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ORIGINAL ARTICLE

Reverdin–Isham procedure for mild or moderate hallux valgus: clinical and radiographic outcomes

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Abstract

Background In the last decade, interests in minimal incision surgery have been growing. Theoretically, this kind of procedure could decrease time to recovery and rehabilitation, with a reduction in morbidity. The present study assessed clinical and radiological outcomes and complications of percutaneous surgery for mild-to-moderate hallux valgus using Reverdin–Isham and Akin osteotomies without fixation after 60 months of follow-up.

Methods A series of 48 patients (57 cases) with medium-to-moderate hallux valgus underwent the same percutaneous surgery, between 2003 and 2011. Data collection involved preoperative dorsal flexion, plantar flexion, M1P1, M1M2, DMAA angles, AOFAS scale score, and subjective satisfaction.

Results AOFAS scale score rose from a preoperative median of 55.9–89.2/100 postoperatively ($p < 0.001$); 51 surgical procedures (89.5%) were considered as satisfactory or very satisfactory by patients at the end of follow-up. Hallux valgus and distal metatarsal articular angle (DMAA) were significantly reduced (29.3° and 14.1°–15.4° and 7.7°, $p < 0.001$, respectively). There was a significant increase in MTPJ 1 stiffness ($p < 0.001$).

Discussion Percutaneous correction by Reverdin–Isham and Akin osteotomies seems to be effective in isolated medium-to-moderate hallux valgus. Stiffness observed is comparable to other percutaneous and open procedures but needs to be compared in a randomized controlled clinical trial to extra-articular percutaneous procedures without capsule detachment in association with an internal fixation which allows an early mobilization.

Level of clinical evidence IV.

Keywords Hallux valgus · Percutaneous osteotomy · Reverdin–Isham · MIS

Introduction

Hallux valgus is a frequent deformity of the first ray of the forefoot. It associates first phalanx abduction and pronation, first metatarsal adduction, pronation and elevation, and lateral capsuloligamentary retraction of the metatarsophalangeal joint (MTPJ 1) of the first ray. Surgical correction is recommended when pain and difficulty with footwear appear. Many procedures have been described, including many first metatarsal osteotomy procedures. Distal metatarsal osteotomy is recommended to correct mild-to-moderate deformity with inter-metatarsal angle (IMA) not exceeding 16° or to correct the distal metatarsal articular angle (DMAA) [1]. In the last decade, the interest of minimal invasive surgery (MIS) has been growing: This has the theoretical advantages of decreasing time to recovery and need for rehabilitation and morbidity [2–4]. Minimally invasive or percutaneous protocols have been described for distal first metatarsal osteotomy, with or without osteosynthesis [1, 4–6]. Reverdin–Isham osteotomy is a percutaneous procedure without fixation, which enables alignment the first ray by medial translation of the first metatarsal head and DMAA correction [3]. This present study assessed clinical and radiological results of percutaneous correction of hallux valgus by Reverdin–Isham and Akin osteotomies at 60 months of follow-up.

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Methods

Between May 2003 and November 2011, 90 patients underwent the same first ray procedure following Isham's technique [3]. Surgery was indicated for painful hallux valgus with functional impact and difficulty with footwear. A percutaneous procedure was indicated for mild-to-moderate deformity: hallux valgus angle (HVA angle) up to 40° and inter-metatarsal angle (IMA angle) up to 16°. Patients with MTPJ 1 osteoarthritis or a previous forefoot surgery were excluded of this study. We excluded 42 patients of the statistical analysis because of an early death ($n=1$), a follow-up under 1 year ($n=25$) or unexploitable X-ray and clinical data ($n=16$). A total of 48 patients (43 females and 5 males) were included, among which nine underwent a bilateral procedure. At least 57 cases were managed by the same percutaneous technique (Fig. 1).

Surgical technique

The patient was installed in supine position, without a tourniquet. A 3-mm incision on the medial and plantar edge of the first metatarsal head was followed by capsule detachment to obtain a working space (Fig. 2a). First, the medial and dorsal protrusion of the first metatarsal head was removed by a conical burr operated on a drill at low speed. Bone resection was monitored under fluoroscopy and pursued up to the functional joint surface of the first metatarsal head, outside the medial sagittal groove. Bone fragments were expelled by manual pressure and with saline serum injection through the incision. In the second stage, first metatarsal Reverdin–Isham osteotomy was performed using a

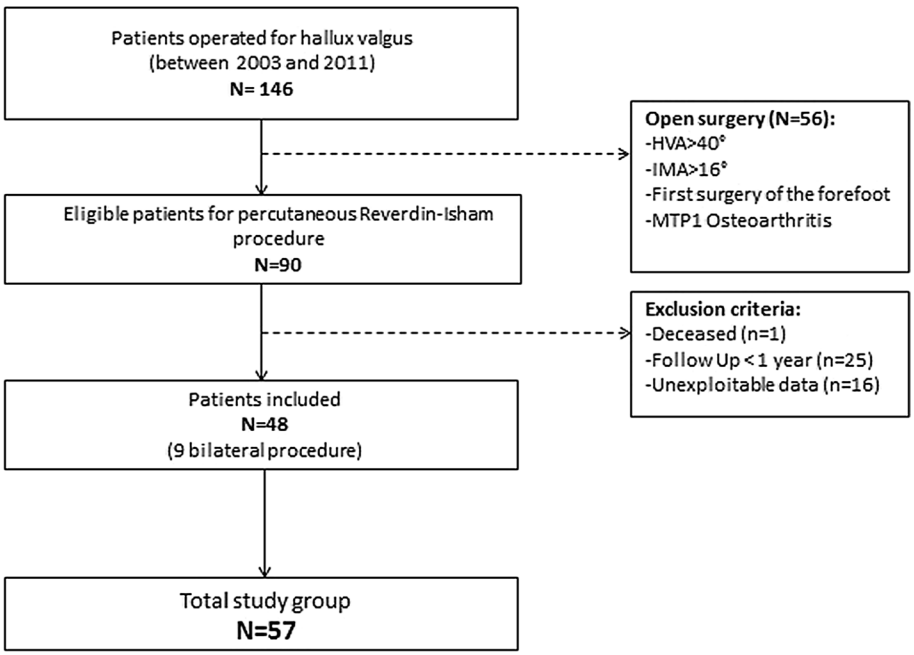

Fig. 1 Patient flowchart

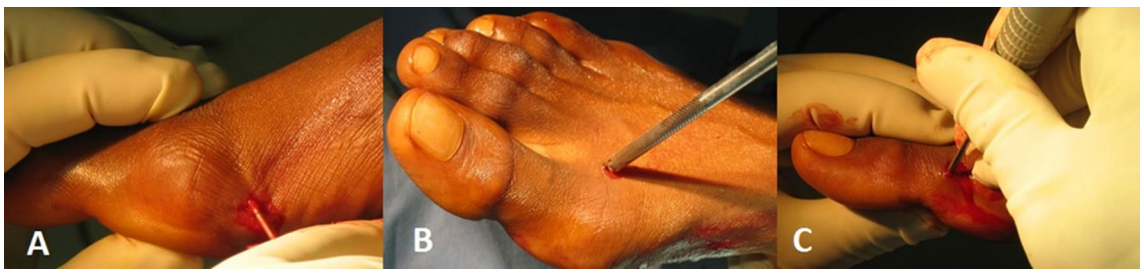

Fig. 2 **a** Medial and plantar incision with capsule detachment for exostosectomy and closing-wedge medial osteotomy of the first metatarsal head. **b** Lateral capsuloligamentary release of the metatarsophalangeal joint was associated with a tenotomy of the adductor hallucis tendon by the Beaver. **c** Dorsomedial approach is realized medially to the extensor hallucis longus tendon for the variation osteotomy of the first phalanx

straight burr (Shannon) through the same medial approach. The medial closing-wedge osteotomy of the first metatarsal distal metaphysis, parallel to the joint surface, was carried out from dorsal, just behind the joint space, to plantar, and from distal to proximal, behind the sesamoid bones, with a slope of 45°. The lateral cortex was preserved. The hallux was then forced in abduction, by medial closure of the Reverdin–Isham osteotomy with DMAA correction. In the third step, lateral capsuloligamentary release of the metatarsophalangeal joint was performed in association with a tenotomy of the adductor hallucis tendon by a Beaver mini-blade through a second dorsolateral approach facing the metatarsophalangeal joint line (Fig. 2b). The final step included variation osteotomy of the first phalanx, through a third dorsomedial approach, 3 mm medially to the extensor hallucis longus tendon (Fig. 2c). The same short straight burr was used for proximal metaphyseal osteotomy of the phalanx, under fluoroscopy, preserving the lateral cortex. Correction was obtained by medial closure of the osteotomy with the hallux forced in valgus. No fixation was performed. The correction was maintained by postoperative dressing in slight hypercorrection to keep the osteotomies closed. Initial dressing was maintained for 15 days and was then changed for a dressing with a cohesive bandage with an arthroplasty maintaining the first ray aligned for 1 month. Complete weight-bearing was allowed immediately, with a rigid flat-soled orthopedic shoe for the first month. Preventive anticoagulation was prescribed for 10 days. Metatarsophalangeal joint mobilization was authorized after the first dressing was removed (15th day).

Evaluation criteria

Pre- and postoperative functional American Orthopedic Foot and Ankle Society (AOFAS) [7, 8] scores were calculated in all cases. Passive MTPJ 1 mobility (sum of dorsal and plantar flexion) was measured with a manual goniometer, patient in supine position, the ankle in neutral position, and the knee in extension. Other parameters were also recorded: patient satisfaction (very satisfied, satisfied, dissatisfied or disappointed) and complications.

Anteroposterior (AP) weight-bearing X-rays were taken preoperatively, postoperatively, and at end of follow-up. Several manual measurements were made on each X-ray, by two senior consultants (one radiologist and one orthopedic surgeon): hallux valgus angle (M1P1 angle), metatarsus varus angle (M1M2 angle), first metatarsal distal joint surface orientation angle (DMAA), and metatarsal index (index plus, index plus–minus, index minus; Fig. 3). All these data were anonymously collected and analyzed in an Excel (Microsoft, Richmond, WA, USA) spreadsheet. The protocol obtained ethical approval by the CNIL (National Commission on Informatics and Liberty).

Statistical analysis

Normal distribution was assessed for quantitative variables using Shapiro–Wilk *W* test. Pre- and postoperative data were compared using two-tailed paired *t* tests. Quantitative variables were expressed as mean followed by extreme values (minimum–maximum) or by standard deviation. The difference was considered significant when $p < 0.05$.

Results

Mean age was 51.5 years (range 13.5–80.1). The mean duration of follow-up was 60.1 months (range 12–132). Patients' characteristics and surgical data are summarized in Table 1.

Clinical results

Mean MTP1 joint preoperative mobility was 74.7° ± 14.2° in dorsiflexion and 23.3° ± 8.1° in plantar flexion. Postoperatively, it was 58.2° ± 18.8° in dorsiflexion and 13.3° ± 10.8° in plantar flexion ($p < 0.05$) (Table 2).

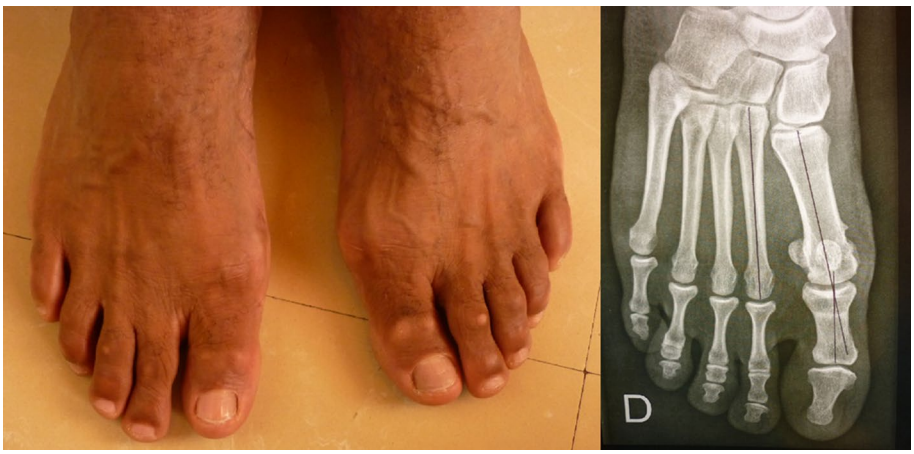

Fig. 3 Postoperative radiological and clinical aspect of a right side percutaneous procedure using Reverdin–Isham osteotomy (2 years of follow-up)

Table 1 Statistical description of the case series ($n=57$ cases in 48 patients)

	$n=57$
Age at surgery (years)	
Mean	51.5 ± 6.9
Range	13.5–80.1
Sex ($n=48$)	
Male	5 (10.4%)
Female	43 (89.6%)
Preoperative ASA score ($n=48$)	
1	27 (56.2%)
2	18 (37.5%)
3	3 (6.2%)
BMI ($n=48$)	
Mean	23.3 ± 4.9
Range	15.0–39.0
Radiologic Metatarsal Index	
Minus	44 (77.2%)
Plus	2 (3.5%)
Minus plus	11 (19.3%)
Forefoot form	
Roman	13 (22.8%)
Egyptian	37 (64.9%)
Greek	7 (12.3%)
Follow-up (months)	
Mean	60.1 ± 16.8
Range	12–132

AOFAS score improved significantly, from a preoperative mean of 55.9/100 ± 15.5 to 89.2/100 ± 9.8 postoperatively ($p<0.05$). All items in the AOFAS scale score (pain, function, alignment) showed significant improvement. Fifty-one surgical procedures (89.5%) were considered as satisfactory or very satisfactory by patients at the end of follow-up.

The preoperative foot shape was Greek in 12.3% ($n=7$), Roman type for 22.8% ($n=13$), and Egyptian type for 64.7% ($n=37$). The foot shape after surgery was: Egyptian in 33.3% ($n=19$), Greek in 33.3% ($n=19$), and Roman in 33.3% ($n=19$).

Radiological results

X-ray analysis found a significant reduction in hallux valgus, with a mean HVA angle of 29.3° ± 7.1° preoperatively and of 15.4° ± 6.4° postoperatively ($p<0.05$). The mean inter-metatarsal IMA angle decreased from 13.5° ± 3.1° preoperatively to 12° ± 2.8° postoperatively (not significant). The DMAA decreased from 14.1° ± 6.9° preoperatively to 7.7° ± 5.7° postoperatively ($p<0.05$; Table 2). We found 94.7% ($n=54$) of postoperative metatarsal index minus (against 77.2% preoperatively, $n=44$), and 1.8% ($n=1$) of postoperative index minus plus (19.3% preoperatively, $n=11$).

Complications

We report a total of 15 patients (26.3%) with complications. Four patients complained of transfer metatarsalgia. There was one deep vein thrombosis, five cutaneous delayed healing, two recurrences, and three transitory hypoesthesia next to the head of the first metatarsal. There were no cases of non-union or osteonecrosis.

Discussion

Percutaneous correction of mild-to-moderate hallux valgus by Reverdin–Isham osteotomy provided significant functional, clinical, and radiological improvement, comparable to results from other open or percutaneous first ray distal metatarsal osteotomy procedures, with or without fixation [4–6, 9, 10]. As highlighted in the literature, the satisfaction obtained with percutaneous Reverdin–Isham osteotomy in our study (89.5%) is comparable to those obtained with conventional percutaneous techniques and open surgical procedures [9, 11–20].

This percutaneous procedure proved efficient in correcting mild-to-moderate deformity, achieving a mean

Table 2 Comparison of the preoperative and postoperative radiographic measurements, MTP mobility and AOFAS score

Outcomes	Preoperative	Postoperative	Δ	95 CI	*p* value
IMA	13.5 ± 3.1	12 ± 2.8			0.07
DMAA	14.1 ± 6.9	7.7 ± 5.7	− 6.4	− 4.6 to − 8.2	**< 0.0001**
DM2A	5.8 ± 5.5	5.5 ± 4			0.71
HVA	29.3 ± 7.1	15.4 ± 6.4	− 13.9	− 12.1 to − 15.7	**< 0.0001**
P1P2	4.9 ± 5.6	6.3 ± 5.6			0.13
Dorsal flexion	74.7 ± 14.2	58.2 ± 18.8	− 16.5	− 11.5 to − 21.5	**< 0.0001**
Plantar flexion	23.3 ± 8.1	13.3 ± 10.8	− 10	− 6.4 to − 13.6	**< 0.0001**
AOFAS score	55.9 ± 15.5	89.2 ± 9.8	+ 33.3	+ 29 to + 37.6	**< 0.0001**

Bold values indicate items with a significant improvement

postoperative HVA of 16°. It reduces DMMA but is not efficient to correct M1M2. That is why it seems to be restricted to isolated IMA ≤ 16°. Furthermore, in other osteotomies (in particular double osteotomies) fixation is needed with the resulting risk of recurrence and infection [6, 9, 19, 21–23].

In the study by Cervi et al. [24], DMMA overcorrection was the major complication. These results could be attributed to fractures of 12 first metatarsal and 9 first phalanx among 184 operated feet, due to an intraoperative rupture of the lateral cortex. No fractures and overcorrection were observed in our experience at 5 years of follow-up. Moreover, we had 4 transfer metatarsalgia cases attributable to first metatarsal shortening and difficulty to control the plantar displacement. The four patients had a preoperatively plus–minus metatarsal index and a postoperatively minus metatarsal index. The main risk associated with the Reverdin–Isham and the Chevron osteotomies is excessive shortening of the first metatarsal, owing to the thickness of the burr [25]. In this recent review of literature about percutaneous distal osteotomies [25], the mean amount of shortening was 2–7 mm, but none of the investigators correlated the shortening with worse clinical outcomes. However, the «V» or «L» shape of the cut used in the chevron osteotomy, associated with internal fixation, can prevent an unexpected elevation [6, 26].

According to Bauer [1], the technique also lacks precision in the case of associated lateral metatarsal osteotomies, with a risk of DMAA overcorrection and an elevated risk of first MTP joint non-congruency. In this case, he proposes another first ray technique: conventional (Scarf, chevron), or minimally invasive or percutaneous chevron osteotomy, with or without fixation [10].

We noted a global postoperative MTPJ 1 stiffness: percutaneous techniques theoretically reduce the risk of stiffness, due to the limited approach, and especially in case of extra-articular metatarsal osteotomy [4, 27]. Percutaneous Reverdin–Isham osteotomy may induce stiffness, due to the capsular detachment and the extensive intra articular medial resection of the metatarsal head [3]. In addition, the need for abundant washing of the working space should be stressed. Bone debris could induce an inflammatory reaction, with fibrosis and stiffening. Magnan et al. [4] reported stiffness of the MTPJ 1 in 9.8% after a subcapital distal linear percutaneous osteotomy with a *K*-wire stabilization. Unlike our Reverdin–Isham osteotomy protocol, the extra-articular character of the percutaneous chevron added to the absence of immobilization of the MTPJ 1 postoperatively due to fixation could decreased MTPJ 1 stiffness [2, 6].

We observed five delayed wound healing cases without infection. It has been shown that rotatory burrs should be operated at low speed with discontinuous cutting, less than 20 s for each sequence to avoid risks of skin burn [28].

Our high rate of complications (26.6%) has been observed at the beginning of the series. Unlike other authors, we included cases of delayed wound healing because it represents an important part of our postoperative complications (33%, $n = 5$). Angthong et al. [29] observed 25% of recurrence of valgus deformity, while we found only 3.5% in this study ($n = 2$). [10, 30, 31], five metatarsalgia were observed (8.8%), according to what can be found in the literature. Rotatory burrs could be responsive of bone shortening and bone loss inducing transfer metatarsalgia [32].

Conclusion

If proper surgical indications are respected, Reverdin–Isham percutaneous osteotomy is a safe and effective procedure for correcting symptomatic mild-and-moderate hallux valgus. However, there is a risk of MTPJ 1 stiffness and first metatarsal shortening with transfer metatarsalgia. Postoperative stiffness observed in this study is comparable to other percutaneous and open procedures but needs to be compared in a randomized controlled clinical trial to extra-articular percutaneous procedures without capsule detachment in association with an internal fixation that allows an early mobilization.

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Compliance with ethical standards

Conflict of interest All authors declare that they have no conflict of interest.

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