The Modified Hohmann Osteotomy: An Alternative Joint Salvage Procedure for Hallux Rigidus

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The purpose of this study was to evaluate the effectiveness of the modified Hohmann osteotomy for treatment of hallux rigidus. By allowing plantarflexion of the first metatarsal head, this osteotomy was theorized to protect gliding motion and to decompress the joint. Twenty-two patients (25 procedures) were assessed preoperatively and postoperatively for the first metatarsal plantarflexory osteotomy. The average postoperative follow-up was 12 months, with a range of 6 to 60 months. Postoperative subjective patient questionnaires showed the following: 96% reported excellent subjective ratings with no fair or poor ratings, 80% reported a return to normal activity within 1 to 2 months, no patients reported any significant limitations in their activity or reoccurrence of pain, and no patients reported any need for a revision surgery other than hardware removal. A goniometer was used to measure preoperative and postoperative dorsiflexion and plantarflexion at the first metatarsophalangeal joint. The patient first metatarsophalangeal joint dorsiflexion increased from a mean 17.76° preoperatively to a mean 58.92° postoperatively. The ability to hold a piece of paper under the hallux for purchase power was also evaluated. Only 2 of 25 procedures lacked the purchase power to effectively hold a piece of paper with the hallux. Thus, the modified Hohmann osteotomy provides an excellent alternative joint-salvaging procedure for moderate to severe hallux rigidus. (The Journal of Foot & Ankle Surgery 43(6):380-388, 2004)

Key words: Hohmann, hallux limitus, hallux rigidus

Hallux rigidus is marked by a progressive degeneration of the first metatarsophalangeal joint (MPJ) and is characterized by decreasing range of motion and the development of osteophytes. It is reported to affect 1 in 45 individuals older than 50 years of age (1). Suggested causes for hallux rigidus include trauma, systemic arthritides (ie, gout, rheumatoid arthritis, psoriatic arthritis), infectious arthritis, a long or short first metatarsal, a long proximal phalanx, metatarsal-sesamoid degeneration, flexor hallucis brevis and medial plantar fascia band contracture, primary or secondary metatarsus primus elevatus, first ray hypermobility, or even use of high-heeled shoes (2–4).

Although there is no definitive evidence proving a specific cause of hallux rigidus, many theories lie behind each of the previously mentioned causes. For instance, a long first metatarsal can overload the first MPJ as the foot enters the propulsive phase of gait, resulting in repetitive jamming at the joint, degenerative joint changes, and limitation of hallux dorsiflexion. This occurs because a long first metatarsal requires a certain amount of elevatus to maintain an even contact with the ground (5). Furthermore, elevatus of the first ray deprives the peroneus longus of its mechanical advantage necessary for stabilizing the first ray during late midstance and propulsion. This results in relative dorsiflexion and inversion of the first metatarsal, rendering it unable to allow dorsal glide of the proximal phalanx over the distal metatarsal head (3, 6). Roukis et al (7) reported that only 4 mm of first ray dorsiflexion is required to decrease first MPJ dorsiflexion by 19%.

One must also consider 3 main soft tissue components when evaluating hallux rigidus: 1) the flexor hallucis brevis and the sesamoid apparatus, 2) the medial band of the plantar fascia, and 3) the joint capsule itself. Root et al (8) stated that, if the sesamoids are located too far proximal to the joint, the first metatarsal cannot plantarflex adequately and move posterior. Forces at the joint will therefore increase, resulting in jamming and the development of hallux equinus (8). Over time, this can lead to sesamoid hypertrophy, arthrosis, sesamoid immobility, and possible ankylosis (9). The consequences of jamming can be seen intraopera-

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TABLE 1 **The Drago, Oloff, and Jacobs (11) classification of hallux limitus**

Grade I	Pre-hallux limitus with a significant metatarsus primus elevatus, plantar subluxation of the proximal phalanx on the first metatarsal head, and significant pronatory component on the rearfoot. Clinically, there is pain on end range of motion. This deformity is functional in nature with only minimal adaptive changes.
Grade II	Reflects some flattening of the first metatarsal head, possibly with an osteochondral defect. There is also pain on end range of motion, but structural adaptation has already occurred. Passive range of motion is limited, but is most pronounced with the forefoot loaded. Viable cartilage is present plantarly on surgical examination with evidence of degeneration of dorsal cartilage. A small dorsal exostosis is common.
Grade III	A more severe flattening of the head of the metatarsal, and osteophytic production, especially a large dorsal exostosis, both on the proximal phalanx and on the head of the first metatarsal. There is nonuniform narrowing of the joint, crepitus, and pain on full range of motion. Degeneration of articular cartilage is found during surgical exploration with loss of range of motion.
Grade IV	This is a more severe form of grade III, with total obliteration of the joint space, loose bodies within the joint or capsule, and less than 10° of total MPJ motion. It is usually associated with inflammatory arthritis. Some of these patients may be asymptomatic if total ankylosis has occurred.

tively as cartilaginous erosions either at the dorsal aspect of the first metatarsal head or plantarly along the sesamoidal grooves.

Both the medial plantar fascia band and the capsule are passive contributors to hallux rigidus. Hicks' windlass mechanism, in which dorsiflexing the great toe stretches the plantar fascia, leads to a rise in the longitudinal arch that can profoundly affect first MPJ motion. A short medial band, either congenital or acquired over time, is capable of decreasing first MPJ dorsiflexion because of its intimate anatomic relationship with the sesamoid apparatus (10). Similarly, the joint capsule can lose its elasticity because of a proliferation of reactive synovitis that results from chronic, repetitive jamming of the MPJ (3).

Numerous authors have attempted to classify hallux rigidus (3, 11–14). Drago, Oloff, and Jacobs (11) were the first to create a classification system based on the condition's radiographic and clinical appearance (Table 1). Generally, the more advanced the degenerative joint disease, the worse the prognosis, regardless of the grading system used (2, 3, 11–16).

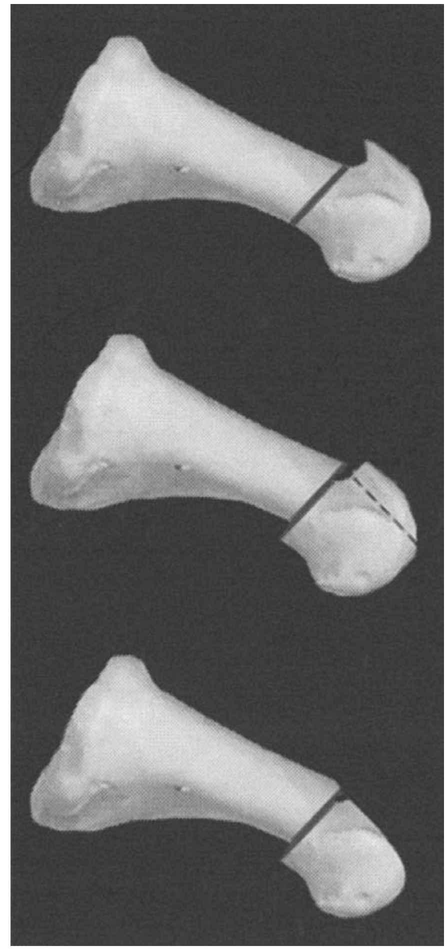


FIGURE 1 The modified Hohmann osteotomy. Lateral view of the first metatarsal. An oblique osteotomy with plantar transposition of the capital fragment followed by resection of the atrophic dorsal osteophyte.

The goal for surgical repair of hallux rigidus is long-term pain relief and improved joint motion while avoiding long-term complications (15). There have been numerous surgical options described in the literature including cheilectomy, first metatarsal osteotomy, proximal phalanx osteotomy, arthrodesis, and implant arthroplasty (2, 3, 16, 17). At present, there is scant information regarding the efficacy of a distal plantarflexory osteotomy in the correction of hallux rigidus.

Hohmann (18–22) first described this first metatarsal osteotomy in 1921 and then modified it during the next 30 years. He was credited with describing a transverse osteotomy at the anatomic neck that addressed sagittal and transverse plane abnormalities of the first metatarsal (23, 24). The goals were to reduce the hallux valgus deformity, to reduce forefoot splay (by combining the same procedure on the fifth metatarsal), and to correct the dorsal bunion. He also was one of the first to take into account the contribution of the dorsal exostosis (13, 14). He also emphasized the

TABLE 2 The University of Maryland 100-point painful foot scoring system

		Points Worth
1.	Presently, regarding my bunion surgery, I have:	
	A. No pain, including sports	45
	B. Slight pain, but it does not affect my work ability	40
	C. Mild pain, but I have to make only minimal changes in my regular daily activity	30
	D. Moderate pain, and I take Aspirin, Tylenol or Advil for it	20
	E. Marked pain, even with minimal activities	10
	F. Disabling pain, for which I take stronger pain pills (if so, what type?)	0
2.	With regards to my bunion surgery area and walking, my walking ability is:	
	A. Unlimited	10
	B. Slightly decreased	8
	C. Moderately decreased	5
	D. Severely decreased	2
	E. Restricted to indoors only	0
3.	With regards to my bunion surgery influencing my walking:	
	A. I feel completely stable when I walk	4
	B. I have a weak feeling when I walk	3
	C. I have an occasional giving way	2
	D. I have instability when I walk (frequently giving way)	1
	E. I need support to walk	0
4.	With regards to my bunion surgery area and support:	
	A. I need no support to walk	4
	B. I need a cane to walk due to my foot	3
	C. I need crutches to walk	1
	D. I need a wheelchair	0
5.	With regards to my bunion surgery and walking:	
	A. I do not feel I have a limp	4
	B. I have a slight limp	3
	C. I have a moderate limp	2
	D. I have a severe limp	1
	a.) E. I cannot walk	0
6.	With regards to my bunion surgery and shoe gear:	
	A. I can wear any type of shoe I desire or want to wear	10
	B. There are some shoes that I cannot wear	9
	C. I can only wear flat heel shoes	7
	D. I need to wear shoes with my orthotics	5
	E. I wear special extra-depth shoes or “orthopedic shoes”	2
7.	With regards to my bunion surgery area and walking:	
	A. I can walk on any surface or terrain	4
	B. I have problems walking up and down hills	2
	C. I have problems walking o flat surfaces	0
8.	With regards to my bunion surgery and walking:	
	A. I can go up stairs normally	4
	B. I need to use the banister	3
	C. I need assistance going up and down stairs	2
	D. I am unable to go up and down stairs	0
9.	With regards to my bunion surgery area and how my foot looks:	
	A. I feel my foot looks normal	10
	B. It looks like I have a mild deformity	7
	C. It looks like I have a moderate deformity	5
	D. It looks like I have a severe deformity	0
10.	With regards to my bunions surgery and the motion I now have in my big toe joint(s):	
	A. I feel I have normal motion	5
	B. I feel my motion is slightly decreased	4
	C. I feel my motion I markedly decreased	0
11.	With regards to my bunions surgery, I was able to return to my normal activity:	
	A. in 1–2 months	
	B. in 2–3 months	
	C. in 3–4 months	
	D. in 4–5 months	
	E. in more than 6 months	

TABLE 2 Continued

		Points Worth
12.	Would you have this procedure performed again? A. Yes B. No	
13.	Would you recommend this procedure to someone else with the same problem? A. Yes B. No	Total 100

Questions 11 to 13 were included for additional subjective results and were not included in the total scoring.

need for transposition in the sagittal plane as well as transverse plane, recognizing the importance of elevatus in hallux rigidus and hallux valgus.

Hohmann used a medial incision that extends from the base of the proximal phalanx to the base of the first metatarsal. The first MPJ was never entered, and a medially based trapezoidal wedge of bone was removed from the first metatarsal neck. The capital fragment was then transposed laterally and plantarly, followed by suturing of the redundant medial capsule proximally into the metatarsal shaft. Internal fixation was not used and the medial eminence was not removed because he believed it was not a true exostosis (27).

The Hohmann osteotomy has been modified several times for correction of hallux valgus as well as for hallux rigidus (28–36). Winston and Wilson (26) first described the use of Kirschner wires for internal fixation to prevent displacement, pseudoarthrosis, and ultimate failure. Pelet (35) used screw fixation and a period of nonweightbearing for 6 weeks. Gerbert (37) described the use of the Hohmann in the correction of hallux valgus with Kirschner wire fixation, followed by 6 weeks of nonweightbearing. The trend toward a nonweightbearing postoperative period may have caused this procedure to fall out of favor in lieu of rigid internal fixation; early active range of motion; and protected, postoperative weightbearing. In addition, recent literature questions the usefulness of plantarflexory osteotomies in the treatment of hallux rigidus altogether (38, 39).

The purpose of this study was to evaluate a modification of the original Hohmann osteotomy in the treatment of hallux rigidus. This study was designed to evaluate the effectiveness of a distal oblique osteotomy with rigid internal fixation and immediate protected, postoperative weight bearing for the correction of hallux rigidus (Fig 1).

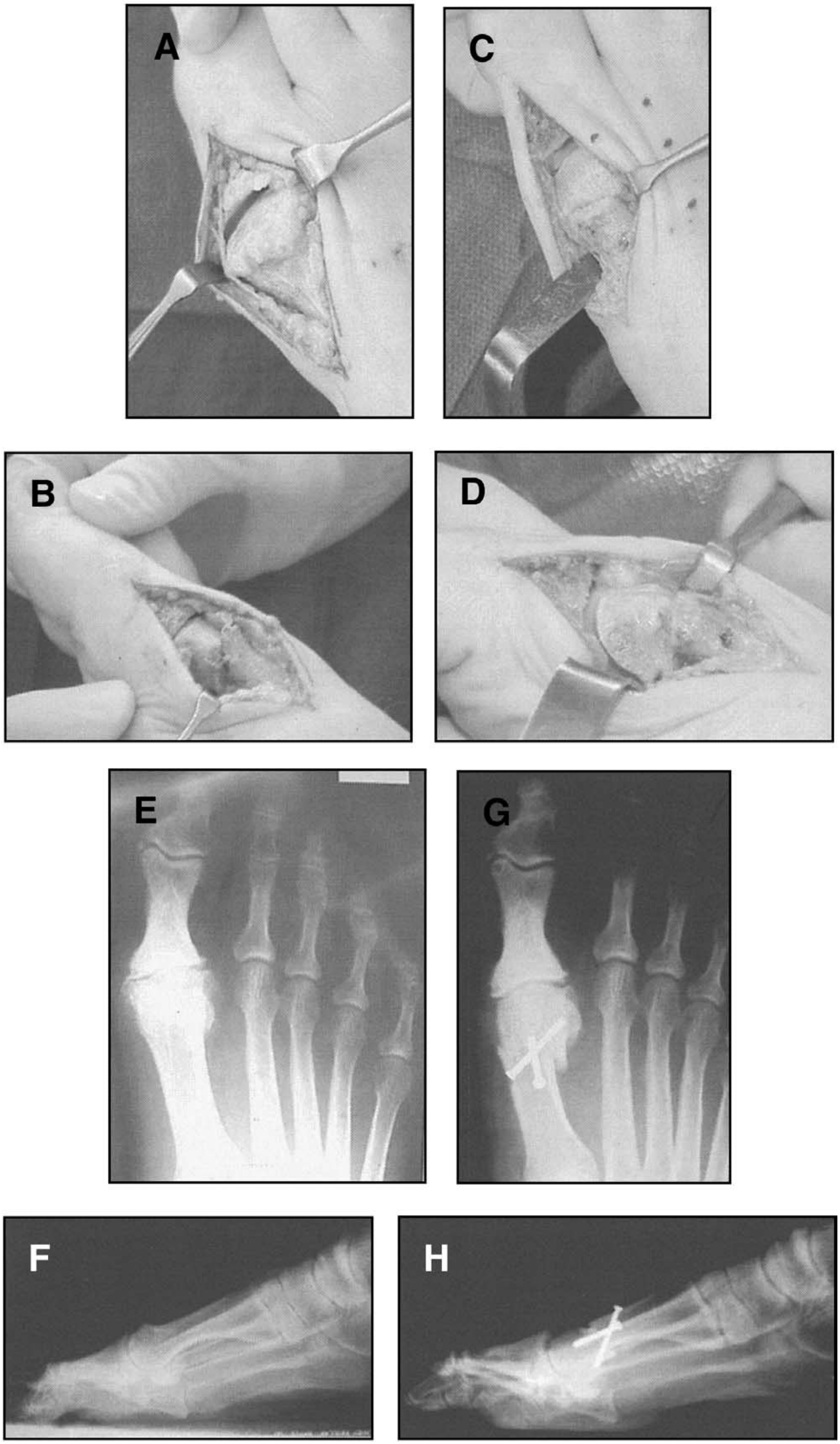
Materials and Methods

This was a retrospective clinical study of patients who underwent a Hohmann osteotomy for treatment of hallux rigidus and were available for follow-up evaluation between August 1997 and May 1998. Patients included in the study showed a decreased range of motion at the first MPJ with pain at the joint. All had failed conservative treatment consisting of shoe gear modifications, temporary strappings, or orthoses. All patients had an elevated first metatarsal on radiographic evaluation, whereas the dorsal cortex of the second metatarsal neck was seen in the middle or lower third of the first metatarsal on the weightbearing lateral radiograph.

Although the patients were not formally classified, most patients exhibited a grade II or grade III hallux rigidus according to the Drago, Oloff and Jacobs classification system (Table 1). Patients with grade IV hallux rigidus were excluded from the study, as were patients with significant osteopenia or severe cystic degeneration of the first metatarsal head seen on radiographs. Furthermore, anyone with a first intermetatarsal angle greater than 14° or anyone with a fused sesamoid apparatus was excluded. Patients who lacked adequate rearfoot inversion were also excluded because of the fact they lacked the subtalar joint compensation necessary to adjust to the more plantigrade attitude of the first metatarsal. Finally, patients who had previous first ray surgery were excluded from the study.

To evaluate the modified Hohmann osteotomy, the authors used postoperative patient satisfaction questionnaires as well as preoperative and postoperative objective clinical examinations performed by 1 of the authors (P.P.G.) at 6 and then a minimum of 12 months postoperatively. Subjective patient satisfaction was determined by using a modified University of Maryland 100-point painful foot scoring system (Table 2) (40). In addition, patients were asked to identify the length of time it took to resume their normal activity, and whether or not they would undergo the surgery again or recommend the surgery to someone with the same problem.

Objective criteria included first MPJ dorsiflexion and plantarflexion as well as purchase power. Preoperative and postoperative first MPJ dorsiflexion and plantarflexion were measured by using a goniometer with the subtalar joint in neutral and the hallux placed through its range of motion. One arm of the goniometer was placed parallel to the midline of the first metatarsal and the other placed parallel to the midline of the proximal phalanx of the hallux. Purchase power was evaluated at 6 and 12 months postopera-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tively. Active patient resistance to plantar paper pullout was tested with the patient standing: the ability to resist the pullout was identified versus the lack of resistance to paper pullout. The strength of the resistance was not evaluated.

Surgical Procedure

The first MPJ was exposed through a dorsomedial linear incision and linear capsulotomy. The dorsomedial eminence was resected. A 30° to 45° oblique osteotomy was performed at the metatarsal neck, coursing from dorsal-distal to plantar-proximal (Fig 1). The capital fragment was plantarly displaced and shortened on the first metatarsal, and then temporarily fixated with 2 crossed 1.1-mm cannulated guide wires. The wires were inserted from dorsal-proximal to plantar-distal, and replaced with two 3.0-mm cannulated screws, with care taken not to violate the articular surface. The atrophic dorsal one-fourth to one-third of the first metatarsal head may then be removed, and subchondral fenestration is performed as needed for cartilage defects (Fig 2). After closure of capsule and skin, a bulky gauze dressing is applied and the patient is allowed to bearweight immediately in a surgical shoe.

Passive and active first MPJ range of motion exercises were started at the first postoperative appointment (within 3 to 5 days) and continued throughout the postoperative period. Passive range of motion exercises consisted of the patients physically ranging the hallux themselves for 5 minutes at a time, at least 5 times daily. Radiographs were taken 2 weeks postoperatively to ensure bony alignment, and the patient was advanced into a soft shoe. Patients were allowed to begin swimming at 3 weeks postoperatively. Follow-up radiographs were taken 6 to 8 weeks postoperatively, and patients were allowed to resume light jogging and return to all other shoe gear at week 7 or 8 postoperatively.

Results

Twenty-two patients (13 men and 9 women) underwent 25 modified Hohmann osteotomies (3 bilateral) (Table 3). Eleven osteotomies were performed on the left foot and 14 were performed on the right foot. The mean age of the patients was 43 years (range, 22 to 63 years) and the mean follow-up was 12 months (range, 6 to 60 months).

Subjectively, 96% of the patients recorded an excellent rating, with no patients reporting a fair or poor rating. Eighty percent (20 patients) reported a return to normal activity within 2 months, 12% (N = 3) returned in 2 to 3 months, and 8% (N = 2) required more than 6 months (Table 4). No patients reported any current limping or any difficulty with stairs or uneven terrain. Twenty patients denied any significant current limitations in their activity or any recurrence of painful symptoms. One patient related slight pain with walking, and was 1 of 2 patients who required hardware removal because of screw irritation.

None of the patients require a supportive device for ambulation. Seven patients (28%) related difficulty with shoe gear, 6 of whom were women and wanted to return to high heels or tight dress shoes. One patient could only wear shoes with orthotics. Two patients complained of a mild palpable bump on the dorsum of the joint, which was actually related to hypertrophic scar formation and not bony regrowth. Seven patients (28%) subjectively related a limitation of first MPJ motion, but objective data showed an improvement of dorsiflexion. Another patient related limited range of motion but believed it was improved from preoperatively. Two patients complained of postoperative sesamoiditis after returning to their normal activities, which was completely resolved with orthotic adjustments. All 22 patients reported they would undergo the surgery again for the same problem, and all would recommend the modified Hohmann osteotomy to someone else.

Objectively, there was a postoperative average increase in first MPJ dorsiflexion of 41.16° (Table 5). The mean preoperative dorsiflexion of 17.76° increased to 58.92° (SD ± 11.39°). A noticeable decrease in postoperative plantar flexion was observed (average, 4.24°; SD ± 6.92°). At 6 months postoperatively, the purchase power test showed 5 patients (20%) who were unable to resist paper pullout with hallux plantarflexion. At 1 year postoperatively, 3 patients were still unable to resist the paper pullout. Postoperative radiographs showed no signs of dorsal migration, delayed union, or nonunion in any patient.

Discussion

The goal for the surgical treatment of hallux rigidus is to relieve pain and to restore dorsiflexion of the hallux. To

FIGURE 2 Case presentation of the modified Hohmann osteotomy. (*A*) Intraoperative view of a 52-year-old man with grade III hallux rigidus. (*B*) Intraoperative view of the modified Hohmann osteotomy, showing the plantar displacement of the capital fragment. (*C*) Final postoperative correction showing the joint space decompression. (*D*) Final postoperative correction, lateral view. Shortening and plantar displacement show joint space decompression. (*E*) Preoperative AP radiograph with joint space narrowing and osteophyte proliferation. (*F*) Preoperative lateral radiograph with metatarsus primus elevatus and intact plantar articular surface. The dorsal cortex of the second metatarsal neck sits in the middle third of the first metatarsal. (*G*) Postoperative anteroposterior radiograph shows shortening of the first metatarsal and decompression at the first MPJ. (*H*) Postoperative lateral radiograph shows the plantar translation of the capital fragment.

TABLE 3 Patient data

Patient	Preoperative Dorsiflexion (°)	Postoperative Dorsiflexion (°)	Increase in Dorsiflexion (°)	Preoperative Plantarflexion (°)	Postoperative Plantarflexion (°)	Change in Plantarflexion (°)	Foot	Sex
1	22	62	40	25	3	−22	Right	Male
2	28	62	34	25	0	−25	Right	Female
3	10	59	49	10	0	−10	Left	Male
4	23	59	36	25	0	−25	Left	Male
5	21	68	47	22	9	−13	Left	Female
6	18	65	47	10	5	−5	Left	Female
7	10	48	38	5	0	−5	Right	Male
8	30	74	44	50	7	−43	Right	Male
9	28	74	46	50	5	−45	Left	Female
10	22	43	21	23	0	−23	Right	Male
11	3	36	33	8	−2	−10	Right	Male
	15	40	25	20	5	−15	Left	
12	18	72	54	25	0	−25	Right	Male
13	18	57	39	10	0	−10	Left	Female
14	12	63	51	8	0	−8	Right	Male
15	10	42	32	20	2	−18	Right	Male
	13	55	42	20	5	−15	Left	
16	20	60	40	30	25	−5	Right	Female
17	20	74	54	20	0	−20	Left	Female
	20	78	58	20	0	−20	Right	
18	25	60	35	35	10	−25	Left	Female
19	18	64	46	19	1	−18	Right	Female
20	12	52	40	25	24	−1	Right	Male
21	10	57	47	16	7	−9	Left	Male
22	18	49	31	17	0	−17	Right	Male
Average	17.76	58.92	41.16	21.52	4.24	−17.28		

TABLE 4 Results of patient satisfaction questionnaire

Score	Rating	Patients (%)	No. of Patients
90–100	Excellent	96	24
75–89	Good	4	1
60–74	Fair	0	0
<60	Poor	0	0

achieve this, one must consider all pathologic forces that may be present. In the authors' opinion, the procedure of choice must be able to decompress the first MPJ and maintain as much biomechanical function possible at the joint. We believe the modified Hohmann osteotomy fulfills both of these requirements.

The results of this study compare favorably to other studies for this patient population. One of the most popular and widely used procedures is the cheilectomy (2–4, 16, 17). Our mean 58.92° of postoperative dorsiflexion is more motion than achieved in any previous study of cheilectomy. The largest amount of postoperative dorsiflexion with a cheilectomy is reported to be 40°, with other studies reporting a range from 28° to 39° of dorsiflexion (15, 41–43). Similarly, the most recent study of the Valenti procedure, a more aggressive partial joint destructive procedure than the cheilectomy, showed a mean 40.4° of postoperative dorsiflexion (44). Most importantly, the modified Hohmann osteotomy does not remove as much of the articular surface as a cheilectomy. In addition, it maintains a more physiologic joint motion, rather than converting the MPJ into a pivot-type joint as occurs with cheilectomy (45). Certainly, further biomechanical studies would have to be performed in order to verify this observation.

Recent literature, based strictly on radiographic evaluation of metatarsus primus elevatus, concluded that elevation of the first metatarsal in hallux rigidus is likely a secondary phenomenon because of the fact that patients with and without symptoms had similar degrees of elevatus (38, 39). The authors also stated that, "it seems unlikely that a plantarflexion osteotomy would have a role in the treatment of hallux rigidus" (38). On the other hand, we believe that the goal of any type of hallux rigidus repair must be to achieve adequate dorsiflexion while maintaining as normal joint biomechanics as possible. The modified Hohmann osteotomy accomplishes these goals, including joint decompression. Not only is the dorsal osteophyte removed but also the metatarsal osteotomy intrinsically decompresses the joint and allows for reduction of any elevatus component. First MPJ kinematics may be preserved by allowing the proximal phalanx to glide rather than to pivot over the first metatarsal. Other procedures may accomplish this goal, but most do not

TABLE 5 Objective findings of the first MPJ

Parameter	Mean	SD	Range	Median	Mode
Preoperative dorsiflexion	17.76°	±6.64	−2°–22°	18°	18°
Postoperative dorsiflexion	58.92°	±11.39	36°–78°	62°	74°
Preoperative plantarflexion	21.52°	±11.26	8°–50°	22°	25°
Postoperative plantarflexion	4.24°	±6.92	0°–25°	0°	0°

allow immediate postoperative weightbearing in a surgical shoe.

Our results show a postoperative improvement in subjective and objective results. The patients interviewed were overwhelmingly satisfied with their results, and all would have the procedure performed again and all would recommend it to others. The 96% excellent rating with the modified Hohmann osteotomy is slightly higher than the 80% to 90% ratings with cheilectomy. The fact that no fair or poor outcomes were reported may be attributed to the relatively small sample size and short follow-up period. The transient patient population of our urban area made it difficult to provide long-term data because of the relocation of many patients.

We were surprised by the fact that 80% of patients in this study related a return to normal activity within 1 to 2 months. In hindsight, the question regarding the return to normal activity (question 11 on Table 2) was vague and unclear as to what "normal activity" is: some may view walking as a normal activity whereas others may consider jogging as a normal activity. We believe that 2 to 3 months is probably a more realistic time frame to return to most activities.

Another study limitation is that the patients were not classified into a hallux rigidus grade, making it impossible to compare the procedure's results for grade II versus grade III patients. We also did not distinguish whether the pain was extraarticular or intraarticular. Similarly, the hallux purchase power was not graded according to the strength of resistance.

The literature has shown that cheilectomy and arthrodesis are adequate surgical options for correction of hallux rigidus. However, we believe the modified Hohmann osteotomy is a viable alternative for patients who may need more than a cheilectomy but who do not require a joint-destructive procedure. Clearly, a larger, more comprehensive study to accurately assess these preliminary findings and provide more long-term follow-up would be helpful in further defining the role of the modified Hohmann osteotomy in hallux rigidus surgery.

Summary

The modified Hohmann osteotomy is a viable alternative procedure for moderate first MPJ arthritis in patients with hallux rigidus. As a distal oblique first metatarsal plantarflexory osteotomy with 2-screw fixation, it allows for immediate, protected postoperative weightbearing and early return to normal shoe gear. Our results show an average increase in hallux dorsiflexion from 17.76° preoperatively to 58.92° postoperatively while eliminating pain and maintaining hallux purchase power.

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