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Proximal Intermetatarsal Divergence in Distal Chevron Osteotomy for Hallux Valgus: An Overlooked Finding

Evren Akpinar, MD, Abdul Fettah Buyuk, MD, Engin Cetinkaya, MD, Sarper Gursu, MD, Hanifi Ucpunar, MD, Akif Albayrak, MD

Orthopedist, Metin Sabancı Baltalimanı Bone Diseases Training and Research Hospital, İstanbul, Turkey

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ABSTRACT

The goal of distal chevron osteotomy for hallux valgus is to restore proper first-toe joint alignment by performing lateral translation of the distal first metatarsal fragment (the metatarsal head). We hypothesized that in some patients this procedure might also result in involuntary medial translation of the proximal first metatarsal fragment, which we called proximal intermetatarsal divergence. The aim of the present study was to compare the pre- and postoperative radiographs of patients with hallux valgus to determine whether we could identify proximal intermetatarsal divergence. We retrospectively compared the pre- and postoperative radiographs of 29 feet in 28 patients treated with distal chevron osteotomy. Two different methods were used to measure the intermetatarsal angles: the anatomic intermetatarsal angle (aIMA) and the mechanical intermetatarsal angle (mIMA). The maximum intermetatarsal distance (MID) was also measured. We defined proximal intermetatarsal divergence as a postoperative increase in the aIMA or MID, coupled with a decrease in the mIMA. For data analysis, we divided the patients into low-angle (mild deformity) and high-angle (severe deformity) groups, according to their preoperative mIMA. The mean ± standard deviation patient age was 41 ± 14 years. In the low-angle group, the mean mIMA decreased (from 10.91° to 7.00°), the mean aIMA increased (from 11.80° to 13.55°), and the mean MID increased (from 17.97 mm to 20.60 mm; $p = .001$, for all). In the high-angle group, the mean mIMA decreased (from 14.30° to 6.90°; $p = .001$), the mean aIMA decreased (from 14.77° to 13.54°; $p = .06$), and the mean MID decreased (from 20.74 mm to 20.37 mm; $p = .64$). The results of our study suggest that proximal intermetatarsal divergence might occur after distal chevron osteotomy for hallux valgus, primarily in patients with a low preoperative mIMA.

Distal chevron osteotomy is an effective surgical treatment for mildly to moderately severe hallux valgus (1–3). First described by Corless in 1976, the procedure restores the alignment of the first toe (the metatarsophalangeal) joint using first metatarsal medial eminence resection, intracapsular distal first metatarsal osteotomy, lateral translation of the distal fragment (first metatarsal head), and capsulorrhaphy (2).

The hallux valgus angle and intermetatarsal angle (IMA) have been used to assess the severity of hallux valgus deformities, guide treatment, and evaluate the treatment outcomes (3–5). The first IMA is the angle formed between the long axes of the first and second metatarsal shafts, and it is not believed to be affected by distal chevron osteotomy (1). Indeed, if defined this way, the IMA should not change, because the primary anatomic alteration created by the procedure is lateral translation of the first metatarsal head.

However, we wondered whether distal chevron osteotomy might sometimes result, not only in lateral translation of the metatarsal head, but also in unexpected or involuntary medial translation of the proximal first metatarsal shaft. If so, such proximal fragment medialization would result in the postoperative divergence of the first and second metatarsals and a change in the IMA. Thus, we performed a retrospective study using 2 radiographic measurements of the IMA (measured using different methods) and the intermetatarsal distance to determine whether distal chevron osteotomy causes proximal intermetatarsal divergence in some patients treated for hallux valgus.

Patients and Methods

We reviewed the pre- and postoperative radiographs of consecutive patients with hallux valgus who had undergone distal chevron osteotomy at our hospital

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Address correspondence to: Evren Akpinar, MD, Metin Sabancı Baltalimanı Bone Diseases Training and Research Hospital, Rumeli Hisarı Caddesi No: 62, Baltalimani İstanbul 34470, Turkey.

E-mail address: drevrenakpinar@gmail.com (E. Akpinar).

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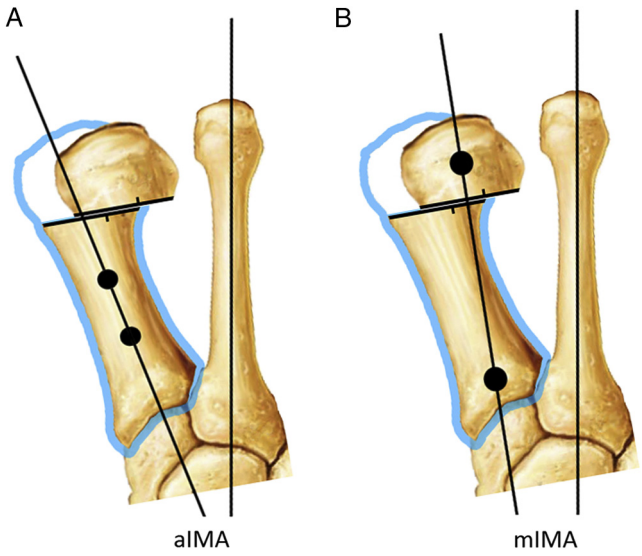

Fig. 1. Measurement of the anatomic intermetatarsal angle (aIMA) and mechanical intermetatarsal angle (mIMA) in the right foot. The intermetatarsal angles were calculated using the longitudinal axes of the first and second metatarsals. The longitudinal axis of the first metatarsal was determined using 1 of 2 methods: (*A*) the line passing through 2 points along the center of the shaft of the first metatarsal (used to measure the aIMA), or (*B*) the line passing through the head and the base of the first metatarsal (used to measure the mIMA). For both methods, the longitudinal axis of the second metatarsal is the line passing through 2 points along the center of the second metatarsal shaft. The *blue outline* is the preoperative position of the first metatarsal.

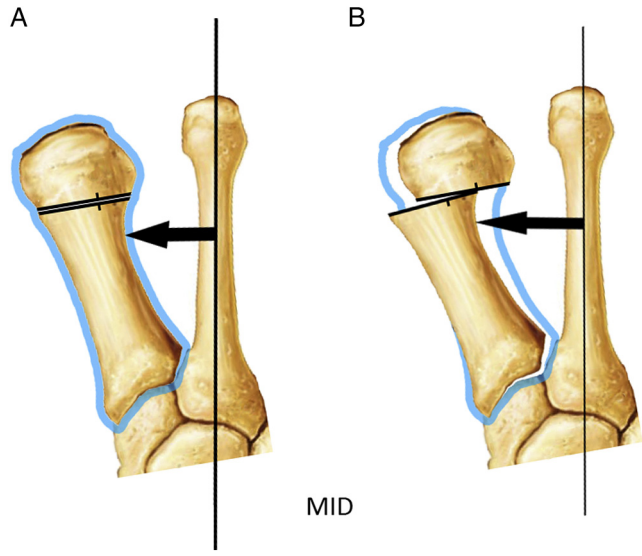

Fig. 2. Measurement of maximum intermetatarsal distance (MID) in the right foot. The MID is the length of the longest line that can be drawn 90° from the longitudinal axis of the second metatarsal to the lateral cortex of the first metatarsal *(arrows)*. Example of proximal intermetatarsal divergence: (*A*) preoperative MID and (*B*) postoperative, post-translational MID, showing proximal intermetatarsal divergence. The *blue outline* is the preoperative position of the first metatarsal.

from January 2012 to June 2013. We excluded patients who had undergone previous surgery for hallux valgus or additional procedures performed concurrently with distal chevron osteotomy and patients with no preoperative standing foot radiograph available. To treat hallux valgus, distal chevron osteotomy was performed on all patients using the technique described by Corless (2). This procedure consisted of medial eminence resection, intracapsular distal metatarsal osteotomy, lateral translation of the distal metatarsal fragment, and capsulorrhaphy. A board-certified orthopedic surgeon measured the distances and angles on the pre- and postoperative standing dorsoplantar digital radiographs using the INFINITT Healthcare picture archiving communication system (INFINITT Healthcare Co., Ltd., Seoul, South Korea).

The first IMA is the angle between the long axes of the first and second metatarsals (3). We measured the IMA using 2 different methods. In the first method, the longitudinal axis of the first metatarsal was a line drawn through 2 points in the midline of the diaphysis (Fig. 1*A*), and we referred to the angle measured as the anatomic IMA (aIMA) (4). In the second method, the longitudinal axis of the first metatarsal was drawn through points at the midline of the first metatarsal head and the base (Fig. 1*B*), with the angle measured referred to as the mechanical IMA (mIMA) (4). In both methods, the longitudinal axis of the second metatarsal was a line drawn through 2 points in the midline of the diaphysis of the second metatarsal. We defined the maximum intermetatarsal distance (MID) as the length of the longest line, oriented at 90° to the longitudinal axis of the second metatarsal, that could be drawn between the longitudinal axis of the second metatarsal and the lateral cortex of the first metatarsal (Fig. 2).

We identified proximal intermetatarsal divergence when a postoperative increase had occurred in the aIMA and MID, coupled with a decrease in the mIMA. For the purposes of the present investigation, we defined a mild first IMA as $<11°$ and a severe first IMA as $>16°$. The data were analyzed using the SPSS Statistics for Windows, version 18.0 (SPSS Inc., Chicago, IL). Changes in the mean mIMA, aIMA, and MID were compared using the Wilcoxon signed-rank test. Statistical significance was defined at the 5% ($p \leq .05$) level, and all tests were 2-tailed.

Results

Of 44 consecutive patients with hallux valgus treated surgically at our institution during the study period, 28 patients (29 feet; 21 females [75%]) met our entry criteria and were included in the present study (Table 1). The mean patient age at surgery was 41 ± 14 years. Patients with a mildly deformed preoperative mIMA had a greater incidence of postoperative proximal intermetatarsal divergence than that of patients with a severely deformed preoperative mIMA. Accordingly, for analysis, we divided the patients into 2 groups according to their preoperative mIMA: a low-angle group ($\leq 13°$) and a high-angle group ($>13°$).

After distal chevron osteotomy, in the low-angle group, the mean mIMA decreased from 10.9° ± 1.6° to 7.0° ± 2.6°, the mean aIMA increased from 11.8° ± 2.0° to 13.6°± 2.4°, and the mean MID increased from 18.0 ± 1.6 mm to 20.6 ± 1.9 mm. These changes were all statistically significant ($p = .001$; Table 2). In the high-angle group, the mean mIMA decreased from 14.3° ± 1.3° to 6.9° ± 2.5°, the mean aIMA decreased from 14.8° ± 2.0° to 13.5° ± 3.0°, and the mean MID decreased from 20.7 ± 1.9 mm to 20.4 ± 2.9 mm. The only statistically significant change in the high-angle group was related to the mean mIMA ($p = .001$; Table 2).

Discussion

We divided our patients into 2 groups according to the severity of the hallux valgus deformity: severe (high-angle) and mild (low-angle). In the high-angle group, the mean mIMA decreased significantly, but the decreases in the mean aIMA and MID were not statistically significant. These results are consistent with reports that lateral translation of the distal first metatarsal fragment can be achieved without a change in the distance between the first and second metatarsals (1). In the low-angle group, the decrease in the mean mIMA and increases in the mean aIMA and MID were all statistically significant. Again, the decrease in the mIMA was expected, based on the surgical technique, which creates lateral translation of the distal first metatarsal fragment. However, the increases in the aIMA and MID were not expected, although ≥1 group has previously reported this finding (6,7).

These results suggest that distal chevron osteotomy can be associated with proximal intermetatarsal divergence, which we defined as postoperative increases in the aIMA and MID, with a