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Correction of Hallux Valgus

Metatarsal Osteotomy Versus Excision Arthroplasty

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The long-term retrospective results (followup range, 10–22 years) of an uncontrolled series of basal metatarsal closing wedge osteotomies and Keller's excision arthroplasties performed in patients 14 to 40 years of age are analyzed. In the osteotomy group, 34 patients (50 feet) were available for clinical review and 26 patients (37 feet) were available for radiologic review. In the Keller group, 24 patients (37 feet) were reviewed clinically and 23 patients (34 feet) were reviewed radiologically. Patients were assessed using the Hallux Metatarsophalangeal Interphalangeal Scale of the American Foot and Ankle Society, an additional clinical score, weightbearing radiographs, the patient's record, and clinical investigation. Statistical analysis revealed significantly better results of the clinical and radiologic outcomes after osteotomy. In the osteotomy group, the first metatarsal was elevated dorsally in 14 feet (38%). The incidence of varus deformities was higher with basal osteotomy (18% versus 5.4%). Metatarsalgia occurred similarly in both groups (28% versus 27%). It is known that these techniques should be applied to different patient populations. However, they formerly were used for the same indication. This long-term analysis shows that the Keller arthroplasty should be abandoned for the treatment of hallux valgus in young and active patients. The basal metatarsal closing wedge osteotomy is conceptually the correct treatment for hallux valgus deformity for the younger patient; nevertheless, it is technically demanding and is associated with a higher risk of failure. The long-term results of both procedures are unacceptable for the patient and the surgeon. The short and middle-term results of the newer basal type osteotomies, such as the proximal crescentic osteotomy, the proximal chevron osteotomy, or the proximal oblique osteotomy combined with distal soft tissue releases, suggest a more satisfying long-term outcome.

Excisional arthroplasty as a treatment for hallux valgus, popularized by Keller in 1904,[13] has been a mainstay in bunion surgery for a long time. Advocates of the procedure emphasize its technical simplicity and the excellent results obtained in deformity improvement, pain relief, and functional range of motion (ROM) of the metatarsophalangeal joint.[22,31] Opponents of the procedure list disadvantages such as metatarsalgia, recurrence of deformity, limitation of flexion, development of hammertoe deformity of the second toe, and

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degenerative arthritis in the interphalangeal joint.[22] Zadik[32] cautioned that the Keller procedure should not be used in the patient with severe deformity, whereas Henry et al[9] reported that a more severe hallux valgus deformity requires excessive resection of the proximal phalanx. Excellent or good results have been reported in patients older than 50 years of age,[6,16,30,31] but a deformity recurrence has been observed more frequently in younger patients after a Keller procedure than after a distal metatarsal osteotomy.[27] Several authors suggested that significant metatarsus primus varus is a contraindication for resection arthroplasty because the deformity may persist because of an unaltered first intermetatarsal angle.[7,10,17]

Adequate joint preserving procedures that reduce the intermetatarsal angle, such as basal or distal metatarsal osteotomies conjuncted with soft tissue procedures, have been performed effectively.[12,17,21,26,29] Metatarsalgia probably is the complication reported most frequently in association with the Keller procedure.[7,9,17] Undesirable side effects after basal metatarsal osteotomies include shortening of the first ray and dorsal malangulation of the first metatarsal, which may lead to metatarsalgia.[17,23,29] Younger patients require pain relief and surgical methods that are capable of obtaining satisfying functional and cosmetic long-term results.

Long-term followup studies with a minimum of 10 years that directly compare the results of different operative procedures are rare in the literature.[4,31] However, little attention has been paid to the younger patient with hallux valgus. The objective of this study was to evaluate the long-term retrospective results with a minimum followup of 10 years after (1) basal metatarsal closing wedge osteotomy combined with a modified McBride procedure and (2) a Keller's excision arthroplasty with a cerclage fibreux[28] performed for the same indication. This long-term followup evaluation allows for an analysis of the effectiveness of these two methods in young and active patients with hallux valgus.

MATERIALS AND METHODS

Forty-nine patients (70 feet) underwent a basal metatarsal closing wedge osteotomy with a modified McBride distal soft tissue release for correction of hallux valgus from 1974 to 1985. For the same indication in 51 patients (77 feet), a Keller excision arthroplasty with a cerclage fibreux[28] was performed between 1980 and 1986. All patients who had undergone these procedures were 40 years of age or younger at the time of surgery.

The indication for surgery was painful hallux valgus that did not respond to conservative treatment within a minimum of 6 months. Patients were examined and treated by a general practitioner and were referred to the authors' clinic for surgery. Both techniques were performed individually by different orthopaedic surgeons after the indication had been confirmed by clinical and radiologic examination.

Exclusion criteria for this study were degenerative arthritis of the first metatarsophalangeal joint, prior involvement of the hallux by surgery, rheumatoid arthritis, trauma, neurologic diseases affecting the lower extremities, and additional simultaneous surgery (except the Hohmann procedure for hammertoe deformity). Fifteen patients (20 feet) in the osteotomy group and 27 patients (40 feet) in the Keller group were not available for followup.

This left 50 feet (34 patients: 32 women and two men, 16 bilateral) for clinical followup and 37 feet for radiologic evaluation in the osteotomy group in this study. Thirty-seven feet (24 patients: 19 women and five men, 13 bilateral) were available for clinical followup, and 34 feet were available for radiologic analysis in the Keller group. The minimum followup was 12 years in the osteotomy group and 10 years in the Keller group.

The age at the time of surgery ranged between 14 and 40 years. The average weight was 73 kg (range, 52–98 kg) for the patients in the osteotomy group. In the Keller group, the average weight for the patients was 75 kg (range, 54–101 kg). All patients in both groups were active in their jobs or managing their households. No patient had diseases causing immobility or functional impairment. The preoperative characteristics of both groups are listed in Table 1.

Operative Technique

All of the operations were performed using peripheral nerve blockade and supramalleolar Esmarch tourniquet after exsanguination.

TABLE 1. Preoperative Characteristics of Study Groups

Characteristics	Osteotomy Group n = 50 feet	Keller Group n = 37 feet
Followup (years) Mean ± standard deviation	18 ± 2.8	13 ± 1.6
Age at surgery (years) Mean ± standard deviation	26 ± 6.8	34 ± 5.2
Patients	34	24
Male	2	5
Female	32	19
Average weight	73 kg (range, 52–98)	75 kg (range, 54–101)
Hallux valgus with painful bunions	100%	100%
Duration of symptoms (years)	mean, 2.8	mean, 2.5

Osteotomy Group

The first web space was incised dorsally, and the adductor tendon was released from its insertion into the lateral aspect of the capsule, the sesamoid, and the proximal phalanx. Two sutures were passed through the tendon and the lateral capsule of the first metatarsal head and the capsule of the second metatarsal head medially. A dorsomedial incision was made along the first metatarsal shaft avoiding the dorsal cutaneous nerve. After incision of the capsule of the metatarsophalangeal joint longitudinally and dorsoplantar, the medial bony eminence was resected from the metatarsal head using an osteotome. A medial capsulorrhaphy was performed to tighten the capsule and draw the sesamoids medially after the basal closing wedge osteotomy was completed. The proximal metatarsal was exposed, and approximately 1 cm distal of the metatarsocuneiform joint, a laterally based wedge, was removed using an oscillating saw and preserving the medial cortex (Fig 1A). Closing the defect, the distal metatarsal was displaced laterally and plantarward and fixed temporarily with Kirschner wires. For proper alignment, the osteotomy was fixed with a cancellous screw (Fig 1B). Finally, the sutures in the first web space were tied, and the skin was closed.

Keller Group

A dorsomedial incision was made and a medial exostosectomy was performed after generating a distal capsular flap. The base of the proximal phalanx was exposed subperiostally and 1/3 to 1/2 of the phalanx was excised. The capsular flap was interpositioned into the neoarticulation gap. A cerclage fibreux[28] was added before skin closure. The sesamoids were released from adhesions to the first metatarsal head, and a lateral longitudinal incision of the joint capsule was made. With the forefoot under compression, the medial surplus capsule strip was excised and a medial capsulorrhaphy was performed with strong sutures.

Postoperative Care

Osteotomy Group

After surgery, the foot was placed in a plaster boot, and the patient was not allowed to bear weight until complete wound healing was achieved. After removal of the sutures, between the tenth and twelfth postoperative days, patients were allowed to be fully weightbearing with a short leg plaster cast. At 6 weeks, the cast was removed and radiographs were taken to confirm union. After approximately 3 months, the screw was removed.

Keller Group

After surgery, a plaster cast with a device to extend the hallux was used for an average of 6 days. Sutures were removed between the tenth and twelfth postoperative days. After the cast was removed, patients were allowed to bear weight with a hallux sandal for 4 weeks.

For clinical assessment, patients were interviewed and graded using a standardized questionnaire based on the Hallux Metatarsophalangeal Interphalangeal Scale of the American Orthopedic Foot and Ankle Society.[14]

This score of 100 points includes the clinical parameters of pain (40 points), activity limitations (10 points), footwear requirements (10 points), metatarsophalangeal joint motion (10 points), interphalangeal joint motion (5 points), metatarsophalangeal interphalangeal stability (5 points), plantar callus related to metatarsophalangeal joints (5 points), and alignment (15 points). The result was rated excellent if the score was between 93 and 100 points, good if the score was between 83 and 92 points, fair if the score was between 66 and 82 points, and poor if the score was less than 66 points.

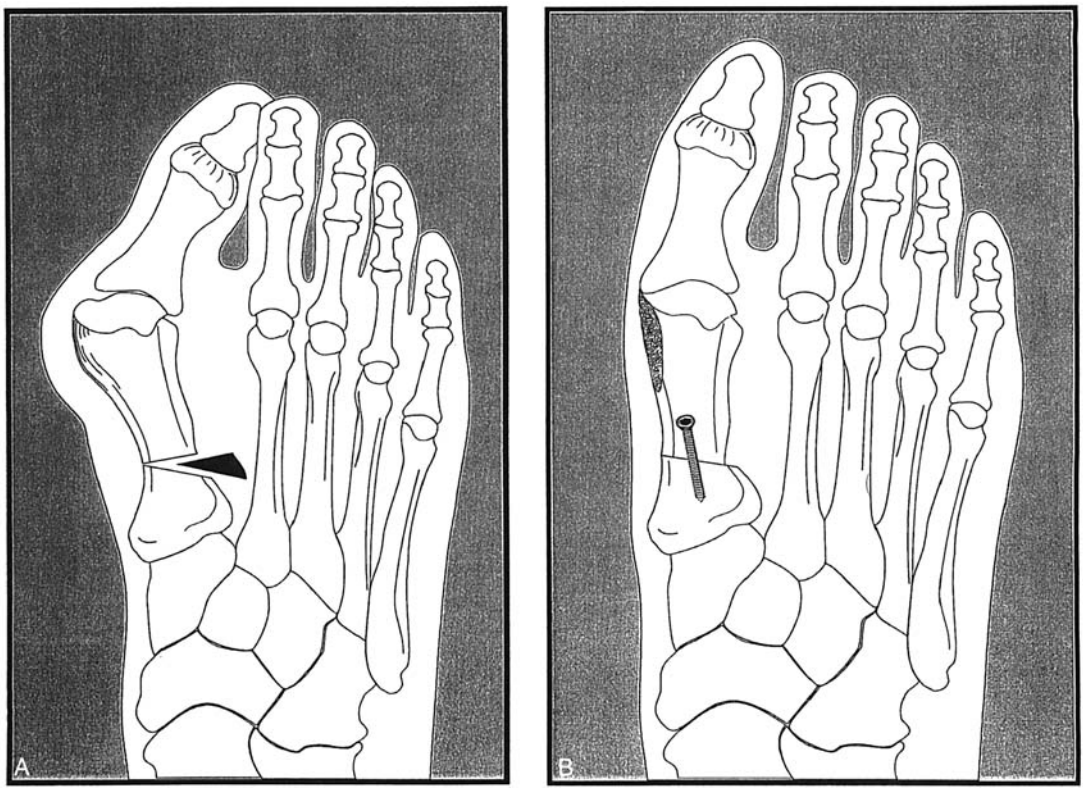

Fig 1A–B. (A) Removal of a laterally based wedge. (B) Fixation of the osteotomy with a cancellous screw.

In addition, patients were evaluated using a clinical score according to Bonney and McNab[2] (Table 2). Subjective criteria were pain relief, activity limitation in respect to job and sports, and cosmetic result. The ROM of the first metatarsophalangeal joint measured with a goniometer was a criterion for objective assessment. Metatarsalgia was differentiated carefully from pain related to the hallux and first metatarsophalangeal joint and was documented separately. Finally, patients were asked if they would again agree to the same surgical procedure in case of deformity.

Dorsoplantar and lateral weightbearing radiographs were obtained at followup, and from these the hallux valgus angle, intermetatarsal I/II angle, and the grade of sesamoid subluxation (Grades 0–3) were measured and compared with the preoperative radiographs as recommended by the American Orthopedic Foot and Ankle Society.[25] Shortening and dorsal elevation[11,19,22,23] of the first metatarsal were evaluated in the osteotomy group. In addition, the neoarticulation gap and the sesamoid retraction (difference of the preoperative and postoperative distance between the distal line of the sesamoids and the distal convexity of the metatarsal head) were measured in the Keller group at followup.

Statistical analysis was done using the SPSS-6.1 statistical software system (SPSS Inc, Chicago, IL). The two-tailed Student's t test was used for normally distributed and numeric variables. The Mann-Whitney U test was used for ordinally scaled or not normally distributed variables. The Kolmogorov-Smirnov test was used to test for normal distribution. Fisher's exact test was used for small numbers. Significance was defined as a p value < 0.05.

TABLE 2. Clinical Score According to Bonney and MacNab[2] (modified)

Grading	Subjective	Objective
Excellent	Free of pain, even in job and/or sports, no limit of mobility, excellent cosmetic result	Active plantar flexion ≥ 15° Active dorsal extension ≥ 30° Hallux valgus angle ≤ 15°
Good	Free of pain, only in job and/or sports sometimes pain, no limit of mobility, good cosmetic result	Active plantar flexion ≥ 15° Active dorsal extension ≥ 15° – 29° Hallux valgus angle 16° – 25°
Satisfied	Sometimes pain, aggravated by job and/or sports, some limit of mobility, satisfying cosmetic result	Active plantar flexion 10° – 14° Active dorsal extension 10° – 14° Hallux valgus angle 26° – 35°
Dissatisfied	Continuous pain, aggravated by job and/or sports, severe limit of mobility, dissatisfying cosmetic result	Active plantar flexion < 10° Active dorsal extension < 10° Hallux valgus angle > 35° Cockup deformity, hallux varus, floppy toe

RESULTS

Clinical Results

Hallux Metatarsophalangeal Interphalangeal Scale

The results of the two methods of treatment were significantly different by Hallux Metatarsophalangeal Interphalangeal Scale evaluation, with an average rating of 91 points (range, 49–100 points) in the osteotomy group and 80 points (range, 29–100 points) in the Keller group ($p < 0.05$). However, the ROM of the first metatarsophalangeal joint was maintained better after osteotomy. In the osteotomy group 35 (71%) patients and in the Keller group 13 (54%) patients had no restriction of footwear and were able to wear any kind of shoes at followup. No patient needed custom-made shoes (Table 3).

Modified Score

In the osteotomy group, subjectively excellent results were achieved in 32 feet in 22 (64%) patients, good results in nine feet in six (18%) patients, satisfactory results in three feet in two (6%) patients, and unsatisfactory results in six feet in four (12%) patients. Objective grading revealed excellent results in 28 feet in 19 (56%) patients, good results in 12 feet in eight (24%) patients, satisfactory results in four feet in three (8%) patients, and unsatisfactory results in six feet in four (12%) patients (Table 4).

In the Keller group, excellent results were obtained subjectively in 15 feet in 10 (40%) patients, good results in 13 feet in eight (35%) patients, satisfactory results in five feet in three (15%) patients, and unsatisfactory results were obtained in four feet in two (10%) patients. Objective grading showed excellent results in 21 feet in 13 (55%) patients, good results in seven feet in five (20%) patients, satisfactory results in eight feet in five (22%) patients, and unsatisfactory results in one (3%) patient.

Total pain relief related to the first metatarsophalangeal joint and the hallux was achieved in 88% (38 feet in 30 patients) of the osteotomy group and in 70% (26 feet in 16 patients) of the Keller group ($p < 0.05$). Overall satisfaction with the cosmetic appearance of the foot was reported for 39 feet in 26 (78%) patients after osteotomy and for 24 feet in 15 (64%) patients after Keller's arthroplasty. When asked if they would consider having bunion surgery again, 78% of the patients in the osteotomy group said yes. In the Keller group, 62% stated they would have the surgery again.

TABLE 3. Overall Clinical Results: Osteotomy Group Versus Keller Group

Parameter	Osteotomy Group n = 50	Keller Group n = 37	p Value
Hallux Metatarsophalangeal Interphalangeal Scale (average points)	91 points	80 points	< 0.05
Active range of motion (average degree)	Plantar flexion 24° Dorsal extension 50°	Plantar flexion 25° Dorsal extension 45°	not significant (> 0.05)
No restriction of footwear	71%	54%	—
Total pain relief	88%	70%	< 0.05
Metatarsalgia	28%	27%	not significant (> 0.05)
Same surgery again	78%	62%	—

Metatarsalgia was present in 14 (28%) feet in 11 patients in the osteotomy group at followup. Four (29%) patients had varus deformity. Subjective grading of the patients with metatarsalgia was excellent in 58%, good in 21%, and dissatisfied in 21%.

Metatarsalgia was present in 10 (27%) feet in eight patients in the Keller group. None of the patients had more than 30° valgus deformity, and none had varus deformity. Subjective grading in this metatarsalgia group was excellent in none of the patients, good in 40% of the patients, satisfied in 20% of the patients, and dissatisfied in 40% of the patients.

The results in the osteotomy group that were unsatisfactory were attributed to a recurrent valgus deformity in two (4%) patients and to a varus deformity in four (8%) patients. Varus deformity occurred within 2 years after surgery, but revision surgery led to a good result at final followup in two patients. The other two patients were satisfied without surgical treatment. Because of metatarsalgia accompanied by painful plantar callosities, four (11%) patients had poor results in the Keller group. Two feet had a cockup deformity develop and had to undergo surgery. Nine (18%) feet in the osteotomy group and two (5.4%) feet in the Keller group had clinically evident varus deformity at followup ($p < 0.05$).

Complications included two cases of delayed wound healing; two cases of pseudarthrosis, which had a delayed osseous consolidation; one deep infection; and one case of osteomyelitis effectively treated by antibiotic therapy in the osteotomy group. In the Keller group, complications included one case of de-

TABLE 4. Clinical Results of the Osteotomy Group (50 Feet in 34 Patients) and the Keller Group (37 Feet in 24 Patients)

	Subjective		Objective	
Grading	*Osteotomy Group Number (%)*	*Keller Group Number (%)*	*Osteotomy Group Number (%)*	*Keller Group Number (%)*
Excellent (1)	32 (64)	15 (40)	28 (56)	21 (55)
Good (2)	9 (18)	13 (35)	12 (24)	7 (20)
Satisfied (3)	3 (6)	5 (14)	4 (8)	8 (22)
Dissatisfied (4)	6 (12)	4 (11)	6 (12)	1 (3)

Clinical score according to Bonney and MacNab[2]; modified.

layed wound healing and two cockup deformities that required revision.

Radiologic Results

In the osteotomy group, an average hallux valgus angle of 38° (range, 26°–54°) was measured before surgery and was corrected to 19° (range, 0°–46°) at followup. The first intermetatarsal angle was corrected from 16° (range, 10°–21°) to 6° (range, 0°–18°). The degree of lateral displacement of the tibial sesamoid was 2.6° (range, 0°–3°) before surgery and 0.9° (range, 0°–3°) at followup (Table 5). In this group, metatarsal shortening averaged 5 mm (range, 0–15 mm) excluding one case with shortening of 26 mm. Dorsal elevation of the first metatarsal was found in 14 (38%) feet. In the Keller group, an average hallux valgus angle of 28° (range, 16°–42°) was measured before surgery and corrected to 19° (range, 2°–32°) at followup. The first intermetatarsal angle was unaffected by excision arthroplasty, averaging from 11° (range, 4°–18°) before surgery to 11° (range, 4°–19°) on review. The degree of lateral displacement of the tibial sesamoid was 1.7° (range, 0°–3°) before surgery and 1.4° (range, 0°–3°) at followup (Table 5). An average proximal migration of the sesamoids of 14.4 mm (range, 6–19 mm) was found in the Keller group but did not occur in the osteotomy group. The measurable neoarticulation gap between the metatarsal head and the phalangeal remnant averaged 2.2 mm (range, 0–5 mm). Divided into two groups, there were 23 (68%) feet with a neoarticulation gap between 0 and 2 mm, and 11 (32%) feet with a gap between 3 and 5 mm. The relationship between cases of metatarsalgia in both groups and the clinical and radiographic findings are shown in Table 6.

DISCUSSION

This study reports an analysis of a patient population who had surgery for hallux valgus either by basal metatarsal closing wedge osteotomy with a modified McBride distal soft tissue release or by Keller's excision arthroplasty with a cerclage fibreux.[28] A followup of 10 to 22 years (mean, osteotomy group 18 years; Keller group, 13 years) allows for accurate determination of the effectiveness of the methods used. Both methods are not comparable technically because it is known they should

TABLE 5. Comparative Radiologic Results of the Osteotomy Group and the Kelley Group

Parameter	Osteotomy Group		Keller Group		Mean Total Correction		p Value
	Preoperative (n = 35)	*Postoperative (n = 37)*	*Preoperative (n = 23)*	*Postoperative (n = 34)*	OG	KG	
Hallux valgus, angle mean ± standard deviation	38° ± 6.4	19° ± 11.1	28° ± 7.3	19° ± 8.2	19°	9°	< 0.05
Intermetatarsal angle mean ± standard deviation	16° ± 3.3	6° ± 4.2	11° ± 3.5	11° ± 3.7	10°	0°	< 0.05
Average sesamoid position	2.6	0.9	1.7	1.4	1.7	0.3	< 0.05

OG = Osteotomy group.
KG = Keller group.

TABLE 6. Relationship Between Metatarsalgia and the Clinical and Radiologic Findings at Followup

Clinical Results	Osteotomy Group (n = 14)	Keller Group (n = 10)
Hallux Metatarsophalangeal Interphalangeal Scale, average points	80 (range, 49 – 95)	61 (range, 29 – 82)
Subjective (cases)[1]	a:8, b:3; c:0; d:3	a:0; b:4, c:2; d:4
Average flexion	24° (range, 10° – 35°)	19 (range, 10° – 35°)
Average extension	44° (range, 25° – 70°)	37° (range, 15° – 55°)
Radiologic results		
Hallux valgus angle, average	22° (range, 9° – 34°)[2]	16° (range, 7° – 30°)
Intermetatarsal angle, average	6° (range, 0° 16°)	10° (range, 4° – 17°)
Sesamoid position, average	1	1.4
Sesamoid migration, average	0	14 mm (range, 6 – 18 mm)
Dorsal elevation (cases)	8 (57%)	0
Metatarsal shortening, average	7.7 mm (range, 1 – 26 mm)	0

a=excellent; b=good; c=satisfied; d=dissatisfied.

Excluding four cases of varus deformity.

Metatarsalgia: osteotomy 14 feet in 11 patients (28%); Keller 10 feet in 9 patients (27%).

be applied to different patient populations. However, the clinical and radiologic long-term followup of both procedures, which were performed for the same indication in a homogenous group of patients, makes this an interesting evaluation. There are comparable studies about basal metatarsal osteotomies but with a maximum followup of 7 years.[5,12,15,17,21,23,29] Published results after Keller's excision arthroplasty, mainly in younger patients, are few, and most have shorter periods of review.[4,27,31]

Previous authors have expressed dissatisfaction with the Keller procedure and suggested that basal metatarsal osteotomy shows clinical, radiologic, and biomechanical advantages over the ablative excision arthroplasty.[17,26] There is no doubt that from a mechanical standpoint, the basal metatarsal osteotomy may achieve better correction of hallux valgus deformity. However, basal metatarsal osteotomies have been established as methods of choice for the treatment of moderate and severe hallux valgus deformity.[3,5,15,17,21,23,26,29] Bonney and McNab[2] reported in their review of the results of basal osteotomy that a frequent cause of an unsatisfactory result was failure to maintain the corrected position achieved during surgery. Shortening and dorsal elevation of the first metatarsal are considered the main problems of basal metatarsal osteotomies that may lead to bad results.[12,17,24]

Until approximately 10 years ago, Keller's operation commonly was used in the treatment of hallux valgus with painful bunion in younger patients. Criticisms of its value for those who also have metatarsalgia and for the younger patient have been used as arguments for alternative methods. With the advent of currently accepted procedures, such as the proximal crescentic osteotomy[17] or the proximal chevron osteotomy[23] combined with distal soft tissue releases, Keller's technique lost its importance in the treatment of hallux valgus, especially in the younger patient. However, it kept its role in the treatment of hallux rigidus, hallux valgus with degenerative arthritis of the first metatarsophalangeal joint in the older patient, and as a salvage procedure after failure of joint preserving techniques.[1,4,7,20,22,27,31]

In the current study, the results of basal metatarsal osteotomy generally were more satisfactory than were those associated with Keller's procedure. However, most failures in the osteotomy group were attributable to tech-

nical failure on the osteotomy site, with loss of correction and overcorrection leading to metatarsalgia or varus deformity. Most failures in the Keller group were attributable to metatarsalgia or cockup deformity. Based on the statistical analysis of the radiologic outcome, basal metatarsal osteotomy achieved a significantly better correction of the hallux valgus angle and first intermetatarsal angle and repositioning of the sesamoids under the first metatarsophalangeal joint than did excision arthroplasty (Table 5). As other authors have reported, Keller's technique is not able to correct metatarsus primus varus.[4,17,22] The preoperative first intermetatarsal angle in the Keller group, averaging 11°, could not be corrected, despite use of a cerclage fibreux.[28] Lack of correction of the metatarsus primus varus is the predisposing factor for recurrence of valgus deformity. Because of this fact, a small correction of 9° on average of the hallux valgus angle was found in this series of Keller procedures.

In the osteotomy group, a satisfactory correction of the hallux valgus angle, the first intermetatarsal angle, and the sesamoid position was achieved. Comparing the results of both procedures, the incidence of varus deformities is higher with basal osteotomy. There were nine feet (18%) in the osteotomy group and two feet (5.4%) in the Keller group with varus deformities. There is a statistically significant difference. However, the numbers are small.

Using a simple score for subjective and objective evaluation with respect to the activity of younger patients, there was a statistically significant difference between the two groups (Table 4). Eighty-two percent of patients in the osteotomy group and 75% in the Keller group rated their outcome as excellent or good. A more remarkable difference is shown by the analysis of both groups with the Hallux Metatarsophalangeal Interphalangeal Scale (Table 3). An excellent or good rating was evident in 84% of the osteotomy group but in only 57% of the Keller group. These results compare favorably with other reported short-term series and suggest that basal metatarsal osteotomies are the superior technique.[5,6,16,17,21,29]

Metatarsalgia is an undesired effect after basal metatarsal osteotomy or excision arthroplasty. The problem is a matter of controversy. Several authors suggested that operative shortening of the first metatarsal after basal metatarsal osteotomy was not related to the incidence of postoperative metatarsalgia but rather to insufficient plantar displacement or dorsal angulation of the distal metatarsal.[18,20,27] Other authors reported that dorsal elevation did not influence the incidence of lateral metatarsalgia in their series.[17,23] Metatarsalgia after Keller's operation occurs because of a loss of stability of the first metatarsophalangeal joint, which is caused by disruption of the insertion of the plantar aponeurosis and the intrinsic muscles into the base of the proximal phalanx.

During the second half (toe-off) of the stance phase of gait, the first metatarsophalangeal joint is destabilized. Instead of the first metatarsal head carrying the normal load of more than 50% of the body weight on toe-off, this weight is shifted laterally to the second and occasionally the third metatarsal heads, which leads to plantar callosities and may result in metatarsalgia.

An investigation by Henry et al[9] using footprint analyses showed that the etiology of pain on the plantar aspects of the middle metatarsal heads was related to increased loading at these sites. They also showed that the big toe bears weight in only 40% of cases after a Keller procedure.

Other authors found that in normal feet, the great toe and the first metatarsal each transmit a load, which is about twice the combined loads of the lateral four toes.[11] After Keller's operation, the loading of the first metatarsal head is increased, that of the hallux is reduced, and that of the lateral metatarsal heads remains unchanged.[8] Cleveland and Winant[6] observed no symptomatic improvement of lateral metatarsalgia after excision arthroplasty. Some authors concluded that excision arthroplasty had an unpredictable effect on metatarsalgia.[2,7,22,27,31]

For patients with painful bunions and metatarsalgia, several authors recommend al-

ternative procedures, such as metatarsal osteotomies, because Keller's operation cannot be expected to relieve metatarsalgia.[4,8,22,27,31] As reported by Wrighton,[31] metatarsalgia that developed after Keller's operation was less common in younger patients after a followup of 10 years. The incidence of metatarsalgia was higher in cases with recurrence of hallux valgus deformity greater than 30°. Broughton and Winson[4] reported that patients younger than 45 years of age had significantly worse results after Keller's procedure than did patients older than 45 years.

In the current study, metatarsalgia was present in 28% of patients in the osteotomy group at a mean followup of 18 years. Of the 26% of patients with preoperative lateral metatarsalgia, symptoms had resolved totally in 54% and had improved in 46% of patients at the time of review. At followup, there was a 57% increase in metatarsalgia developing after surgery. Showing a correlation between dorsal malalignment and development of lateral weight transfer, 57% of all patients with metatarsalgia had dorsal elevation on lateral weightbearing radiographs. This finding may underline the theoretical notion that if, after osteotomy, the distal metatarsal is placed plantarward and maintained in this position until union occurs, a lateral weight transfer that may cause metatarsalgia can be avoided.

In the Keller group, metatarsalgia was observed in 27% at a mean followup of 13 years. Of the 23% of patients with preoperative lateral metatarsalgia, symptoms had resolved in 50% and improved in 50% at the time of review. At followup, there was a 40% increase in metatarsalgia developing after surgery.

Numerous authors agree that patients with

Fig 2A–B. (A) Dorsoplantar weightbearing radiograph of a 31-year-old woman with hallux valgus before surgery. Hallux valgus angle, 38°; intermetatarsal angle, 14°; sesamoid subluxation, Grade 3; metatarsophalangeal joint, incongruent. (B) Dorsoplantar weightbearing radiograph of a 47-year-old woman 16 years after basal metatarsal closing wedge osteotomy, with a satisfying correction. Hallux valgus angle, 7°; intermetatarsal angle, 8°; sesamoid subluxation, Grade 0; metatarsophalangeal joint, congruent; screw in situ.

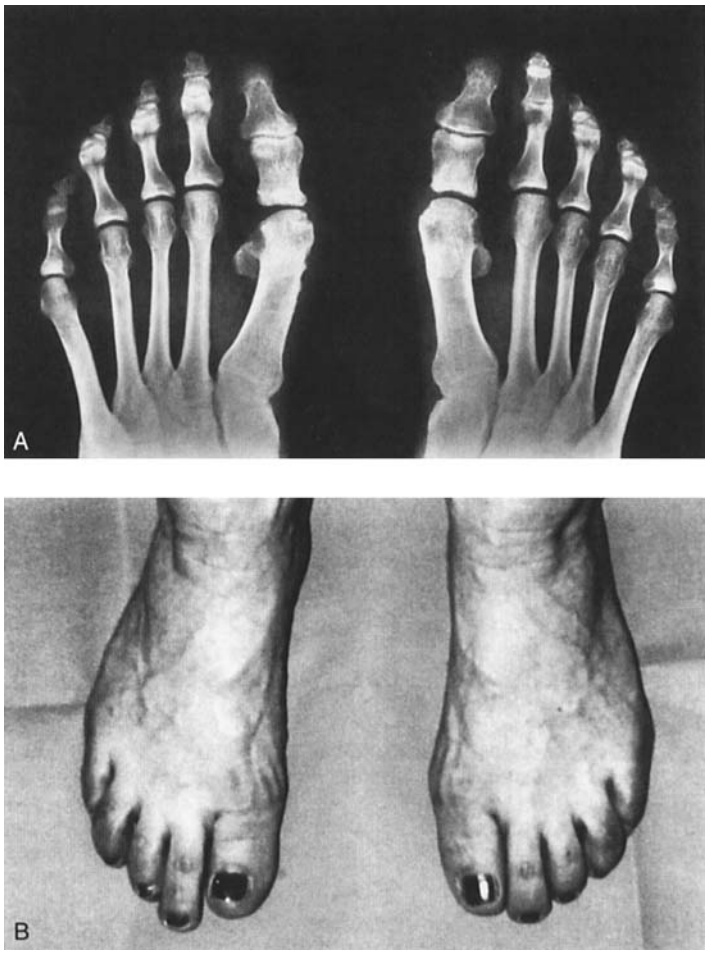

Fig 3A–B. (A) Dorsoplantar weightbearing radiograph of a 48-year-old woman 13 years after bilateral Keller's excision arthroplasty, with a satisfying result. Hallux valgus angle, right 16°, left 18°; intermetatarsal angle, right 8°, left 11°; sesamoid subluxation, right Grade 1, left Grade 1. (B) Dorsoplantar photograph of a 48-year-old woman 13 years after bilateral Keller's excision arthroplasty at followup, with a satisfying cosmetic result.

hallux valgus and metatarsus primus varus require correction at the proximal metatarsal.[3,7,17,19,21–23,26] Basal wedge osteotomies are demanding technically, and it is not possible to determine the dimensions of the wedge from preoperative radiographs when trying to plan the correction. Thus, the amount of correction is neither predictable nor reproducible. Basal metatarsal closing wedge osteotomy bears the risk of extensive shortening and dorsal malangulation during surgery and the loss of correction after surgery, leading to a metatarsus elevatus. If the osteotomy is performed accurately, a satisfying correction of the deformity can be obtained, and excellent long-term results can be achieved (Fig 2).

Keller's excision arthroplasty also is capable of achieving excellent long-term results in younger patients but only in a few cases in which a small first intermetatarsal angle is present (Fig 3). This is because of the inability of excision arthroplasty to correct a metatarsus primus varus. Adequate repositioning of the sesamoid complex is not achieved.

These facts and the dysfunction of the great toe caused by the ablative character of this technique suggest it is necessary to perform metatarsal osteotomies combined with soft tissue procedures in the treatment of hallux valgus of the younger patient.

In addition to complete pain relief, patients require excellent functional and cosmetic long-term results. Requirements in young patients may be higher than in older patients. To

meet these requirements, adequate joint preserving procedures that efficiently correct the deformity should be the method of choice.

This long-term analysis indicates that the Keller arthroplasty should be abandoned for treatment of hallux valgus in young and active patients. The basal metatarsal closing wedge osteotomy is conceptually the correct treatment for hallux valgus deformity; however, it is technically demanding and is associated with a higher risk of failure. The long-term results of both procedures are unacceptable for the patient and the surgeon. The short and middle-term results of the newer basal type osteotomies, such as the proximal crescentic osteotomy, the proximal chevron osteotomy, or the proximal oblique osteotomy combined with distal soft tissue releases, suggest a more satisfying long-term outcome.

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