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Proximal Supination Osteotomy of the First Metatarsal for Hallux Valgus

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Abstract

Background: Risk factors for hallux valgus recurrence include postoperative round-shaped lateral edge of the first metatarsal head and postoperative incomplete reduction of the sesamoids. To prevent the occurrence of such conditions, we developed a proximal supination osteotomy of the first metatarsal. Our aim was to describe this novel technique and report the outcomes in this report.

Methods: Sixty-six patients (83 feet) underwent a distal soft tissue procedure combined with a proximal supination osteotomy. After the proximal crescentic osteotomy, the proximal fragment was pushed medially, and the distal fragment was abducted, and then the distal fragment of the first metatarsal was manually supinated. Outcomes were assessed using the American Orthopaedic Foot & Ankle Society (AOFAS) score and radiographic examinations. The average follow-up duration was 34 (range, 25 to 52) months.

Results: The mean AOFAS score improved significantly from 58.0 points preoperatively to 93.8 points postoperatively ($P < .0001$). The mean hallux valgus and intermetatarsal angle decreased significantly from 38.6 and 18.0 degrees preoperatively to 11.0 and 7.9 degrees postoperatively, respectively (both, $P < .0001$). Sixty-nine feet (69/83, 83%) had a positive round sign preoperatively, and 66 feet (66/83, 80%) had a negative round sign postoperatively. According to the Hardy's classification of position of the sesamoids, all feet were classified as grade V or greater preoperatively, and 49 feet (49/83, 59%) were classified as grade IV or less postoperatively. Three feet (3/83, 4%) had recurrence of hallux valgus, defined as a hallux valgus angle $\geq$ 25 degrees.

Conclusion: The rates of occurrence of a positive round sign and incomplete reduction of the sesamoids significantly decreased postoperatively, which may have contributed to the low hallux valgus recurrence rates. We conclude that a proximal supination osteotomy was an effective procedure for correction of hallux valgus and can achieve a low rate of hallux valgus recurrence.

Level of Evidence: Level IV, retrospective case series.

Keywords: hallux valgus, proximal supination osteotomy, recurrence, operative outcome

Numerous operative procedures have been described for treating hallux valgus, and many investigators have reported the results of a distal soft tissue procedure combined with a proximal crescentic osteotomy of the first metatarsal, and have recommended this procedure for patients with moderate and severe hallux valgus deformity.[1-4,9-12,18-21,26,27] Postoperative hallux valgus recurrence is a relatively common complication and is associated with unsatisfactory operative results.[1,22] Risk factors for hallux valgus recurrence include a round-shaped lateral edge of the first metatarsal head and lateral displacement of the sesamoids following a proximal metatarsal osteotomy.[16,17]

To avoid postoperative positive round sign and lateral displacement of the sesamoids, we devised a novel technique of proximal supination osteotomy of the first metatarsal combined with a distal soft-tissue procedure. The purposes of the present study were to describe the operative technique of the proximal supination osteotomy and to prospectively review the results of this procedure for treatment of symptomatic adult hallux valgus.

Methods

This study was conducted in accordance with the World Medical Association Declaration of Helsinki. All patients provided informed consent and this study was approved by

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our institutional review board. From January 2008 through December 2011, 76 consecutive adult patients (94 feet) underwent the proximal supination osteotomy combined with a distal soft-tissue procedure. All patients were operated on by 2 of the authors (TY and RO). The indication for this procedure was symptomatic moderate to severe hallux valgus deformity (a hallux valgus angle greater than 25 degrees with subluxation of the first metatarsophalangeal joint, and/or an intermetatarsal angle greater than 12 degrees). Conservative treatment, including modification of shoe wear, nonsteroidal anti-inflammatory medications, or arch supports, had failed in these patients. All patients had pain at the medial eminence of the first metatarsophalangeal joint. Exclusion criteria were less than 20 years of age, previous surgery on the affected foot, and rheumatoid arthritis or other inflammatory diseases. In addition, hallux valgus with the angular shaped lateral edge of the first metatarsal head on a preoperative AP weight-bearing radiograph, which was classified as type A according to a measurement system[16] described further below, were excluded. Ten patients (11 feet) were lost to follow-up because they had moved and could not be located. The remaining 66 patients (83 feet) were available for follow-up for at least 2 years (average, 34 months; range, 25 to 52). The average age at surgery was 60 (range, 26 to 83) years.

Eighty-three feet were divided into 2 groups according to the preoperative hallux valgus and the preoperative intermetatarsal angles: Group M (23 feet) had a preoperative hallux valgus angle of 40 degrees or less and a preoperative intermetatarsal angle of less than 18 degrees (moderate deformity), and Group S (60 feet) had a preoperative hallux valgus angle of greater than 40 degrees or a preoperative intermetatarsal angle of 18 degrees or greater (severe deformity).

Clinical and Radiological Assessment

All patients were evaluated clinically and radiologically preoperatively and at the most recent follow-up. All patients were assessed using the American Orthopaedic Foot & Ankle Society hallux-metatarsophalangeal-interphalangeal (AOFAS) scale.[7] In addition, the range of motion of the first metatarsophalangeal joint was measured. The range of motion of the first metatarsophalangeal joint was measured by placing 1 goniometer arm parallel to the hallux and other goniometer arm parallel to the long axis of the first metatarsal, then passively moving the first metatarsophalangeal joint from maximum flexion to maximum extension.

AP and lateral weight-bearing radiographs were taken preoperatively and at the time of the most recent follow-up. The hallux valgus angle (the angle between the longitudinal axes of the first metatarsal and the proximal phalanx) and the intermetatarsal angle (the angle between the longitudinal axes of the first and second metatarsals) were measured on the AP weight-bearing radiograph. The longitudinal axis of the first metatarsal was defined as the line connecting the center of the metatarsal head with the center of the proximal articulation.[23] The longitudinal axis of the proximal phalanx was defined as the line connecting the center of the proximal end of the diaphysis with the center of the distal end of the diaphysis. The longitudinal axis of the second metatarsal was defined as a line connecting the center of the proximal end of the diaphysis with the center of the distal end of the diaphysis.

The shape of the lateral edge of the first metatarsal head, which was consisted of the articular surface and the lateral cortical surface of the metatarsal head on radiographs, was classified as one of 3 types, round (type R), angular (type A), or intermediate (type I) according to a previously published measurement system (Figure 1).[16] We defined the round sign as being positive when the shape of the lateral edge was classified as type R, and we defined it as being negative when the shape of the lateral edge was classified as either type I or type A.[16]

The position of the medial sesamoid in relation to a line drawn along the longitudinal axis of the first metatarsal on the AP weight-bearing radiograph was evaluated and classified as grades I, II, III, IV, V, VI, or VII according to the measurement system proposed by Hardy and Clapham (Figure 2).[6] On the basis of the results regarding the sesamoid positions in previous studies,[17,24,25] we defined grade IV or less as the normal sesamoid position and grade V or greater as lateral displacement of the sesamoid on AP weight-bearing radiograph.[17]

The inclination angle of the first metatarsal was measured on the lateral weight-bearing radiograph. The inclination angle was the angle between the longitudinal axis of the first metatarsal and the floor.[16] The longitudinal axis of the first metatarsal was defined as a line connecting the center of the proximal articular surface with the center of the distal end of the diaphysis.

Operative Technique and Postoperative Management

The operative technique consisted of the release of the distal soft tissue, excision of the medial eminence, plication of the medial part of the capsule, and a proximal crescentic osteotomy of the first metatarsal. The medial eminence was excised to preserve the distal articular surface of the first metatarsal head. The adductor hallucis tendon was then dissected from its insertion. The transverse metatarsal ligament was released and a longitudinal incision was made in the dorsolateral capsule of the first metatarsophalangeal joint. A crescentic osteotomy was performed 1.5 cm distal to the metatarsocuneiform joint with a curved saw blade. The osteotomy was curvilinear, and the concavity of the cut was directed distally. The proximal fragment was pushed

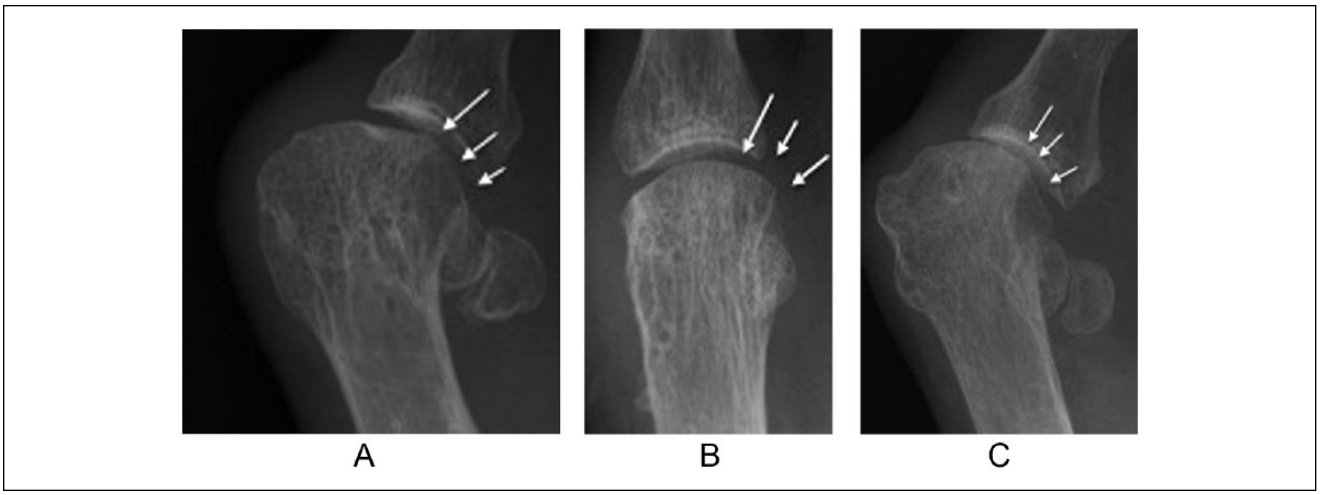

Figure 1. Radiographs illustrating the classification system for the shape of the lateral edge of the first metatarsal head. (A) The shape was classified as type R if the lateral edge had a round shape (arrow). (B) The shape was classified as type A if the lateral edge had an angular shape (arrow). (C) The shape was classified as type I if the lateral edge had an intermediate shape (arrow).

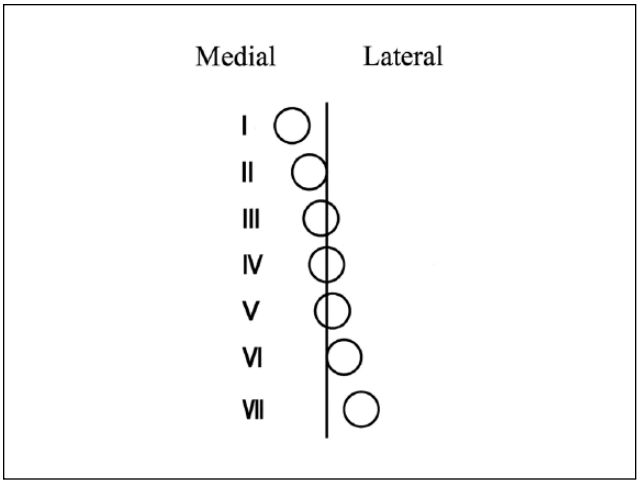

Figure 2. The position of the medial sesamoid was classified on the basis of its relationship to the longitudinal axis of the first metatarsal.

medially with an elevator, and the distal fragment was abducted to achieve parallelism between the first and second metatarsals, and then the distal fragment of the first metatarsal was manually supinated (Figure 3). After a temporary fixation with a 1.5-mm Kirschner wire was performed at the osteotomy site, we checked the shape of the lateral edge of the first metatarsal head on the AP fluoroscopic view. We simulated the weight-bearing view fluoroscopically as follows: the plantar surface of the foot was placed on the image intensifier with the ankle in 20 to 30 degrees of plantarflexion and the metatarsophalangeal joint of the hallux in 10 to 20 degrees of extension while the patient was in the supine position. The lateral and medial sides of the forefoot and heel pad were simultaneously pushed manually toward the image intensifier. If the round or intermediate-shaped lateral edge of the first metatarsal head did not changed to an angular-shaped lateral edge, we added further supination correction so that the round or intermediate-shaped lateral edge of the first metatarsal head on the AP fluoroscopic view changed to an angular-shaped lateral edge (Figures 4 and 5). Although we did not precisely measure the amount of supination achieved, we confirmed that the round sign was negative in all feet on intraoperative radiographs. Two or 3 crossed 1.5-mm Kirschner wires were used to fix the osteotomy site for about 6 months. The medial part of the capsule and the abductor hallucis tendon were plicated. In 27 patients (32 feet) who had severe painful plantar callosity at the second or third metatarsal heads or both, a proximal shortening osteotomy of the second and third metatarsal was performed because the preoperative projection of the second and third metatarsal was greater than the normal means.[15] In 26 patients (28 feet) with chronic dorsal dislocation of the second or third metatarsophalangeal joint or both, open reduction combined with reconstruction of the collateral ligaments[14] instead of repair of the atrophic plantar plate with or without a proximal shortening osteotomy of the second and third metatarsal was performed. Intraoperative AP and lateral radiographs of the foot were made to evaluate the hallux valgus angle (<15 degrees), the intermetatarsal angle (<10 degrees), the sesamoid position (<V), a round sign (negative), and sagittal alignment of the first metatarsal (no angulation at the osteotomy site).

Postoperatively, a short-leg cast and non-weight-bearing were continued for 2 weeks. Partial weight-bearing in a short-leg plaster shell and active and passive extension and

Figure 3. Intraoperative photograph shows the manual correction. The proximal fragment was pushed medially (white arrow) with an elevator, and the distal fragment was abducted (black arrow); then, the distal fragment was manually supinated (dotted arrow).

flexion exercises of the first metatarsophalangeal joint were then encouraged. Three weeks after surgery, patients were instructed to wear street shoes with an arch support, and full weight-bearing was allowed.

Statistical Analysis

The differences in the measured variables between the preoperative and final follow-up values and between the 2 groups were analyzed with the *t* test. The chi-square test was used to compare the dichotomous data. Differences with a *P* value less than .05 were considered significant.

Figure 4. Before supination of the distal fragment, a round-shaped lateral edge (arrow) of the first metatarsal head (a positive round sign) was observed on the AP view.

Results

The results of the clinical evaluation are shown in Table 1. The mean AOFAS score improved significantly from 58.0 points preoperatively to 93.8 points postoperatively ($P < .0001$). The mean pain, function, and alignment scores improved significantly from 23.3, 30.6, and 4.1 points before surgery to 36.7, 42.6, and 14.5 points after surgery, respectively. The mean postoperative AOFAS scores in Group M and S were 95.4 and 93.2, respectively ($P = .2935$). The difference between Group M and Group S in the postoperative pain ($P = .8089$) and alignment score ($P = .5877$) on the AOFAS scale was not significant. However, the postoperative function score on the AOFAS scale in Group M was significantly greater than that in Group S (44.2 and 42.0, respectively, $P = .0074$).

The mean extension of the first metatarsophalangeal joint was significantly decreased from 75.1 degrees preoperatively

Figure 5. After supination of the distal fragment, an angular-shaped (arrow) lateral edge (negative round sign) was observed on the AP view.

to 61.5 degrees postoperatively ($P < .0001$). The mean flexion of the first metatarsophalangeal joint was significantly decreased from 32.2 degrees preoperatively to 22.8 degrees postoperatively ($P < .0001$).

The results of the radiographic measurements are shown in Table 2. The mean hallux valgus angle decreased significantly from 38.6 degrees preoperatively to 11.0 degrees postoperatively ($P < .0001$), and the mean intermetatarsal angle decreased significantly from 18.0 degrees preoperatively to 7.9 degrees postoperatively ($P < .0001$).

The mean postoperative hallux valgus angle in Group M and S were 9.5 and 11.6 degrees, respectively ($P = .3970$). The mean postoperative intermetatarsal angle in Group M and S were 7.7 and 8.0 degrees, respectively ($P = .7828$).

The mean inclination angle of the first metatarsal decreased significantly from 15.9 degrees preoperatively to 13.5 degrees postoperatively ($P < .0001$). The mean inclination angle in Group S decreased significantly from 14.9 degrees preoperatively to 12.4 degrees postoperatively ($P = .0036$). The mean inclination angle in Group M decreased from 16.5 degrees preoperatively to 15.3 degrees postoperatively ($P = .0721$). Nineteen feet (19/83, 23%) had a decrease of 5 degrees or greater (5 to 14 degrees) in the inclination angle. In these 19 feet, the mean preoperative inclination angle was 17.8 degrees. The mean postoperative inclination angle was 16.7 degrees at 1 month after surgery and 10.6 degrees at the final follow-up evaluation. The AOFAS score in these 19 feet and remaining 64 feet was 93.8 and 93.9, respectively ($P = .9751$).

Distribution of the shape of the lateral edge of the first metatarsal is shown in Table 3. Sixty-nine feet (69/83, 83%) were classified as having a positive round sign preoperatively, and 66 feet (66/83, 80%) had a negative round sign postoperatively (Figure 6). The prevalence of the round shape of the first metatarsal head was significantly greater preoperatively than postoperatively ($P < .0001$). Two feet (2/23, 9%) in Group M and 15 feet (15/60, 25%) in Group S were classified as having a positive round sign postoperatively. The postoperative prevalence of the round shape of the first metatarsal head was greater in Group S than Group M ($P = .0786$). In these 17 patients, the mean intermetatarsal angle decreased significantly from 19.0 degrees preoperatively to 6.7 degrees at the recent follow-up ($P < .0001$), thus correction of the intermetatarsal angle was achieved.

Distribution of the position of the medial sesamoids is shown in Table 4. All feet were classified as grade V or greater (displacement position) preoperatively, and 49 feet (49/83, 59%) were classified as grade IV or less (normal position) postoperatively (Figure 6). The rate of incomplete reduction of the sesamoids was significantly decreased postoperatively. The rate of lateral displacement of the sesamoids, defined as a grade V or greater, at the most recent follow-up was significantly lower than that before surgery ($P < .0001$). The mean sesamoid position improved significantly from 6.8 preoperatively to 3.8 at the most recent follow-up ($P < .0001$). The postoperative sesamoid positions in Group M and Group S were 3.1 and 4.0, respectively ($P = .0199$).

Postoperative Complications

The recurrence of a hallux valgus deformity, defined as a hallux valgus angle ≥ 25 degrees, was observed in 3 feet (3/83, 4%) at the time of the most recent follow-up. These 3 feet were classified in Group S preoperatively. In all 3, the shape of the lateral edge of the first metatarsal was classified as type R at the most recent follow-up. Hallux varus deformity, defined as a hallux valgus angle < 0 degrees,

Table 1. Pre- and Postoperative AOFAS Score.

	Preoperative	Most Recent Follow-Up	*P* Value
Pain	23.3 ± 8.1 (0-30)	36.7 ± 5.2 (20-40)	<.0001
Function	30.6 ± 5.7 (15-40)	42.6 ± 3.4 (32-45)	<.0001
Alignment	4.1 ± 4.0 (0-8)	14.5 ± 2.2 (0-15)	<.0001
Total	58.0 ± 13.0 (22-78)	93.8 ± 8.5 (62-100)	<.0001

The values are given as the mean and standard deviation with the range in parentheses.

Table 2. Radiographic Measurements.

	Preoperative	Most Recent Follow-Up	*P* Value
Hallux valgus angle	38.6 ± 9.8 (27-60)	11.0 ± 9.5 (0-42)[a]	<.0001
Intermetatarsal angle	18.0 ± 3.2 (13-28)	7.9 ± 3.6 (0-17)	<.0001
Inclination angle	15.9 ± 3.5 (8-25)	13.5 ± 3.9 (2-22)	<.0001

The values are given as the mean and standard deviation with the range in parentheses.
[a]Four feet with a hallux varus deformity were excluded.

Table 3. Distributions of the Shape of the Lateral Edge of the First Metatarsal.

	Preoperative	Most Recent Follow-Up
Type A: round sign (−)	0 (0%)	45 (54.2%)
Type I: round sign (−)	14 (16.9%)	21 (25.3%)
Type R: round sign (+)	69 (83.1%)	17 (20.5%)

$P < .0001$ (chi-square test).

occurred in 4 feet (4/83, 5%) at the most recent follow-up. Three feet were classified in Group S, and the remaining foot was classified in Group M. In 3 feet, the shape of the lateral edge of the first metatarsal was classified as type R and 1 foot was type A at the most recent follow-up. These patients did not have pain, stiffness of the joint, or difficulty with wearing shoes. We defined dorsiflexion deformity as a decrease of 5 degrees or greater in the inclination angle between the preoperative and the final follow-up evaluations. Nineteen feet (19/83, 23%) had a decrease of 5 degrees or greater (5 to 14 degrees) in the inclination angle. Three feet in Group S had sensory disturbance over the medial aspect of the great toe. There was no infection, delayed wound healing, nonunion, or transfer lesions in any of the patients.

Discussion

In the present study, we described a novel proximal supination osteotomy combined with a distal soft-tissue procedure for correction of hallux valgus, and prospectively reviewed the results of this procedure. Our clinical and radiological results demonstrated that the proximal supination osteotomy achieved significant correction of hallux valgus deformity, and significant improvement in pain and function. In the present study, the postoperative score on the AOFAS scale was 93.8, which is greater than that previously reported for proximal osteotomy.[3,5,27] Furthermore, the rates of a round sign and incomplete reduction of the sesamoids were significantly decreased postoperatively. Postoperative hallux valgus recurrence is a common complication. We previously reported a high rate of postoperative recurrence of hallux valgus after proximal metatarsal osteotomy without supination correction.[17] Okuda et al[16,17] demonstrated that postoperative positive round sign and postoperative incomplete reduction of the sesamoids could be a risk factors for the recurrence of hallux valgus. Moreover, they presumed that a positive round sign on radiography was due to pronation of the first metatarsal from an anatomical point of view, which causes the dorsolateral displacement of the sesamoids. In the present study, the proximal fragment was pushed medially, and the distal fragment abducted, and then the distal fragment of the first metatarsal was manually supinated. In addition, we confirmed that the round sign was negative and complete reduction of the sesamoids was obtained in all feet on intraoperative radiographs. Consequently, proximal supination osteotomy led to high rates of a negative round sign and complete reduction of the sesamoids at the most recent follow-up and a low rate of hallux valgus recurrence.

Figure 6. (A) This case is a 63-year-old woman with a severe hallux valgus deformity and chronic dorsal dislocation of the second metatarsophalangeal joint. Preoperative AP weight-bearing radiograph demonstrating a hallux valgus angle of 50 degrees, an intermetatarsal angle of 16 degrees, a grade VII position of the medial sesamoids, and a round-shaped lateral edge of the first metatarsal head (a positive round sign). (B) Preoperative lateral weight-bearing radiograph demonstrating an inclination angle of the first metatarsal of 16 degrees. (C) At the 44-month follow-up evaluation, AP weight-bearing radiograph demonstrating a hallux valgus angle of 4 degrees, an intermetatarsal angle of 1 degree, a grade II position of the medial sesamoids, and an angular-shaped lateral edge of the first metatarsal head (a negative round sign). (D) Lateral weight-bearing radiograph demonstrating an inclination angle of the first metatarsal of 15 degrees. No angulation at the osteotomy site is observed.

Table 4. Distribution of the Position of the Medial Sesamoid.

Grade	Preoperative	Most Recent Follow-Up
I	0	6 (7%)
II	0	13 (16%)
III	0	21 (25%)
IV	0	9 (11%)
V	4 (5%)	25 (30%)
VI	6 (7%)	7 (8%)
VII	73 (88%)	2 (2%)
Normal-position group (Grades I~IV)	0 (0%)	49 (59%)
Displacement group (Grades V~VII)	83 (100%)	34 (41%)

$P < .0001$ (chi-square test).

Several investigators have recommended weight-bearing tangential radiographs to evaluate the sesamoid position;[8,25,28] however, that method cannot be used for patients with severe hallux valgus deformity who have excessive erosion of the intersesamoid ridge of the first metatarsal head.[25] Furthermore, different degrees of dorsiflexion of the metatarsophalangeal joint might modulate the sesamoid position on a tangential radiograph.[28] Thus, we used the method described by Hardy and Clapham[6] to evaluate the sesamoid position.[17]

Postoperative recurrence of hallux valgus is a common complication in hallux valgus surgery. Several authors have reported a rate of postoperative recurrence of hallux valgus of 4% to 25% following proximal metatarsal osteotomy, although there were various definitions of recurrence among

the articles.[3-5,11,17,27] In the present study, the rate of recurrence of hallux valgus (4%) was relatively low in spite of a large number of patients with severe hallux valgus deformity. We believe that the high rates of a negative round sign and complete reduction of the sesamoids at the most recent follow-up contributed to a low rate of hallux valgus recurrence in the present study.

There have been several studies to compare the results of proximal metatarsal osteotomy between patients with moderate and severe hallux valgus. Mann et al[11] found no differences in radiological results between patients with moderate and severe hallux valgus. Furthermore, Moon et al have found that proximal chevron osteotomy provides an effective and reliable means of correcting hallux valgus regardless of the severity of deformity.[13] On the other hand, Okuda et al[18] reported that the correction of moderate hallux valgus is likely to produce clinically and radiologically better outcomes than the correction of severe hallux valgus. We compared clinical and radiological results in Group M and Group S. The postoperative score on the AOFAS scale in Group M was greater than that in Group S, but there was no significant difference between the groups (P = .2935). However, the postoperative function score on the AOFAS scale in Group M was significantly greater than that in Group S (P = .0054). The mean postoperative hallux valgus angle and intermetatarsal angle were smaller in Group M than in Group S, but the difference was not significant (P = .3970 and P = .7828, respectively). The postoperative prevalence of the round shape of the first metatarsal head was greater in Group S than in Group M (P = .0786), and the postoperative sesamoid position was significantly smaller in Group M than that in Group S (P = .0199). The recurrence of hallux valgus was seen in Group S but not in Group M. Consequently, our procedure was an effective method regardless of the severity of hallux valgus. However, the correction of moderate hallux valgus was likely to be better than that of severe hallux valgus. Therefore, we consider that operative treatment at an early stage should be recommended for patients with moderate hallux valgus deformity in the future.

In the present study, the inclination angle was significantly decreased postoperatively. A decrease in the inclination angle indicates dorsiflexion of the distal fragment. Dorsiflexion of the distal fragment, which is caused by incorrect positioning of the distal fragment, inadequate fixation, or early postoperative weight-bearing, is a common complication of proximal crescentic osteotomy.[5,22,26] We did not find dorsiflexion of the first metatarsal for several weeks after surgery; however, dorsiflexion deformity occurred after weight-bearing was encouraged. We believe that inadequate fixation of the osteotomy site and early weight-bearing after surgery seem to be causes of postoperative dorsiflexion deformity in the present series. More rigid fixation or later weight-bearing might help prevent postoperative dorsiflexion deformity. Hence, since 2012, we have performed fixation of the osteotomy site with a locking plate for a more rigid fixation. Mann et al[11] found dorsiflexion of the first metatarsal in 28% of patients, and stated that postoperative dorsiflexion did not influence the prevalence of transfer metatarsalgia. However, Thordarson and Leventen[26] stated that postoperative dorsiflexion of the first metatarsal may lead to intractable plantar callosities. In the present study, no postoperative transfer lesions developed in any patients. In addition, there was no significant difference in AOFAS score between patients with and without a decrease in the inclination angle after surgery (P = .9751). Therefore, we found no evidence to support the notion that a decrease in the inclination angle after surgery influences the postoperative clinical score.

Our study limitation is that the psychometric properties of the AOFAS scoring system including validity and reliability have never been examined. However, there is still value in the comparison of our results with those of other published studies.

In conclusion, the clinical and radiological results indicate that the proximal supination osteotomy procedure described in the present study is effective for the correction of moderate to severe hallux valgus deformity and improvement in pain and function, and is associated with a low rate of recurrence of hallux valgus.

Declaration of Conflicting Interests

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