The Scarf Osteotomy

A Salvage Procedure for Recurrent Hallux Valgus in Selected Cases

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Abstract

Background The Scarf osteotomy was described as a technique to correct a metatarsus primus varus in primary hallux valgus surgery, but it is unclear whether the technique could correct recurrent hallux valgus when an initial procedure failed to provide any or an adequate lateral displacement of the metatarsal head.

Questions/purposes We asked whether the Scarf osteotomy could reduce pain, improve the AOFAS score, reduce the deformity, and prevent further recurrence when used as a revision procedure.

Patients and Methods Of 41 patients (45 feet) we treated for failed initial operations, we retrospectively reviewed 35 (39 feet) who underwent a Scarf osteotomy. We administered a VAS for pain and the AOFAS score preoperatively and postoperatively. Preoperative and postoperative radiographs were taken to assess the hallux valgus angle [HVA] and intermetatarsal angle [IMA]. The minimum followup was 24 months (mean, 42 months; range, 24–89 months).

Results The mean VAS for pain improved from 5.9 to 0.4 points. The mean AOFAS score improved from 56 to 90 points. The radiographic evaluation showed improvement

of the mean HVA from 30° to 8° and improvement of the IMA from 13° to 4°. Complications included one asymptomatic recurrence with a 20°-HVA, one overcorrection with a 3°-varus deformity, and pain attributable to irritation caused by screws in five patients.

Conclusions As a revision procedure the Scarf osteotomy clinically and radiographically corrected recurrent hallux valgus recurrence in most patients.

Level of Evidence Level IV, therapeutic study. See Guidelines for Authors for a complete description of levels of evidence.

Introduction

Recurrence of hallux valgus deformity is a well-known complication attributable to several reasons, such as insufficient or no primary lateral displacement of the metatarsal head [11], malunion or fracture of a metatarsal osteotomy [11], untreated pes planovalgus [11], insufficient soft tissue technique [11], or a combination of any of the above. Revision surgery sometimes is required owing to pain and discomfort. Careful determination of the cause is important to determine the best corrective method. In case of an uncorrected metatarsus primus varus attributable to insufficient lateral displacement of the metatarsal head or to the failure to perform an osteotomy, a method is needed to correct the metatarsus primus varus.

Not all methods described in earlier reports [10, 14, 18, 21, 33, 34] address metatarsus primus varus in revision cases. Various studies, however, propose the following methods: arthrodesis of the first metatarsal-cuneiform joint [8], arthrodesis of the first metatarsophalangeal (MTP1) joint [10, 14, 18, 21, 33, 34], repeat resection arthroplasty [18, 21], and proximal osteotomy [17].

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Each author certifies that his or her institution has approved the human protocol for this investigation, that all investigations were conducted in conformity with the ethical principles of research, and that informed consent for participation in the study was obtained.

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The Scarf osteotomy was described as a technique for primary correction of a metatarsus primus varus [23] and used by many subsequent authors [2, 3, 13, 15, 20]. The technique consists of a diaphyseal Z-shaped osteotomy of the first metatarsal (MT1), in which the distal plantar part of the MT1 is moved laterally to correct the increased IMA. In 2000 we began using the Scarf osteotomy as a revision procedure in selected patients with recurrent hallux valgus deformity sharing a similar pathomechanism whose original operation may or may not have included an osteotomy or a nonjoint-preserving procedure (eg, resection arthroplasty). The goals of revision hallux valgus surgery are pain relief, reduction of the deformity, and prevention of recurrence.

To see if the Scarf osteotomy meets these goals, we asked whether the osteotomy (1) reduced pain levels; (2) improved the AOFAS score; and (3) improved the HVA, IMA, and distal metatarsal articular angle, and the dislocation of the sesamoid bones. We then asked whether (4) pain, functional scores, or angles differed among patients operated on after differing previous kind of surgeries; and (5) whether the correction would be maintained between 6 weeks and final followup, and if not, whether any factors would predict loss of correction.

Patients and Methods

We retrospectively reviewed 60 patients who had surgery from 2000 to 2006 for persistent complaints after primary hallux valgus surgery. We considered performing the Scarf osteotomy in patients with: (1) recurrent hallux valgus deformity attributable to an uncorrected or undercorrected IMA; (2) pain only at the medial eminence of the MTP1; (3) an IMA angle between 10° and 20°; and (4) persistent pain after nonoperative treatment (NSAIDs, accommodating shoes) for at least 3 months. We considered the following as contraindications for the procedure: (1) prior arthrodesis to the ankle or foot; (2) symptoms of hallux rigidus; (3) ROM less than 40°; (4) cock-up deformity or unstable first toe after resection arthroplasty; (5) metatarsalgia unresponsive to orthoses; (6) recurrence attributable to fracture or malunion; (7) unstable first tarsometatarsal (TMT1) joint; (8) peripheral neuropathy; (9) Charcot arthropathy; and (10) peripheral vascular disease. Of the 60 patients, 19 did not meet indication criteria or had one or more contraindications, and five patients were lost to followup (Table 1). We thus report on 35 (89%) patients (39 feet, 89%): 16 resection arthroplasties (14 patients); 15 bunionectomies with medial capsulorrhaphy (13 patients); five Chevron osteotomies (five patients); one Kramer osteotomy (one patient); and two Scarf osteotomies (two patients) (Table 1). The time between the primary and revision surgeries was, on average,

Table 1. Distribution of patients treated between 2000–2006 for persistent or recurrent complaints

	Subtotal		Total
Total number of patients treated for complaints after primary hallux valgus surgery			60
Patients not meeting criteria (contraindications)			19
1 patient: IMA 22°; basal osteotomy	1 patient: TMT1 instability; TMT1 arthrodesis	1 patient: malunion after Ludloff osteotomy; MT1 plate stabilization	15 patients: complaints (cock-up deformity, metatarsalgia unresponsive to orthoses, unstable first toe) after Keller resection arthroplasty; MTP1 arthrodesis
Patients having revision Scarf osteotomy lost to followup			6
4 patients (bunionectomy): 2 patients: phone consultation	1 patient (chevron): phone consultation	1 patient (Kramer): unable to contact	
1 patient: followup < 24 months			
1 patient: died from unrelated cause			
Actual number of patients included in our study			35
14 patients/16 feet (Keller resection arthroplasty)	13 patients/15 feet (bunionectomy with medial capsulorrhaphy)	5 patients/5 feet (chevron osteotomy)	1 patient/1 foot (Kramer osteotomy)
IMA = intermetatarsal angle; TMT1 = first tarsometatarsal; MTP1 = first metatarsophalangeal; MT1 = first metatarsal.			
2 patients/2 feet (Scarf osteotomy)			

Table 2. Preoperative values for the three subgroups showing similar values for all parameters

Parameters measured	Resection arthroplasty (n = 16)		No previous osteotomy (n = 15)		Previous osteotomy (n = 8)	
	Mean	95% CI	Mean	95% CI	Mean	95% CI
Age (years)	59.0	[54.85; 63.15]	58.3	[50.50; 66.17]	59.5	[51.88; 67.12]
HVA (°)	29.6	[27.01; 32.11]	31.0	[27.36; 34.64]	28.4	[26.59; 30.16]
IMA (°)	13.5	[12.32; 14.68]	12.2	[10.91; 13.49]	14.1	[11.18; 17.07]
DMAA (°)	7.8	[11.10; 16.40]	15.9	[11.97; 19.90]	9.0	[6.55; 11.45]
Sesamoid bone position (%)	54.7	[41.62; 67.76]	60.0	[47.40; 72.60]	78.1	[60.68; 95.57]
Index (mm)	−0.8	[−1.92; 0.29]	−0.8	[−2.70; 1.10]	−1.9	[−4.79; 1.04]
AOFAS	56.1	[53.58; 58.42]	56.0	[51.44; 60.56]	56.1	[49.15; 63.10]
ROM	71.6	[62.04; 81.08]	73.7	[62.72; 84.62]	66.3	[57.67; 74.83]
VAS	5.6	[5.01; 6.24]	6.3	[5.99; 6.68]	5.8	[5.34; 6.41]

HVA = hallus valgus angle; IMA = intermetatarsal angle; DMAA = distal metatarsal articular angle; AOFAS = American Orthopaedic Foot and Ankle Society; VAS = visual analog scale.

9.7 years (range, 1–23 years). All but one patient was female. The mean age of the patients was 58.8 years (range, 33–78 years). All were Caucasian. We differentiated between three groups by primary procedure: (1) primary osteotomy, (2) no osteotomy, and (3) nonjoint-preserving procedure (resection arthroplasty). We found similar baseline parameters (age, AOFAS score, ROM, VAS for pain, HVA, IMA, distal metatarsal articular angle [DMAA], sesamoid bone position, metatarsal index) among the different groups (Table 2). The minimum followup was 24 months (mean, 42.1 months; range, 24–89 months). We assumed most recurrences of deformity would occur within 24 months if they were to occur. The study was approved by the Institutional Review Board. All patients provided written informed consent.

Surgery was performed with the patient in a supine position with a tourniquet applied above the ankle. Unless the hallux valgus deformity was reducible to a 5° varus position and no sesamoid bone dislocation was present, we released the metatarsosesamoid ligament and the lateral MTP1 joint capsule through a dorsal skin incision in the first intermetatarsal webspace. For the osteotomy, the skin incision of the primary procedure (medial, dorsomedial) was used. We incised the MTP1 joint capsule horizontally. If the primary surgery was a resection arthroplasty, the fibrous tissue in the MTP1 joint remained untouched. Next, two 1.0-mm Kirschner (K) wires were inserted at the corner points of the osteotomy. The proximal K wire was located 2 cm distal to the joint line of the TMT1 joint, 1 mm above the inferior aspect of the metatarsal; the distal K wire was 0.5 cm proximal to the dorsal cartilage surface of the metatarsal head, 1 mm plantar of the dorsal aspect of the metatarsal (Fig. 1). We placed the K wires in a 15°- to 20°-oblique angle to the plantar surface, thus accomplishing plantarization of the MT1 head. We made the vertical cuts at angles of 40° to 50° to the longitudinal cut. The

Fig. 1 The drawing shows the Scarf osteotomy (lateral view of metatarsophalangeal) as it was performed in this study.

distal plantar fragment was transferred laterally by at least half the width of the MT1 shaft. The osteotomy was fixed with one compression screw (Barouk® screw, DePuy Orthopaedics, Warsaw, IN), based on good experience with one-screw fixation technique in primary Scarf osteotomies. We placed the screw from dorsal to plantar in a 40° to 50° angle to the longitudinal axis of the metatarsal (Figs. 2–4). An Akin osteotomy [1] was performed in one case (primary Chevron) and in three cases (primary bunionectomy) to correct a hallux valgus interphalangeus (HVI) angle [24] greater than 15°; and in five cases (one primary Scarf osteotomy; four primary bunionectomies), in which an intraoperative loading test still showed contact between the distal ends of the great and second toes. The medial capsulorrhaphy was performed as described by Kristen et al. [20]. Additionally, four proximal interphalangeal resection arthroplasties (three patients) on the lesser toes were performed to correct hammertoe deformities.

Postoperatively, patients wore a wooden-soled shoe for a minimum of 6 weeks and were allowed to fully weight-bear without crutches on the first postoperative day. Patients were seen at Weeks 1, 2, 4, and 6 after surgery for dressing changes. Stitches were removed 2 weeks postoperative; radiographic control films (foot in weightbearing

Fig. 2 The hallux valgus deformity recurred after a primary bunionectomy and capsulorrhaphy, with reduction of the width of the head of the MT1.

Fig. 3 Revision surgery by Scarf osteotomy provides good alignment after a bunionectomy and capsulorrhaphy (dorsoplantar view).

Fig. 4 The lateral view of a Scarf osteotomy, performed after a failed primary bunionectomy and capsulorrhaphy, shows good bone healing.

position, AP and lateral views) were obtained 6 weeks postoperative. If these radiographs showed complete healing of the osteotomy, the patient was allowed to wear regular shoes. Return to full activity and sports was allowed 2 months postoperative.

After the 6-week followup, we followed patients at 3 months and at the final followup. The following clinical and functional variables were evaluated preoperatively and at the last followup: unsegmented VAS score for pain (0–10); ROM of the MTP1; and AOFAS score [16]. Radiographs were taken preoperatively, at 6 weeks and at final followup.

Three of us (UL, AK, MP) evaluated the radiographs for alignment according to the guidelines described by the AOFAS [31] on weightbearing AP radiographs. The following variables were assessed preoperatively, 6 weeks postoperatively, and at last followup: HVA; IMA; DMAA; metatarsal index measured by a perpendicular line drawn from the distal-most point of the MT2 to the MT1; and position of the tibial sesamoid on the AP radiograph in relation to a line drawn along the center of the longitudinal axis of the MT1. A dislocation of 25% means $\frac{1}{4}$ of the tibial sesamoid bone laterally overlaps this line. The axis of the MT1 was determined as follows: a line was drawn from the center of the head of the MT1 through the center of the base of the MT1 as described by Miller [24]. As there is extensive literature regarding interobserver variability of measurement of the HVA (0.98/0.96; preoperative/postoperative), IMA (0.94/0.86; preoperative/postoperative), and DMAA (0.09/0.002; preoperative/postoperative) [6, 26, 28, 29], only the metatarsal index and sesamoid bone position also were measured by three individuals (UL, AK, MP) not involved in the clinical evaluation. We found a Cronbach's alpha between 0.893 (sesamoid bone position preoperative/postoperative) and 0.988 (index preoperative/postoperative).

Variables were described by frequencies, mean $\pm$ SD, and range. Differences among the three subgroups regarding preoperative and postoperative variables were analyzed using the Kruskal-Wallis test; differences between times (evaluation of improvement of clinical, functional, and radiographic outcome variables) were calculated using the Wilcoxon test. Spearman's correlation was used to assess a possible relationship for the following parameters: the loss of reduction of HVA at final followup versus different preoperative and postoperative values (HVA, IMA, sesamoid bone position, loss of correction of sesamoid bone position). Statistical analysis was performed using SPSS[®] 15.0 (SPSS Inc, Chicago, IL).

Results

Pain according to the mean VAS improved ($p < 0.001$) from 5.9 points preoperatively to 0.4 points postoperatively (Table 3).

The mean AOFAS score improved ($p < 0.001$) from 56 points to 90 points (Table 3). Some subscore elements

(interphalangeal joint motion, metatarsophalangeal-interphalangeal stability) remained unchanged (Table 4).

The radiographic outcome measurements improved at last followup (Table 3). Shortening of the MT1 was expressed by the first metatarsal index with a preoperative value of -1.0 mm (range, -9 mm to $+7$ mm), a postoperative value of -2.9 mm (range, -10 mm to $+4$ mm), and average shortening of 1.9 mm (range, 0 – 4 mm).

The postoperative AOFAS score differed ($p = 0.024$) among the three groups: the group after previous osteotomy showed the lowest score (87 ± 3), followed by the group after resection arthroplasty (89 ± 7), and the group without primary osteotomy (92 ± 6) (Table 5). We observed no difference ($p > 0.05$) in the VAS for pain and the radiographic variables between the three groups.

The HVA ($+2.0^\circ$; $p = 0.005$) and the dislocation of the sesamoid bone ($+4.6\%$; $p = 0.020$) increased during the period between the 6-week and final followup radiographs (Table 6). The IMA and DMAA did not change. We found no correlation between the increase of the HVA and dislocation of the sesamoid bone and any of the following parameters: preoperative HVA, IMA, sesamoid bone

Table 3. Radiographic and clinical preoperative and postoperative variables

Parameter	Preoperative		Postoperative		p Value
	Mean	SD	Mean	SD	
HVA ($^\circ$)	30.0 (20–45)	5.1	7.7 (-3 – 20)	5.3	< 0.0001
IMA ($^\circ$)	13.1 (10–19)	2.6	4.3 (1–10)	2.1	< 0.0001
Sesamoid bone position (%)	61.5 (0–100)	24.2	11.5 (0–50)	16.1	< 0.001
DMAA ($^\circ$)	15.0 (5–28)	6.0	8.0 (1–15)	3.7	< 0.0001
Index (mm)	-1.0 (-9 – 7)	2.9	-2.9 (-10 – 4)	3.1	< 0.001
AOFAS	56.2 (42–68)	6.8	89.8 (68–100)	6.1	< 0.0001
ROM	71.1 (50–105)	17.0	59.4 (30–100)	16.1	< 0.0001
VAS	5.9 (4–8)	0.92	0.4 (0–3)	0.89	< 0.0001

HVA = hallus valgus angle; IMA = intermetatarsal angle; DMAA = distal metatarsal articular angle; AOFAS = American Orthopaedic Foot and Ankle Society; VAS = visual analog scale.

Table 4. AOFAS subscores for all patients

Subscore (maximum points possible)	AOFAS score (points)*		p Value
	Preoperative	Postoperative	
Pain (40)	23.5 (20–30)	38.8 (30–40)	< 0.0001
Function (10)	5.1 (0–10)	9.9 (7–10)	< 0.0001
Footwear (10)	7.8 (5–10)	7.1 (5–10)	0.1
Metatarsophalangeal joint motion (10)	6.8 (5–10)	5.6 (5–10)	0.0008
Interphalangeal joint motion (5)	5	5	> 0.05
Metatarsophalangeal-interphalangeal stability (5)	5	5	> 0.05
Callus (5)	2.8 (0–5)	4.9 (0–5)	< 0.0001
Alignment (15)	0 (0–15)	13.4 (8–15)	< 0.0001

* Values are expressed as means, with ranges in parentheses; AOFAS = American Orthopaedic Foot and Ankle Society.

Table 5. Postoperative values for the three subgroups

Parameter	Resection arthroplasty (n = 16)		No previous osteotomy (n = 15)		Previous osteotomy (n = 8)		p Value
	Mean	SD	Mean	SD	Mean	SD	
HVA (°)	7.4	5.7	7.9	5.0	8.6	5.2	0.959
IMA (°)	4.6	2.5	4.2	2.0	4.4	1.7	0.950
Sesamoid bone position (%)	10.9	15.7	8.3	15.4	18.8	17.7	0.272
DMAA (°)	7.8	3.2	8.1	3.7	7.9	4.2	0.988
Index (mm)	−2.6	2.9	−2.9	3.2	−3.1	3.7	0.837
AOFAS	88.9	6.9	92.3	5.6	86.6	2.9	0.024
ROM	57.5	19.6	64.3	13.7	53.8	12.5	0.221
VAS	0.38	0.89	0.3	0.84	0.75	1.0	0.199

HVA = hallus valgus angle; IMA = intermetatarsal angle; DMAA = distal metatarsal articular angle; AOFAS = American Orthopaedic Foot and Ankle Society; VAS = visual analog scale.

Table 6. Comparison of radiographic outcome variables

Parameter	6 weeks	Last followup	p Value
HVA (°)	5.7	7.7	0.0037
IMA (°)	4.6	4.3	0.18
Sesamoid bone position (%)	6.9	11.5	0.0088
DMAA (°)	8.1	8.0	> 0.05

Values are expressed as means; HVA = hallus valgus angle; IMA = intermetatarsal angle; DMAA = distal metatarsal articular angle.

position; HVA, IMA, sesamoid bone position 6 weeks postoperatively and at final followup.

Seven patients (seven feet) wore orthotic devices preoperatively (five after primary resection arthroplasty, two after bunionectomy) attributable to metatarsalgia and continued wearing them postoperatively. One patient had an asymptomatic recurrence (20° HVA, 10° IMA) after a bunionectomy; the preoperative HVA measured 35°; the preoperative IMA was 16°; no additional surgery was performed. One patient had overcorrection of 3° hallux varus after a primary resection arthroplasty; the patient complained of mild pain (VAS, 2). Three patients had intermittent paresthesias and five had pain attributable to the screw (three, head of the screw; two, tip of the screw), and the screws were removed. All the osteotomies had healed by the last followup. No patients had head necrosis, secondary displacement, or troughing (ie, when the cortices wedge into the softer cancellous bone of the metatarsal shaft, causing a functional elevation and malrotation of the first ray). No patient had increased metatarsalgia.

Discussion

Recurrent hallux valgus is a well-known complication. Among other reasons, insufficient lateral displacement or

failure to perform an osteotomy, causing insufficient or no correction of an increased IMA, can lead to recurrence. Knowing the potential of the Scarf osteotomy to correct an increased IMA, we chose this method for revision of recurrent hallux valgus deformity for selected patients. To see whether the Scarf osteotomy successfully corrected the recurrent deformities, we asked whether (1) the Scarf osteotomy results in a reduction of the pain level; (2) the Scarf osteotomy improves the AOFAS score; (3) the Scarf osteotomy improves radiographic outcome variables; (4) results of the aforementioned outcome variables (VAS for pain, AOFAS score, radiographic outcome variables) differ among the three different study subgroups (5) the HVA, IMA, and DMAA and the dislocation rate of the sesamoid bones increase during the period between the 6-week postoperative control and final followup radiographs.

There are some limitations to our study. First, the number of patients is relatively small. This can be attributed to the generally low numbers of hallux valgus revision surgeries performed (Table 7). Second, we imposed limited indications and had some contraindications for the surgery. Not every patient with complaints after primary hallux valgus surgery was eligible for the Scarf osteotomy; however, our aim was to determine whether the Scarf osteotomy was reasonable for treating recurrent hallux valgus in a selected group of patients sharing a similar pathomechanism. We did not consider this operation in patients for whom we considered other methods to be more suitable (eg, cock-up deformity, unstable TMT1) [8, 9, 19, 21]. Third, we lacked historical or concurrent controls. Our goal was to determine the applicability of the Scarf osteotomy in a selected group of patients and not its superiority over other methods. Fourth, the majority of the patients included in this study probably are not representative of the typical patients with recurrent hallux valgus. Most recurrences were caused by failure to do an osteotomy.

Table 7. Comparison of data from previous and current studies

Study	Year of publication	Applied method	Number of patients (feet)	Number of patients (feet) at clinical followup	Time of followup (months)*	Number of different primary surgeries	Type and numbers of primary surgeries	Percentage of satisfactory results (good/excellent)
Vienne et al. [33]	2006	MTP1 arthrodesis	26 (28)	20 (22)	34 (24–48)	1	Resection arthroplasty	91
Grimes & Coughlin [14]	2006	MTP1 arthrodesis	42	29 (33)	96 (1–252)	5	Bunionectomy (3) MT1 osteotomy (17) Soft tissue (6) Resection arthroplasty (5) Arthrodesis TMT1 (1) Arthrodesis MTP1 (1) MT1 osteotomy (25) Soft tissue (1) Resection arthroplasty	72
Coetzee et al. [8]	2003	Modified Lapidus	24 (26)	24 (26)	22 (6–36)	6	MT1 osteotomy (25) Soft tissue (1) Resection arthroplasty	81
Machacek et al. [21]	2004	MTP1 arthrodesis	32 (33)	28 (29)	36 (24–76)	1	Resection arthroplasty	79
Machacek et al. [21]	2004	Repeat Keller or tendon lengthening	26 (29)	18 (21)	74 (27–132)	1	Resection arthroplasty	29
Kitaoka & Patzer [17]	1998	Proximal crescentic	15 (16)	10 (11)	60 (24–168)	2	MT1 osteotomy (6) Bunionectomy (10)	73
Kitaoka & Patzer [18]	1998	Resection arthroplasty	10 (11)	10 (11)	120 (36–180)	4	Bunionectomy (8) Proximal osteotomy (2) Akin osteotomy (1) Arthrodesis (1)	55
Kitaoka & Patzer [18]	1998	MTP1 arthrodesis	8 (9)	8 (9)	60 (24–96)	4	Bunionectomy (4) Proximal osteotomy (3) Akin osteotomy (1) Resection arthroplasty (1) Resection arthroplasty	67
Coughlin & Mann [10]	1987	MTP1 arthrodesis	11 (16)	11 (16)	24 (24–48)	1	Resection arthroplasty (1) Resection arthroplasty	100
Current study	2010	Scarf osteotomy	41 (45)	35 (39)	42 (24–89)	5	Bunionectomy (15) Resection arthroplasty (16) MT1 osteotomy (8)	Not given

* Values are expressed as means, with ranges in parentheses; AOFAS = American Orthopaedic Foot and Ankle Society; MTP1 = first metatarsophalangeal; MT1 = first metatarsal; TMT1 = first tarsometatarsal.

Table 8 Comparison of outcome variables for previous and current studies

Study	Method	Parameters											
		VAS for pain ⁺											
		AOFAS score ⁺		HVA ⁺		IMA ⁺		DMAA ⁺		Sesamoid bone position ⁺	Metatarsal length (mm) ⁺		
Preoperative		Post-operative	Preoperative	Post-operative	Preoperative	Post-operative	Preoperative	Post-operative	Preoperative	Post-operative	Preoperative	Post-operative	
Vienne et al. [33]	MTP I arthrodesis	*	*	44 (maximum points, 90)	85 (maximum points, 90)	24	16	10	11	*	*	*	With bone graft, +10
Grines & Coughlin [14]	MTP I arthrodesis	7	3	*	73 (maximum points, 90)	23	16	9	8	*	*	*	Without bone graft, −4
Coetzee et al. [8]	Modified Lapidus	6.2	1.4	48	88	37	17	18	9	*	*	*	*
Machacek et al. [21]	MTP I arthrodesis	*	*	*	76 (maximum points, 90)	27	15	10	10	*	*	*	−2.7
Machacek et al. [21]	Repeat Keller or tendon lengthening	*	*	*	48 (maximum points, 90)	*	*	*	*	*	*	*	*
Kitaoka & Patzer [17]	Proximal crescentic	*	*	*	*	33	14	13	6	*	*	*	*
Kitaoka & Patzer [18]	Resection arthroplasty	*	*	*	*	39	3	14	10	*	*	*	*
Kitaoka & Patzer [18]	MTP I arthrodesis	*	*	*	*	48	25	12	10	*	*	*	*
Coughlin & Mann [10]	MTP I arthrodesis	4	1.3	*	*	*	13.3	*	*	*	*	*	*
Current study	SCARF osteotomy	5.9	0.4	56	90	30	8	13	4	15	8	62%	12%
													−1.9

* No data available; ⁺ values are expressed as means; AOFAS = American Orthopaedic Foot and Ankle Society; VAS = visual analog scale; MTP1 = first metatarsophalangeal; MT1 = first metatarsal; TMT1 = first tarsometatarsal; HVA = hallux valgus angle; IMA = intermetatarsal angle; DMAA = distal metatarsal articular angle.

Bunionectomy and resection arthroplasty generally are considered simple and outdated procedures that are performed in a minority of cases, which may have resulted in a less complex recurrence, as opposed to patients with more complex cases, such as those with malunion, fracture, or undercorrection after primary osteotomy. Fifth, although our patients had various primary procedures, all had similarities in the pathomechanism: an uncorrected or undercorrected IMA. Finally, adding an Akin osteotomy could limit the success of the Scarf osteotomy. We do not think this is the case because (1) the Akin osteotomy addresses the HVA whereas the Scarf osteotomy addresses an increased IMA and the osteotomy reduced the IMA; (2) the Akin osteotomy is an established method within the concept of forefoot correction by the Scarf osteotomy [1, 2, 11, 12, 17], and (3) in revision cases the width of the first metatarsal often is reduced, thus limiting lateral displacement of the metatarsal head. An Akin osteotomy in these cases can reduce the likelihood of contact between the distal ends of the great and second toes as in five of our patients.

Pain is the main reason for undergoing a salvage procedure for a recurrent deformity. A substantial reduction was observed in our patients. Only three other studies [8, 10, 14] report on reduction of pain measured by a VAS (Table 8). Our patients had the lowest postoperative level of pain.

Comparing the AOFAS score in our study with reported scores (Table 8), our results are in the upper range, taking a lower maximum score because of loss of motion after arthrodesis in some studies into account.

All radiographic measures improved. The amounts of reduction of the HVA and IMA are similar to those of TMT1 fusion [8] and proximal osteotomy [17], differing only by up to 2° (Table 8); MTP1 arthrodesis generally achieves less reduction of the HVA and IMA (Table 8). The average shortening in our patients was 1.9 mm. Shortening of 2.7 mm for TMT1 fusion is slightly greater [8]. Primary use of TMT1 fusion shows shortening rates of 4 mm [4], 4.7 mm [5], 4.5 mm [22], and 5 mm [27].

We found similar pain reduction and radiographic measurements in the three subgroups and only minor differences for the AOFAS score. Thus, our study identified the Scarf osteotomy as a proven method to solve recurrences in selected patients after resection arthroplasty (Figs. 5–7). Previous studies [10, 14, 21, 33] recommend arthrodesis of the MTP1 for complaints after resection arthroplasty (such as an unstable MTP1 joint, a cock-up deformity, transfer metatarsalgia, or a recurrence). If metatarsalgia can be treated successfully nonoperatively,

Fig. 5 The hallux valgus deformity recurred after primary resection arthroplasty (Keller-Brandes).

Fig. 6 Revision surgery using the Scarf osteotomy provides good alignment after a primary Keller-Brandes procedure (AP view).

we see no need to fuse the MTP1 joint. Even more fusion does not guarantee pain-free lesser metatarsals [21]. Although the joint is not normal after resection

Fig. 7 A lateral view after a Scarf osteotomy was performed for recurrence after the Keller-Brandes procedure is shown.

arthroplasty, there is a joint-like structure, a theory supported by de Palma et al. [12].

We observed an increase of the HVA by an average of 2° and in the rate of sesamoid bone dislocation by an average of 4.6%, between 6 weeks postoperatively and the latest followup. We do not, however, consider these levels of changes clinically important. Further, we identified no factors that influenced the increase in these measures between 6 weeks and the last followup.

In selected patients with recurrent hallux valgus, we found that the Scarf osteotomy reduced pain, corrected the deformity, improved the functional score, and caused only one asymptomatic recurrence. We recommend the Scarf osteotomy for salvage of recurrent hallux valgus deformity in selected patients with a stable and functional MTP1 joint, pain solely on the medial side of the MTP1, and only mild signs of osteoarthritis, and in whom the underlying pathomechanism is an uncorrected or insufficiently corrected IMA. The Scarf osteotomy should not be considered the preferred procedure if the reason for recurrence is more complex, such as a malunion or fracture. Advantages of the Scarf osteotomy include simple postoperative treatment with a wooden-soled shoe and its biomechanical stability [25, 32]. No major complications as described earlier [7, 30] were seen. For patients after resection arthroplasty, we consider only those with a stable joint showing sufficient ($> 40^\circ$) ROM without the presence of a cock-up deformity. In case of a cock-up deformity, an unstable first toe, or metatarsalgia not responsive to nonoperative treatment, we recommend an arthrodesis of the MTP1 joint.

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