoot surgery (PFS) represented an important trend in the treatment of HV. The surgery is performed through the smallest possible working incision (1-3 mm) without direct visualization of the underlying target structures; it relies on the tactile senses of the surgeon who uses a mini-blade for soft tissue dissection

Corresponding Author: Sheila Shytaj, Department of Orthopaedic and Trauma Surgery, University of Pisa, Italy
Email: shytajs@gmail.com

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and a power rotary burr for osseous procedures. Percutaneous techniques are usually performed under intraoperative fluoroscopic guidance. Percutaneous forefoot surgery has shown several advantages when compared to traditional open surgery and minimally invasive surgeries (MISs) in terms of hospitalization, rehabilitation time and complications such as surgical site infection, pseudoarthrosis and metatarsal head necrosis. At the same time, it reduces operative times and patients' postoperative pain (6). However, the use of percutaneous techniques is not still globally accepted; few evidences are reported in the literature and there is still lack of trials comparing percutaneous surgery to MIS or open surgery (7-9). The main concern regarding PFS techniques is the risk of deformity recurrences that some authors believe to be much higher when compared to traditional or MIS techniques since there is no internal fixation. In this study, our aim was to evaluate the clinical and radiological outcomes in patients with mild to severe HV treated with PFS.

Materials and Methods

Between May 2011 and December 2015, 156 patients had undergone PFS for mild, moderate or severe HV in our institute. Of them, 124 met the following inclusion criteria: presence of a symptomatic hallux valgus deformity and radiographic evidence of a hallux valgus angle (HVA) >15° and an intermetatarsal angle (IMA) >8°. Patients with a neurologic HV, rheumatic or metabolic diseases, congenital foot deformities, previous foot surgeries, instability of the first tarsometatarsal joint, laxity, and stiffness or osteoarthritis of the first MTP joint were excluded. The study was conducted with the remaining 96 patients (124 feet).

All patients signed an informed consent in order to participate in this study. All procedures were performed by our senior author who also examined every single patient preoperatively and at follow-ups. Standard anteroposterior and lateral weight-bearing X-rays were taken preoperatively and at the final follow-up to measure and compare the following parameters: HVA, first IMA, and distal metatarsal articular angle (DMAA) [Figure 1]. The HVA was calculated by measuring the angle between the mid-longitudinal axes of the first metatarsal and proximal phalanges, the IMA by measuring the angle between the longitudinal axes of the first and second metatarsal bones, and the DMAA by measuring the angle between the tangent line to the articular cartilage of the 1st metatarsal head and its longitudinal axis (10). The clinical assessment was made using the American Orthopaedic Foot and Ankle Society (AOFAS) score both preoperatively and during follow-up, while the results of the final follow-up were used for the statistical analysis (11).

Surgical technique

All patients underwent resection of the first medial metatarsal exostosis, complete first metatarsal distal osteotomy without hinges, adductor hallucis tendon release, and Akin osteotomy of the proximal phalanx (12). Ankle block anesthesia was performed on three spots; the tibial nerve, as it passes through the tarsal tunnel in the posterior malleolar space, the sensory branches of the superficial peroneal nerve, along a line between the anterior border of the two malleoli, and on the deep peroneal nerve, laterally to the tendon of the extensor hallucis longus. Several special surgical instruments including cutting instruments (Beaver blade), rasps for percutaneous surgery, straight burrs, wedge burrs and cylindrical burrs connected to a micromotor were used during the PFS procedures [Figure 2]. The patients were positioned in dorsal decubitus without a pneumatic tourniquet and under fluoroscopic control. An incision of 3 mm was performed on the plantar side of the medial border of the first metatarsal head (MTH), proximally to the medial sesamoid bone and deep within the first MTP joint capsule [Figure 3]. The capsule was then detached from the medial MTP exostosis by introducing a small rasp with a sweeping movement, after which a cylindrical burr (D: 3.1 mm - L: 15 mm) was introduced and used to reduce the bunion volume until a flat surface was achieved and confirmed radiologically. After the

Figure 1. Hallux valgus of the left foot treated with PFS. In the preoperative (a) clinical and (b, c) radiological images, HVA was 42°, IMA was 10° and DMAA was 8°.
DMAA: distal metatarsal articular angle, HVA: hallux valgus angle, IMA: intermetatarsal angle, PFS: percutaneous foot surgery.

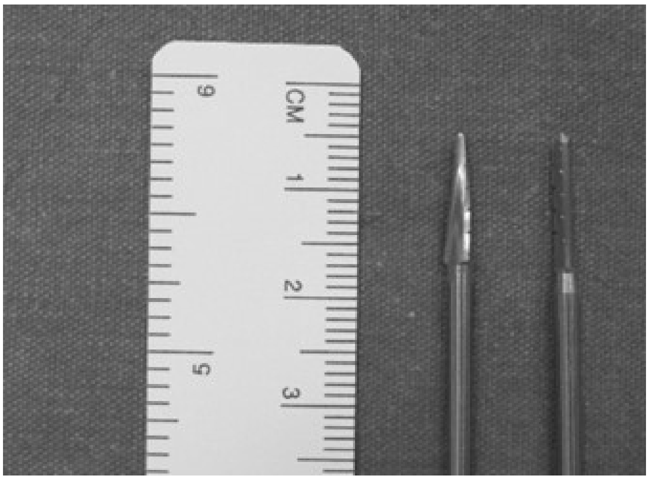

Figure 2. A wedge burr (left) and a Beaver blade (right).

resection, we removed the intracapsular bone debris using saline solution and specific rasps. Through the same incision, a Shannon straight burr (D: 2 mm - L: 15 mm) was positioned to the bone surface at the metaphysis. An extraarticular osteotomy was performed perpendicular to the long axis of the second MTH in anteroposterior view, while in the lateral view, the osteotomy was begun dorsally perpendicular to the long axis of the first MTH and then given a 45° slope, in a dorsal-distal to plantar-proximal direction. Once the osteotomy was complete and the bone was free to move, a direct, lateral translation of the MTH was performed and radiographically checked [Figure 4]. Then, through a 3 mm dorsal incision at the first MTP joint, a blade was inserted parallel to the extensor tendons deeply within the joint and was advanced to the point of insertion of the adductor hallucis tendon at the base of the proximal phalanx to perform tenotomy of the adductor hallucis. A percutaneous Akin incomplete osteotomy of the proximal metaphysis was performed using a Shannon burr from dorsal to plantar without damaging the lateral cortex. All incisions were closed with resorbable

Figure 4. Osteotomy line.
PFS: percutaneous foot surgery

Figure 3. Hallux valgus of the left foot treated with PFS. Surgical incision is made on the plantar side of the medial border of the first metatarsal.
PFS: percutaneous foot surgery

sutures and the metatarsal osteotomy was stabilized using a functional bandage [Figure 5]. Applying a gentle traction to overcorrect the first toe, a gauze was placed between the first and the second toe and then crossed over the medial aspect of the bunionectomy. The gauze was then fixed with a tape for bandaging. All patients were then fitted a postoperative shoe with a rigid sole for a period of 35 days and were then immediately allowed to walk. The first follow-up was performed after two weeks with a radiographic control, suture removal and replacing the bandages always in gentle overcorrection. On the postoperative 35th day, the bandage was removed

Figure 5. Hallux valgus of the left foot treated with PFS. Intraoperative (a) anteroposterior and (b) oblique fluoroscopic images.
PFS: percutaneous foot surgery

**Figure 6. Hallux valgus of the left foot treated with PFS. Corrective bandage application.
PFS: percutaneous foot surgery**

and a silica interdigital separator was applied between the first and the second toe. The patients could fit in a common but large shoe and walk normally bearing full weight. In order to regain the mobility of the first MTP and interphalangeal (IP) joints, patients were given an exercise program. On the 60th day postoperatively, anteroposterior and lateral weight-bearing X-rays were taken [Figure 6].

Statistical analysis

The differences between pre- and postoperative mean values for each parameter were calculated. Student's two-tailed test was performed for statistical evaluation of the AOFAS clinical scores and the mean angle values, and in order to detect the differences of greater or less than 20 degrees in the postoperative HVA in relation to the preoperative IMA.

Results

The mean follow-up time was 46.7 months (range: 23 to 92 months). The mean age at the time of surgery was 62.5 years (95% CI: 60.7-64.3) [Table 1]. The mean HVA was measured as 34.2° preoperatively (95% CI: 31.7-35.9) and 14.4° at the final follow-up (95% CI: 13.4-15.5), showing a significant mean correction of 19.7° (95% CI: 18.5-21; *P<0.0001*). Postoperatively, the mean IMA decreased from 14.8° (95% CI: 14-15.6) to 9.5° (95% CI: 8.8-9.7), showing a significant mean correction of 5.8° (95% CI: 5.2-6.2; *P<0.0001*). The mean DMAA decreased from 8.2°±5° (95% CI: 7-9.4) to 7.7° (95% CI: 6.7-8.7), which meant a mean correction of 0.3° (95% CI: -1.5-0.7; *P=0.498*) [Table 2]. However, the difference was insignificant. The mean AOFAS score jumped to 93.8 (95% CI: 92.4-95.3) from the preoperative mean of 70.2 (95% CI: 65.3-77.1). Patients who had a previous IMA of more than 20° resulted in a mean correction of HVA of 9.8° less on average (95% CI: 6.7-12.9; *P<0.001*) when compared to the group of patients with a preoperative IMA less than 20°. At the final follow-up, we did not observe any recurrences or unhealed osteotomies. None of our cases developed osteonecrosis, infections or significant stiffness. Incomplete correction of deformity was reported in 11 feet (8.9%) resulting in an HVA of more than 20°. We observed 12 feet (9.7%) with a transfer metatarsalgia and two feet (1.6%) with an overcorrection of HV postoperatively.

Table 1. Some characteristics and radiographic measurements of the hallux valgus patients

Characteristics	Mean	IC 95%
Age	62.5	60.7 -64.3
Final follow up (months)	46.7	23-92
HVA	34.2	31.7 – 35.9
IMA	14.8	14 – 15.6
DMAA	8.2	7 – 9.4

DMAA: distal metatarsal articular angle, HVA: hallux valgus angle, IMA: intermetatarsal angle.

Table 2. Comparison of the pre- and postoperative radiographic measurements

	Pre operative (IC 95%)	Final follow up	Difference	*P-value*
HVA	34.2 (31,7- 35,9)	14.4	19.7 (18.5 – 21)	< 0.0001
IMA	14.8 (14 - 15,6)	9.5	5.8 (5.2 – 6.4)	<0.0001
DMAA	8.2 (7 - 9,4)	7.7	0.3 (-1.5 + 0.7)	0.498

DMAA: distal metatarsal articular angle, HVA: hallux valgus angle, IMA: intermetatarsal angle.

Discussion

Our study is a retrospective, single-center and single-surgeon study performed to evaluate the outcomes in patients suffering from mild to severe HV who were treated with PFS without osteosynthesis and were followed up for an average period of 46.7 months. Naturally, it is affected by limitations such as the lack of a control group with similar patients treated with the traditional techniques in the same institution, and the retrospective design. Nevertheless, considering the size of the population involved and the significance of the results, we believe these aspects had partially affected our results. Our functional and radiological outcomes were comparable to those obtained by other authors that performed percutaneous distal osteotomies for HV correction (9, 13). The review of Caravelli *et al.* included four studies in which a total of 717 feet with HV were treated with the percutaneous technique and achieved a correction of approximately 14° in each foot (13). In the review of Bia *et al*., of the 18 studies included, four referred to percutaneous surgery with a total of 504 feet, and a correction ranging from 20° to 30° was achieved (9).

The radiological data revision underlined a lower rate of correction for DMAA, as was the case in other series of the same author (14). Nevertheless, we believe that a good HV correction with no recurrence can be achieved basically when the articular congruency of the first MTP joint is restored, regardless of the DMAA.

The key points of our technique are the absence of internal fixation, the extraordinary features of the osteotomy and the immediate postoperative weight-bearing.

In our series, no recurrences or nonunions were observed. Kadakia *et al.* described a high rate (69%) of nonunion following percutaneous distal osteotomy stabilized with K-wires (15). The author ascribes his results to the loss of correction when the K-wire is removed since it pushes the distal phalanx in an increased varus position maintained only by the K-wire itself. In our technique, the absence of a hardware gives almost immediately the definitive correction, without the risk of overestimation. Since there is no fixation, an instability of the osteotomy leading to a delayed healing may be expected. Nevertheless, we did not observe any case of nonunion. We believe that an osteotomy with a slight obliquity (from dorsal to ventral) provides much more stability than a transverse one, especially during weight-bearing, allowing the MTH to reach its right position.

In our series, we did not observe any cases of osteonecrosis of the MTH. Since Jones *et al.* remarked the importance of preserving the insertions of the MTP capsule in order to maintain the blood supply to the MTH, we always preferred to perform an extraarticular osteotomy (16).

Our clinical results were positive and patients overall were satisfied. When compared to those obtained by other authors both with percutaneous and other techniques, our results varied from theirs. Bauer *et al.* reported a postoperative AOFAS score of 87.5 performing a Reverdin-Isham percutaneous osteotomy, while Trnka *et al.* reported an average of 90 points after open Chevron osteotomy on 89 feet (17, 18).

Percutaneous forefoot surgery without osteosynthesis provides a quick functional recovery with mild to moderate postoperative pain, in addition to other benefits such as the use of local anesthesia, the use of a low-speed burr, the absence of a tourniquet, and the absence of a hardware fixation; all features which reduce the risk of thermal and vascular damage to the bone and soft tissues. Patients can immediately walk with full weight-bearing wearing a rigid sole shoe with mild pain and achieve a quick return to daily activities.

We had no cases of postoperative stiffness of the first MTP joint in our series, which is one of the most feared and reported complications during open correction (18, 19) and is prevented through abundant and frequent lavage. Patients who experienced a transfer metatarsalgia were treated conservatively with adequate supporting insoles; only two cases required further surgical correction.

Interestingly, we observed that patients who had a preoperative IMA of more than 20° reported a lower rate of HVA correction when compared to those who had a previous IMA less than 20°. Moreover, we noticed that patients who had a severe HVA but an IMA of less than 20° still had an acceptable correction during the follow-up period. Therefore, we suggest that the evaluation of both HVA and IMA is of primary importance in order to select the patients who can benefit from our technique, excluding those with an IMA more than 20°, especially when associated to a hypermobility of the first tarsometatarsal joint. For moderate to severe deformity with an IMA of more than 20°, a proximal metatarsal osteotomy should be considered since it allows better correction of the IMA compared to a distal osteotomy (20, 21).

Based on the results of our study we can consider the PFS for HV correction as safe and effective for mild to moderate HV as traditional surgery. Nevertheless it is crucial to be aware of some pitfalls. First of all the first MTT osteotomy should be complete and extra-articular in order to protect the blood supply to the metatarsal head and to permit its free lateral translation. Second, but not less important is the correct indication for PFS: it should be based on a global preoperative evaluation of foot anatomy: we believe that a preoperative IMA < 20 degrees and a good stability of the first tarso-metatarsal joint are crucial for a satisfactory result.

Two key points of the percutaneous technique are the absence of internal fixation and the immediate postoperative weigh bearing, with much more comfort to the patient. However to allow a good positioning of the MTT head during ambulation it is fundamental the orientation of the MTT osteotomy and a correct bandage avoiding the dorsal and/or medial migration of the head.

In conclusion, we can consider PFS without osteosynthesis a safe and effective method for the correction of mild to moderate HV. However, despite its apparent simplicity, this kind of surgery requires appropriate surgical experience and the development of a good tactile sensation, considering that all procedures are performed without direct visualization. A detailed knowledge of foot biomechanics, indications and a significant learning curve to achieve a reproducible performance are necessary for the surgeon to obtain the best possible outcome.

Patient consent: All patients signed an informed consent as participant of the study.

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Giuseppe Restuccia MD SD[1]
Alessandro Lippi MD SD[1]
Sheila Shytaj MD[2]
Federico Sacchetti MD[2]
Fabio Cosseddu MD[2]
1 Ortopedia e Traumatologia, Specialist in Orthopedics and Traumatology Azienda Ospedaliero-Universitaria Pisana Pisa, Italy
2 Department of Orthopaedic and Trauma Surgery, University of Pisa, Italy

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