Acta Orthop. Belg., 2009, **75**, 661-670

ORIGINAL STUDY

Treatment of hallux valgus deformity : Preliminary results with a modified distal metatarsal osteotomy

Naeder Helmy, Patrick Vienne, Arndt von Campe, Norman Espinosa

From Balgrist Hospital, University of Zurich, Zurich, Switzerland

This study aimed to investigate the preliminary results achieved with a modified distal first metatarsal osteotomy (reversed L-shaped) for correction of moderate and severe hallux valgus deformities.

This prospective study included 31 patients (39 feet) with a mean age of 56 years. All patients underwent a reversed L-shaped osteotomy of the first metatarsal. At follow-up all patients were reviewed clinically and radiologically. Patients were categorized into two groups (MTP angle A : < 20°, and B : 20-40°).

The AOFAS score improved from 53 points to 91 points at follow-up ($p < 0.0001$). Group A showed an increase from 56 to 90 points ($p = 0.003$), group B from 52 to 92 points ($p < 0.0001$). The mean 1-2-intermetarsal angle (IMA) decreased from 12.5° preoperatively to 8° at follow-up ($p < 0.005$) : from from 11° to 9° in group A ($p = 0.09$) and from from 13° to 7° in Group B ($p < 0.0001$). No nonunion or avascular necrosis was observed. One diabetic patient developed a resistant postoperative infection.

The L-shaped osteotomy provided good and excellent clinical as well as radiological results in the mild and moderate-to-severe hallux valgus deformities treated. The mid- and long-term effect of this type of osteotomy needs to be further investigated.

Keywords : hallux valgus ; metatarsal ; osteotomy.

INTRODUCTION

The degree of the hallux valgus deformity has implications on the surgical treatment. Mild deformities, with a metatarso-phalangeal angle (MTPA) up to 30° and an intermetatarsal angle (IMA) less than 13°, can be treated by distal metatarsal osteotomies only (e.g. chevron osteotomy), whereas moderate deformities, with an MTP angle up to 40° and IM angle more than 13°, require a more proximal metatarsal correction, e.g. scarf osteotomy or proximal crescentic osteotomy (*9*). The chevron, as well as the more diaphyseal and proximal scarf osteotomy have become popular among European orthopaedic surgeons (*2*). The chevron osteotomy is easy to perform and is associated with good clinical and cosmetic results. However, due to the small contact areas provided by the osteotomy, its use is limited to mild and moderate deformities.

■ Naeder Helmy, MD, Orthopaedic Surgeon, Department head.
Department of Orthopaedics, Bürgerspital Solothurn, Solothurn, Switzerland.
■ Patrick Vienne, MD, Orthopaedic Surgeon.
■ Arndt von Campe, M.D, Orthopaedic Surgeon.
■ Norman Espinosa, MD, Orthopaedic Surgeon, Head of Foot and Ankle Surgery.
Department of Orthopaedics, University of Zurich, Balgrist Hospital, Zurich, Switzerland.
Correspondence : Naeder Helmy, Department of Orthopaedics, Bürgerspital Solothurn
Schoengruenstrasse 42, CH-4500 Solothurn, Switzerland.
E-mail : nhelmy_so@spital.ktso.ch

No benefits or funds were received in support of this study

The scarf technique in contrast, provides large contact areas, which allow sufficient shift of the fragments to correct severe hallux valgus deformities. However, a decreased primary stability in the sagittal plane could be observed (*1*). Short-term outcomes after the modified chevron- and scarf-osteotomies have demonstrated good to excellent results (*11,12,30*). Both surgical techniques, however, can be associated with serious complications such as transfer metatarsalgias, recurrence of hallux valgus or undercorrection (*2,5,23,27,28*). Besides the functional outcome, cosmetic aspects (e.g. large incisions needed for the scarf) might play an important role in patient satisfaction as most of the patients treated for hallux valgus deformity are women (*26*).

More recently, we modified the Reverdin-Todd procedure (reversed-L-shaped osteotomy) in order to provide an easy and standardized technique, that allows maximal correction with enhanced stability and at the same time minimizes the complication rate and cosmetic disturbances (*4*). Previous mechanical analyses showed that this type of osteotomy provides similar stability as the classic chevron osteotomy as well as a corrective potential similar to the scarf osteotomy (*40*).

Based on those findings we conducted a prospective study to further investigate the preliminary clinical and radiological outcome and feasibility of that technique for the treatment of mild and moderate-to- severe hallux valgus deformities in the clinical setting.

MATERIAL AND METHODS

All patient data and outcome parameters were prospectively collected and subsequently analyzed. Thirty-six patients (44 feet) underwent a reversed-L-shaped osteotomy for the treatment of symptomatic hallux valgus deformity. All operations were performed between March 2000 and September 2001.

In order to achieve a homogenous population, specific inclusion criteria were defined : a painful hallux valgus deformity with a metatarsophalangeal angle up to 40° with complete clinical and radiographic documentation, including the American Orthopedic Foot and Ankle Society-score (AOFAS), weight bearing dorsoplantar and lateral views of the feet ; a minimum follow-up of 24 months.

Exclusion criteria included : Hypermobility of the first ray ; an intermetatarsal angle greater 20° ; a metatarso-phalangeal angle greater than 40° ; an additional Akin procedure in order to correct the greater toe alignment ; any major foot and ankle deformity (e.g. severe flatfoot ; cavus foot) ; arthritic degeneration of the first metatarso-phalangeal joint ; systemic diseases (e.g. rheumatoid arthritis) ; neoplasia ; neurological diseases and generalized metatarsalgia.

Eight patients were lost to follow-up : three patients died due to medical reasons not related to surgery (mean age 67 years ; range 56-80 years). One patient moved abroad ; one refused to participate in the study, three patients had an incomplete clinical and radiographic documentation. Finally, 28 patients (36 feet) participated in the study. Twenty-seven females and one male with an average age of 55 years (22-85) were included in the study. The mean follow-up averaged 33 months (range 25 to 42). Patient demographics are shown in table I.

With respect to Coughlin's classification of mild and moderate hallux valgus deformities and in order to estimate the corrective potential of the osteotomy, the patients were divided into two groups according to their MTP angles (*10*) : Group A (8 feet) included patients with an MTP angle up to 20° and Group B (28 feet) included those with MTP angles ranging from 21° to 40°.

Every patient gave written informed consent and the institutional review board of our Hospital approved the study.

Surgical technique and postoperative management (*13*)

The patient is placed in the supine position and a tourniquet is applied at the shank. After routine draping, a 3 to 4 cm longitudinal incision medially over the first metatarso-phalangeal joint with a longitudinal capsulotomy is performed. Subsequently the plantar capsule at the base of the first metatarsal head is released by sharp dissection. Injury to the vessels entering the metarsal head from plantar must be avoided. Plantarflexion of the greater toe facilitates exposure of the plantar aspect of the first metarsal head. Next, the dorsal aspect of the distal metatarsal is addressed. The great toe is dorsiflexed to relax the capsular tissue and to improve visualization. During exposure of the dorsal aspect of the distal metatarsal it is important to limit the exposure posterolaterally, to prevent injury to the vascular supply of the metatarsal bone. The lateral capsule is released through the same medial approach. The blade of the scalpel is held towards the shaft of the second metatarsal bone and

Table I. — Patient demographics (n=28, 36 feet)

	Patient	Age	Gender	Side	MTP I° preop	IM I-II° preop	Sesamoid preop	Concomitant diagnosis	Simultaneous procedure
1	IC	22	F	r	23	13	5		
2	VC	27	F	l	25	14	5		
3	HLS	32	F	l	21	11	4		
4	MY	35	F	l	16	10	4	Hammer toe V	Girdlestone-Taylor V
5	BS	35	F	r	17	11	3		
6	BS	35	F	l	24	11	3		
7	SE	44	F	r	23	13	5		
8	SE	44	F	l	24	12	3		
9	BK	45	M	r	23	11	3	Pes cavus	
10	GO	46	F	r	25	13	4		
11	PY	48	F	r	7	7	3	Hammertoe V	Girdlestone-Taylor V
12	PY	48	F	l	14	8	5	Hammertoe V	Girdlestone-Taylor V
13	MM	50	F	r	26	13,5	5	Hallux valgus recurrence	
14	SE	54	F	r	25	15	6		
15	SE	54	F	l	26	15	5		
16	RK	54	F	r	26	13,5	5		
17	RK	54	F	l	28	13	4		
18	HA	55	F	r	13,5	12	3		
19	GG	58	F	r	19,5	12,5	4		
20	PMT	58	F	l	28	15	7	Tailor's bunion V	Buniectomy V
21	FR	59	F	r	30	12	5	Hamertoes II-V, tailor's bunion V	Girdlestone-Taylor II-V, Coughlin osteotomy V
22	FR	59	F	l	36	15	7	Hamertoes II-V, tailor's bunion V, unguis incarnatus I	Girdlestone-Taylor II-V, Coughlin osteotomy V
23	ZU	60	F	l	25	18	5	Hammertoe II & V, Unguis incarnatus I, Morton Neuroma II/III & III/IV	Girdlestone-Taylor & Hohmann osteotomy II and V, Kocher procedure, neurectomy II/III & III/IV
24	PM	61	F	l	14	8	3	Lisfranc osteoarthrosis, pes planus,	
25	PM	61	F	r	22	10	4	Lisfranc osteoarthrosis, pes planus,	
26	CA	62	F	l	24	17,5	7	Hammertoe II, pes planus,	Girdlestone-Taylor II
27	BR	65	F	l	19,5	9	3	Subtalar pseudarthrosis, Mortom Neuroma III/IV	Subtalar rearthrodesis, neurectomy III/IV
28	SD	67	F	r	28	16	5	Hammertoe and tailor's bunion V, had osteotomy MT V	Hohmann osteotomy V
29	KT	68	F	l	21,5	16	7		
30	HM	70	F	l	19	16	5	Status after ankle distorsion	
31	BE	70	F	l	25	10	4	Hammertoes II-V	Girdlestone-Taylor & Hohmann osteotomy II-IV
32	KS	71	F	l	27	10	3	Hammertoes II-V	Girdlestone-Taylor II-V
33	KS	71	F	r	36	12	5	Hammertoes II-V	Girdlestone-Taylor II-V
34	TA	78	F	r	29	14	6	Hammertoe II-III	Girdlestone-Taylor & Hohmann osteotomy II-III
35	SN	80	F	l	27	6	5	Hammertoe II-III	Girdlestone-Taylor II-III
36	HF	85	F	r	39	13	5	Hammertoe II	Hohmann osteotomy II

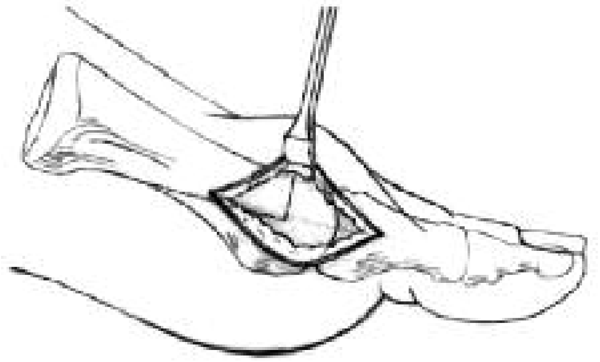


Fig. 1. — The image depicts the medial approach to the metatarso-phalangeal joint. The incision averages 3 centimeters. The capsule is exposed and longitudinally incised. Care is taken not to injure the cutaneous branch of the superficial peroneal nerve. We usally use a cautery to mark out the L-shaped osteotomy.

in 20° of dorsoplantar inclination. The lateral capsule is then longitudinally incised. Adductor tenotomy is usually not performed. The apex of the reversed-L-shaped osteotomy is placed midway between the dorsal and plantar aspect of the first metatarsal head and is approximately 10 mm proximal to the metatarso-phalangeal joint line (fig 1). We advise marking the osteotomy with the cautery before the definite cut is performed. The osteotomy starts with a short dorsal arm that is directed vertically to the ground (a metal cover of the instrument box can be pressed onto the planta pedis in order to find the ground plane) but perpendicular to the shaft of the second metarsal bone. This avoids shortening or lengthening of the first metatarsal (fig 2). The second cut, i.e. the long plantar arm, is made parallel to the floor plane and perpendicular to the first cut. It should exit the plantar cortex of the first metatarsal approximately 30-40 mm proximal to the apex. In cases with an abnormal distal metatarsal articular angle (DMAA), an additional medial wedge can be resected on the dorsal arm to achieve biplanar correction. The distal head fragment is displaced laterally, between half and two thirds of the width of the head depending on the correction needed to re-center the sesamoid bones, and the osteotomy is fixed with one 2.4 mm cortical lag screw which is inserted from dorsal proximal to plantar distal (fig 3). For bilateral corrections we also use two 2.4 mm cortical lag screws, one in the metatarsal head and the other slightly more proximally, exiting plantarly through the metatarsal cortex. The medial bony prominence on the metatarsal head (pseudo-exostosis) is resected in line with the medial cortex of the metarsal. Application of bone wax on the resected area avoids excessive postoperative bleeding. Care is taken not to injure the branch of the superficial peroneal nerve. The overhang of the capsule is trimmed, and subsequently reefed with single oblique absorbable monofilament sutures. The skin is closed in a usual manner (fig 4). The patient is immediately mobilized in a postoperative shoe with a rigid sole for a total of six weeks. Patients are instructed how to apply the dressing to assure correct position of the greater toe for six weeks.

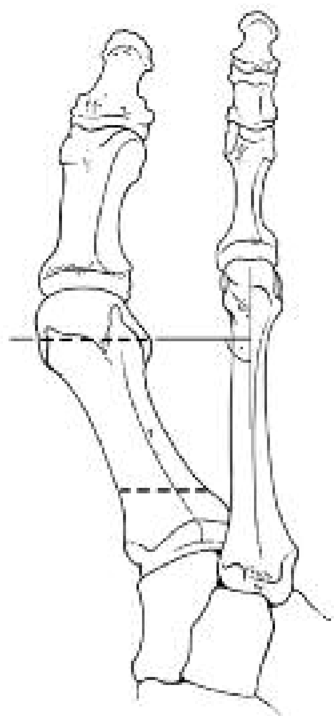


Fig. 2. — In order to avoid metatarsal shortening the dorsal cut is made perpendicular to the long axis of the shaft of the second metatarsal bone.

Clinical evaluation

Preoperatively and postoperatively each patient was clinically evaluated, interviewed and the AOFAS forefoot score was assessed (*21*). To evaluate range of motion we measured plantarflexion and dorsiflexion of the MTP I preoperatively and at follow-up while holding the ankle joint in a neutral position. To evaluate postoperative stiffness the range of motion in the MTP joint acoording to the AOFAS Score was recorded. Standard goniometry was used to measure range of motion, each measurement

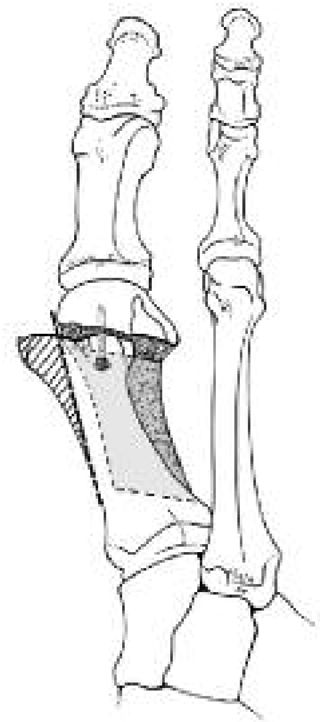
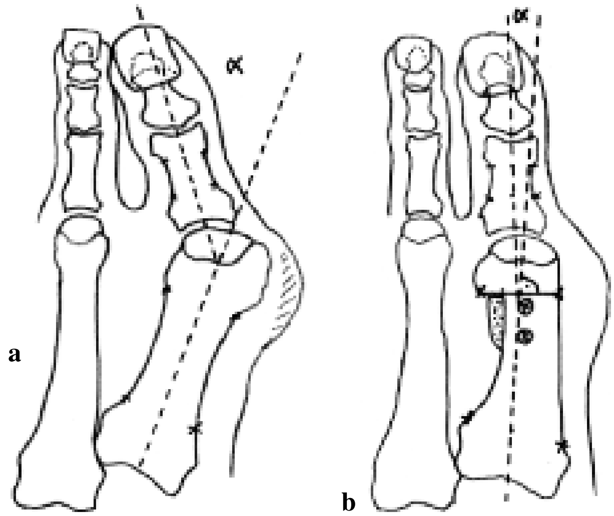


Fig. 4. — For closure of the capsule a duplication technique is used to assure a tight fit. The excess of the superior part of the capsule is excised after closure.



Figs. 5a & b. — The figures demonstrate the method of metatarsophalangeal angle measurement. Figure 5a depicts the preoperative assessment according to Coughlin *et al*.
Figure 5b shows the postoperative assessment. As reproducible landmarks for defining the diaphyseal axis, distally, the medial and lateral endpoints of the dorsal cut edge were chosen and the midpoint was defined. At the proximal diaphyseal shaft the midpoint was set as described by the method of Coughlin et al. The postoperative diaphyseal axis was obtained by drawing a line between the distal and proximal midpoints. The intersection between the midlines running through the proximal phalanx and the first metatarsal defined the metatarsophalangeal angle.

was performed three times and the arithmetic mean was used for the study. Every patient had to give subjective ratings for the preoperative as well as follow-up status. The ratings were categorized into good-to-excellent, moderate and poor.

Radiographic evaluation

Reproducible standard weight bearing dorsoplantar and lateral radiographs of the foot with the X-ray tube inclined 20° in the cranio-caudal direction were taken before surgery, and at final follow-up (33 months postoperatively ; range : 25-42). All radiographs were analyzed by the metaphyseal/diaphyseal reference point technique as previously described by Coughlin and Freund (*8*). The metatarso-phalangeal angle was measured by drawing a line bisecting the metatarsal shaft as well as the proximal phalanx of the big toe (fig 5). The intermetatarsal angle is determined by measuring the angle between two lines bisecting the shafts of the first and second metatarsals. Sesamoid position underneath the metarsal head was evaluated using the classification system of Hardy and Clapham (*17*).

Statistical analysis

Statistical analysis of the results was undertaken to determine whether any of the outcome parameters changed significantly over time. A non-parametric distribution was assumed. To evaluate the statistical significance of each measured variable from the preoperative to postoperative values within each group, the nonparametric, paired Wilcoxon signed rank test was used. The Spearman's rho-correlation matrix was used to determine any relation between specifically chosen variables. The level of significance was set at $p = 0.05$. All statistical analyses were performed with the SPSS statistical program, (SPSS Inc. Chicago, USA).

RESULTS

Clinical results

The AOFAS score for the entire study group improved significantly ($p < 0.0001$) from 53 points (35 to 78) preoperatively to 91 points (70 to 100) at follow-up. Group A showed a significant improvement of the AOFAS score from 56 points (35 to 70) to 90 points (70 to 100) ($p = 0.003$). The AFOAS in group B increased significantly from 52 to 92 ($p < 0.0001$). No significant decrease in either dorsiflexion or plantarflexion or overall range of motion was found ($p > 0.05$). Dorsiflexion averaged 41° (SD ± 8.35) preoperatively and 35° (SD ± 8) at follow-up. Plantarflexion averaged 34° (SD ± 10) preoperatively and 25° (SD ± 16) at follow-up. Twelve feet showed a decrease in the range of dorsal extension/plantarflexion by dropping one rank in the subgroup of the AOFAS, whereas two feet moved one rank up.

Eighty-seven percent of the feet were rated as good-to-excellent, three as moderate and 2 as poor. The latter two patients pertained to Group B. Both patients presented with a slight residual hallux valgus deformity at follow-up.

Radiographic results

The hallux valgus (HV) angle of the entire group decreased significantly from 24° (16° to 39°) preoperatively to 13° (6° to 20°) at follow-up ($p < 0.005$). The HV-angle in Group A improved from 17° (16° to 20°) preoperatively to 10° (6° to 15°) at follow-up ($p < 0.0001$), whereas Group B showed a decrease from 27° preoperatively (21° to 39°) to 14° (6° to 20°) at follow-up ($p < 0.0001$). The 1-2nd-intermetarsal angle (IMA) of the entire group decreased from 12.5° preoperatively (6° to 18°) to 8° (4° to 13°) at follow-up ($p < 0.005$). The IMA in Group A improved from 11 ° (7° to 16°) preoperatively to 9° (4° to 12°) at follow-up ($p = 0.09$). The IMA in Group B improved from 13° preoperatively (10° to 18°) to 7° (4° to 13°) at follow-up ($p < 0.0001$). There was no significant loss of correction at last follow-up ($p < 0.005$). Sesamoid position in Group A has been corrected from a preoperative stage of 3.6 back to 3.25 postoperatively (p = n.s.). In Group B we found a greater correction from 4.8 preoperatively to 3.5 postoperatively ($p < 0.05$). No non-unions, mal-unions or osteonecroses have been found. A typical radiographic result at two years postoperatively is shown in figure 6.

Fig. 6a & b. — a. Preoperative radiograph of a painful hallux valgus deformity (HV angle : 36°, I-II IMA : 18°) in a 40-year-old female patient ; b. Two-year result after correction of the hallux valgus deformity through distal osteotomy (HV angle : 4°, I-II IMA : 4°).

Complications

There were two intraoperative fractures of the first metatarsal head due to technical difficulties, which were immediately fixed during surgery ; the fractures healed uneventfully. In five patients screw removal was necessary after 6 to 12 months due to chronic capsular irritation.

DISCUSSION

In 1881 Reverdin was first to describe his bicorrectional metatarsal head osteotomy in order to correct mild to moderate hallux valgus deformities and their abnormal proximal articular set angles (*33*). Since its introduction several modifications have been made to the original procedure. Green in 1977 added a plantar and horizontal cut focusing on prevention of disruption of the first metatarsal sesamoid articulation rather than avoiding injury to the plantar blood vessels (*4*). The lateral cortex was not cut. This was later modified by Laird who performed the same osteotomy as published by Green but with transsection of the lateral cortex (*22*). Todd introduced a new technique based on the Reverdin-Laird procedure describing a method quite similar to that used in the current study (*4*). Despite its intrinsic stability and versatility the Reverdin-Todd procedure has never become very popular. In contrast the chevron osteotomy became widely used to treat mild hallux valgus deformities. The classic chevron osteotomy is a simple and effective method with good-to-excellent results in the mid- and long-term but its use is limited to mild to moderate hallux valgus deformities (*7*). Although there is a small effect on the intermetatarsal angle (IMA) the latter cannot be substantially altered because of the small bony contact surfaces offered by the design of the osteotomy. Interestingly, a smaller IMA preoperatively has been associated with a better overall satisfaction rate and outcome after chevron osteotomy (*34,35*). Recurrence after chevron osteotomy has been reported in up to 20% of cases ; together with undercorrection of the deformity, it represents the most frequent complication. Avascular necrosis, however, is the most serious complication and rates between 4% and 20% have been reported (*20,24,25*). To overcome problems such as malunion, nonunion, malpositioning of the sesamoids or avascular necrosis, various modifications have been introduced. They include changes in shape of the osteotomy, fixation technique and additional lateral release (*15,18,19,25,28,29,32,36,37,39*). Because of the limitations seen with the chevron osteotomy moderate to severe hallux valgus deformities with greater intermetatarsal angles are usually treated with more proximal osteotomies. The advantage of the scarf osteotomy, popularized by Weil and Barouk, is that the large bone fragments assure a greater contact area thus allowing better and larger correction of the deformity (*3*). The scarf osteotomy, however, is technically demanding and various complications including loss of fixation, fractures at the osteotomy site and troughing of the fragments have been reported (*1,6*). Troughing results in dorsiflexion of the first ray and may lead to transfer metatarsalgia (*14,16*). Additionally postoperative hallux varus deformities have been found in up to 20%. Due to extensive soft tissue stripping (especially when performed by less experienced surgeons) there is a risk to develop avascular necrosis (*11*). Another potential disadvantage is the cosmetic issue related to the extended medial incision needed to perform the osteotomy. Based on the findings in the literature we modified the Reverdin-Todd procedure by omitting any medial wedge removal from the metatarsal neck and adding a long plantar arm that exits proximal to the plantar vessels. It has been called the "reversed-L-shaped osteotomy" because it resembles an "L" that lies on its back. The current study shows that the "reversed L-shaped osteotomy" yields good clinical and radiographic outcome at 2 years postoperatively even in the presence of moderate-to-severe hallux valgus deformities. We think that the latter findings are important as this type of osteotomy can also be used in greater deformities without the need for excessive soft-tissue stripping or larger osteotomies.

The reversed-L-shaped osteotomy combines the advantages of both, the chevron and scarf osteotomy. Three very important aspects contribute to its effectiveness : First the configuration of the reversed-L-shaped osteotomy provides intrinsic stability in the sagittal plane similar to that of the Reverdin-Todd- and chevron osteotomy and withstands vertically directed forces far better than the scarf osteotomy (*40*). Second it has larger contact areas between the proximal and distal fragment, which ensure sufficient lateral displacement with true anatomic correction of the 1-2 IMA if compared to the conventional chevron osteotomy. Third it is an easy and standardized technique necessitating only a minimal skin incision, thus improving the cosmetic result.

The reversed-L-shaped osteotomy is performed through a medial approach only and soft-tissue stripping is limited to the dorsal aspect of the distal metatarsal bone. With this technique the plantar and dorsolateral vessels remain preserved, guaranteeing adequate perfusion and therefore reducing the risk of avascular necrosis of the metatarsal head. In our series no postoperative osteonecrosis could be shown. Interestingly, an article recently published by Murawski and Beskin showed excellent results after chevron osteotomy even in severe hallux valgus deformities ; their study supports the current findings of our modified technique for mild to moderate deformities (*31*). Besides stability and preserved perfusion, cosmesis plays an important role for the patients. Our technique allows correction of small and severe deformities but is less invasive and is associated with smaller scars than conventional techniques. A potential downside however, might be the high rate of hardware removal of 15%. The shape of the 2.4 mm titanium screw heads might explain this high rate of hardware removal. We observed that prominent screw heads could lead to bursitis and pain. Since the termination of this study, we routinely countersink the screw head to further reduce its prominence. Eighty-seven percent of all feet included in the present study were rated good-to-excellent regarding the cosmetic result. Five percent of the feet were rated as poor due to a residual deformity. Both patients had preoperative deformities of 39°. This observation might indicate the limitation of the reversed-L-shaped osteotomy in the treatment of deformities around 40°. We are fully aware, that the rating of the cosmetic results by the patients in this study is purely subjective and is not part of a validated outcome score and therefore limited to our study. However we think it is a very interesting approach as we think that the cosmetic result is important for many, especially for female patients. We had two intraoperative fractures of the metatarsal head. We attribute this to the malpositioning of two 2.4 mm screws in a small metatarsal head.

The average AOFAS score significantly improved from 53 points preoperatively to 91 points at last follow-up and this is comparable to results reported by other authors with other techniques (*2,12,19,30,36,38,39*). We found no significant relation between patient satisfaction, improvement in AOFAS score, and correction of HV angle ($p = 0.07$ and $p = 0.89$, respectively). Eighty percent of the feet had a mean medial sesamoid position equal to or less than 4 according to the Hardy and Clapham classification, which might be due to the fact that we avoid tenotomy of the adductor tendon. The postoperative range of motion did not alter significantly. However it appears that there is tendency to decreased postoperative plantarflexion. This may be due to the dissection of the dorsal soft tisuue to perform the lateral capsulotomy, thus inducing scarring and reducing plantarflexion.

A weakness of our study is certainly the small number of individuals included and the short follow-up time of two years thus limiting the strength of the conclusions that can be drawn. An additional weakness of our study is that eight patients were lost to follow-up, representing nearly 25% of the study group. However only one patient refused to participate in the study, thus potentially minimizing the possibility of a negative outcome following surgery. Another weakness might be the lack of a randomized control group for the comparison of two different techniques although the data in the literature seems to be very robust to allow a comparison between studies. However, as the early results with that technique were very promising, the reversed L-shaped osteotomy is currently used as a standard procedure in our institution to correct hallux valgus deformities up to 40°. As the follow-up time is short, our results can only be interpreted as preliminary and further studies are needed to investigate the mid- to long-term outcomes after reversed-L-shaped osteotomy.

The results of our study indicate that the distal metatarsal osteotomy presented allows a reliable and stable correction of mild to moderate hallux valgus deformities. Additionally a significant correction of the intermetarsal angle can be achieved and with the use of a minimal invasive technique, a good cosmetic result can be obtained, thus further enhancing patient satisfaction. Further investigations are necessary to investigate its usefulness for severe hallux valgus deformities as well.

REFERENCES

1. **Acevedo JI, Sammarco VJ, Boucher HR *et al.*** Mechanical comparison of cyclic loading in five different first metatarsal shaft osteotomies. *Foot Ankle Int* 2002 ; 23 : 711-716.
2. **Austin DW, Leventen EO.** A new osteotomy for hallux valgus : a horizontally directed “V” displacement osteoto-

my of the metatarsal head for hallux valgus and primus varus. *Clin Orthop Relat Res* 1981 ; 157 : 25-30.

3. **Barouk LS.** Scarf osteotomy for hallux valgus correction. Local anatomy, surgical technique, and combination with other forefoot procedures. *Foot Ankle Clin* 2000 ; 5 : 525-58.
4. **Beck E.** Modified Reverdin technique for hallux abducto valgus (with increased proximal articular set angle). *J Am Podiatr Med Assoc* 1974 ; 64 : 657.
5. **Bonney G, Macnab I.** Hallux valgus and hallux rigidus ; a critical survey of operative results. *J Bone Joint Surg* 1952 ; 34-B : 366-385.
6. **Coetzee JC.** Scarf osteotomy for hallux valgus repair : the dark side. *Foot Ankle Int* 2003 ; 24 : 29-33.
7. **Coughlin MJ.** Hallux valgus. *Instr Course Lect* 1997 ; 46 : 357-391.
8. **Coughlin MJ, Freund E.** Roger A. Mann Award . The reliability of angular measurements in hallux valgus deformities. *Foot Ankle Int* 2001 ; 22 : 369-379.
9. **Coughlin MJ, Grimes S.** Proximal metatarsal osteotomy and distal soft tissue reconstruction as treatment for hallux valgus deformity. *Keio J Med* 2005 ; 54 : 60-65.
10. **Coughlin MJ, Saltzman CL, Nunley JA, 2nd.** Angular measurements in the evaluation of hallux valgus deformities : a report of the ad hoc committee of the American Orthopaedic Foot & Ankle Society on angular measurements. *Foot Ankle Int* 2002 ; 23 : 68-74.
11. **Dereymaeker G.** Scarf osteotomy for correction of hallux valgus. Surgical technique and results as compared to distal chevron osteotomy. *Foot Ankle Clin* 2000 ; 5 : 513-524.
12. **Donnelly RE, Saltzman CL, Kile TA, Johnson KA.** Modified chevron osteotomy for hallux valgus. *Foot Ankle Int* 1994 ; 15 : 642-645.
13. **Espinosa NM, Dominik C, Von Campe, A, Helmy N, Vienne P.** A new modified distal first metatarsal osteotomy for the treatment of hallux valgus deformity : The reversed L-shaped osteotomy. *Techniques in Foot & Ankle Surgery* 2006 ; 5 : 7.
14. **Freslon M, Gayet LE, Bouche G *et al.*** [Scarf osteotomy for the treatment of hallux valgus : a review of 123 cases with 4.8 years follow-up.] (in French). *Rev Chir Orthop Reparatrice Appar Mot* 2005 ; 91 : 257-266.
15. **Gerbert J.** Complications of the Austin-type bunionectomy. *J Foot Surg* 1978 ; 17 : 1-6.
16. **Hammel E, Abi Chala ML, Wagner T.** [Complications of first ray osteotomies : a consecutive series of 475 feet with first metatarsal Scarf osteotomy and first phalanx osteotomy.] (in French). *Rev Chir Orthop Reparatrice Appar Mot* 2007 ; 93 : 710-719.
17. **Hardy RH, Clapham JC.** Observations on hallux valgus ; based on a controlled series. *J Bone Joint Surg* 1951 ; 33-B : 376-391.
18. **Horne G, Tanzer T, Ford M.** Chevron osteotomy for the treatment of hallux valgus. *Clin Orthop Relat Res* 1984 ; 183 : 32-36.
19. **Johnson JE, Clanton TO, Baxter DE, Gottlieb MS.** Comparison of Chevron osteotomy and modified McBride bunionectomy for correction of mild to moderate hallux valgus deformity. *Foot Ankle* 1991 ; 12 : 61-68.
20. **Jones KJ, Feiwell LA, Freedman EL, Cracchiolo A, 3rd.** The effect of chevron osteotomy with lateral capsular release on the blood supply to the first metatarsal head. *J Bone Joint Surg* 1995 ; 77-A : 197-204.
21. **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.
22. **Laird P, Silvers S, Somdahl J.** Two Reverdin-Laird osteotomy modifications for correction of hallux abducto valgus. *J Am Podiatry Assoc* 1988 ; 78 : 403.
23. **Lewis RJ, Feffer HL.** Modified chevron osteotomy of the first metatarsal. *Clin Orthop Relat Res* 1981 ;157 : 105-109.
24. **Malal JJ, Shaw-Dunn J, Kumar CS.** Blood supply to the first metatarsal head and vessels at risk with a chevron osteotomy. *J Bone Joint Surg* 2007 ; 89-A : 2018-2022.
25. **Mann RA.** Complications associated with the Chevron osteotomy. *Foot Ankle* 1982 ; 3 : 125-129.
26. **Mann RA, Coughlin MJ.** Hallux valgus—etiology, anatomy, treatment and surgical considerations. *Clin Orthop Relat Res* 1981 ;157 : 31-41.
27. **Mann RA, Donatto KC.** The chevron osteotomy : a clinical and radiographic analysis. *Foot Ankle Int* 1997 ; 18 : 255-261.
28. **Meier PJ, Kenzora JE.** The risks and benefits of distal first metatarsal osteotomies. *Foot Ankle* 1985 ; 6 : 7-17.
29. **Mitchell CL, Fleming JL, Allen R *et al.*** Osteotomy-bunionectomy for hallux valgus. *J Bone Joint Surg* 1958 ; 40-A : 41-58 ; discussion 59-60.
30. **Muhlbauer M, Zembsch A, Trnka HJ.** [Short-term results of modified chevron osteotomy with soft tissue technique and guide wire fixation – a prospective study.] (in German). *Z Orthop Ihre Grenzgeb* 2001 ; 139 : 435-439.
31. **Murawski D, Beskin J.** Increased displacement maximizes the utility of the distal chevron osteotomy for hallux valgus deformity correction. *Foot Ankle* 2008 ; 29 : 155-163.
32. **Peterson DA, Zilberfarb JL, Greene MA, Colgrove RC.** Avascular necrosis of the first metatarsal head : incidence in distal osteotomy combined with lateral soft tissue release. *Foot Ankle Int* 1994 ; 15 : 59-63.
33. **Reverdin J.** Anatomie et opération de l'hallux valgus. *Int Med Congr* 1881 ; 2 : 408.
34. **Saro C, Andren B, Wildemyr Z, Fellander-Tsai L.** Outcome after distal metatarsal osteotomy for hallux valgus : a prospective randomized controlled trial of two methods. *Foot Ankle Int* 2007 ; 28 : 778-787.
35. **Saro C, Johnson DN, Martinez De Aragon J *et al.*** Reliability of radiological and cosmetic measurements in hallux valgus. *Acta Radiol* 2005 ; 46 : 843-851.
36. **Steinbock G.** [Austin's horizontal V-shaped sliding osteotomy of the metatarsal head (Chevron-osteotomy) in

the treatment of hallux valgus.] (in German). *Orthopade* 1996 ; 25 : 308-316.

37. **Trnka HJ, Zembsch A, Easley ME *et al.*** The chevron osteotomy for correction of hallux valgus. Comparison of findings after two and five years of follow-up. *J Bone Joint Surg* 2000 ; 82-A : 1373-1378.
38. **Trnka HJ, Zembsch A, Wiesauer H *et al.*** Modified Austin procedure for correction of hallux valgus. *Foot Ankle Int* 1997 ; 18 : 119-127.
39. **Velkes S, Ganel A, Nagris B, Lokiec F.** Chevron osteotomy in the treatment of hallux valgus. *J Foot Surg* 1991 ; 30 : 276-278.
40. **Vienne P, Favre P, Meyer D *et al.*** Comparative mechanical testing of different geometric designs of distal first metatarsal osteotomies. *Foot Ankle Int* 2007 ; 28 : 232-236.