Comparison between Pin Fixation and Combined Screw Fixation in Proximal Chevron Metatarsal Osteotomy for Hallux Valgus Deformity Correction

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Background: Problems associated with hallux valgus deformity correction using Kirschner-wire (K-wire) fixation include pin pull-out and loss of stability. These complications are pronounced in the osteopenic bone, and few reports have focused on pin versus screw fixation. We examined the use of additional screw fixation to avoid these problems. The aim of this study was to compare outcomes of K-wire fixation (KW) and a combined K-wire and screw fixation (KWS).

Methods: Two groups with hallux valgus deformity, who were treated with a proximal chevron metatarsal osteotomy (PCMO), were compared based on the fixation method used. The KW group included 117 feet of 98 patients, and the KWS group included 56 feet of 40 patients. Clinically, the preoperative and final follow-up visual analog scale (VAS) pain score, American Orthopedic Foot & Ankle Society (AOFAS) hallux score, and patient satisfaction score were evaluated. Radiographically, hallux valgus angle (HVA) and intermetatarsal angle (IMA) were measured.

Results: The mean VAS score decreased from 6.3 preoperatively to 1.6 postoperatively in the KW group and from 5.7 preoperatively to 0.5 postoperatively in the KWS group (p < 0.001). The mean AOFAS scores of the KW and KWS groups improved from 59.4 and 58.2, respectively, to 88.9 and 95.3, respectively (p < 0.001). Eighty-five percent in the KW group and 93% in the KWS group were satisfied with surgery. Clinical differences were not significant. The mean HVAs decreased from 34.7° to 9.1° in the KW group and from 38.5° to 9.2° in the KWS group (p < 0.001). The mean IMA decreased from 14.5° (range, 11.8°–17.2°) to 6.4° (range, 2.7°–10.1°) in the KW group and from 18.0° (range, 14.8°–21.2°) to 5.3° (range, 2.5°–8.1°) in the KWS group (p < 0.001). When IMA values at the 3-month postoperative and the final follow-up were compared, the IMA was significantly increased only in the KW group (p < 0.001) and no difference was found in the KWS group (p = 0.280).

Conclusions: We found a statistically significant difference in the decrease in IMA between the 2 groups. We recommend the combined pin and screw fixation in PCMO to enhance fixation stability and prevent potential hallux valgus correction loss.

Keywords: Hallux valgus, Proximal chevron metatarsal osteotomy, Pin fixation, Combined screw fixation

Over 100 procedures to correct hallux valgus deformity have been reported, and the primary endpoints of treatment are pain relief and restoration of first metatarsophalangeal (MTP) joint function.1–4 Many surgeons prefer a proximal metatarsal osteotomy because of its ability to correct the deformity. We utilize the reverse proximal chevron metatarsal osteotomy (PCMO) among various techniques.5–7
Fixation methods for a metatarsal osteotomy vary greatly. Among such methods, Kirschner-wire (K-wire) fixation is commonly performed due to the high technical feasibility, although K-wire only fixation often results in inadequate fixation stability or pin loosening and migration, leading to potential complications such as correction loss or skin irritation. The alternate use of plates and screws provides a stronger fixation construct, but the current literature reports that poor contour or non-anatomic placement leads to loss of correction. The potential for poor fixation stability and pin migration with K-wires led us to the idea of combined fixation with K-wires and screws for PCMO. Moreover, few published articles have compared fixation methods for hallux valgus correction, and most articles compare K-wire and screw fixation or K-wire and plate constructs. Most of these studies are limited to examinations of biomechanical aspects rather than clinical outcomes. Therefore, we investigated the clinical and radiographic outcomes of K-wire fixation alone and combined pin and screw fixation for hallux valgus correction.

Our hypothesis was that K-wires with additional screw fixation would show better stability and improved outcomes than those of K-wire fixation alone. The aim of this study was to compare clinical and radiographic outcomes between K-wire fixation alone and combined pin and screw fixation.

**METHODS**

We conducted this study in compliance with the principles of the Declaration of Helsinki. The protocol of this study was reviewed and approved by the Institutional Review Board of Konkuk University Hospital (IRB No. KUH1060171). The need for informed consent was waived.

This study included 2 groups that underwent different fixation methods (the K-wire fixation [KW] group and the K-wire and screw fixation [KWS] group) from February 2008 to March 2013 with at least 1 year of follow-up. The KW group included 117 feet from 98 patients with hallux valgus deformity treated with PCMO and Akin osteotomy with fixation performed using 2 or 3 K-wires. The KWS group included 56 feet of 40 patients with the same deformity approached in the same manner with fixation performed using 2 K-wires and 1 headless cannulated screw. The KW group included 90 female patients and 8 male patients, and the KWS group included 39 female patients and 1 male patient. The KW group included 59 right feet and 58 left feet, and the KWS group included 30 right feet and 26 left feet. At the time of operation, their average age was 46.0 ± 14.9 years (range, 20–75 years) in the KW group and 55.0 ± 9.5 years (range, 20–67 years) in the KWS group. All patients in both groups were followed up for at least 1 year. The average follow-up period was 17.5 ± 7.9 months (range, 12–48 months) in the KW group and 16.3 ± 4.8 months (range, 12–28 months) in the KWS group (Table 1). Patients who had any previous foot surgery, underwent revision surgery for hallux valgus, or had less than 1 year of follow-up were excluded from the study. All operative procedures were performed by 1 senior orthopedic surgeon (HGI).

### Operative Technique

A single medial incision approximately 10 cm was made along the medial side of the first ray. The skin incision...
over the first MTP joint capsule was carefully performed, taking care to protect the dorsomedial hallucal branch of the superficial peroneal nerve (SPN) and preserving this branch under the skin flap. This flap was dissected in a proximal to distal direction and flipped laterally to expose the first web space dorsally. The soft tissues in the first web space were released in a superficial to deep order. This release began with the intermetatarsal ligament holding the hallux in the valgus position. The lateral metatarsosesamoid suspensory ligament and the lateral capsule were then cut along the metatarsal axis to facilitate relocation of the sesamoids under the first metatarsal head.

The medial capsule was then incised in a manner corresponding to the original approach, and removal of the medial eminence was performed. Then, the first metatarsal was dissected to the first tarsometatarsal (TMT) joint, and a micro-sagittal saw was used to perform a PCMO at 60° vertical to the first metatarsal shaft with the apex pointing proximally from 7 mm distal to the first TMT joint line. Changing of the intermetatarsal angle (IMA) up to 0° was checked with an image intensifier, and the osteotomized metatarsal bone was fixed with two or three 1.4- or 1.6-mm K-wires in the KW group and 2 K-wires with 1 3.0-mm headless compression screw in the KWS group (Barouk screw; Zimmer-Biomet, Warsaw, IN, USA) (Fig. 1). Akin osteotomy was then additionally performed in most cases to make straight hallux and to maintain first MTP joint congruency.15) Medial capsulorrhaphy of the MTP joint was then performed, and final hallux valgus correction was confirmed with an image intensifier.

Postoperative care was the same in both groups. All patients in both groups wore postoperative shoes for 6 weeks, and partial weight-bearing through the heel was allowed during that period. At 5 to 6 months after operation, the implanted materials were removed.

Clinical and Radiographic Evaluation
Clinically, the preoperative and final follow-up visual analog scale (VAS) pain scores, the preoperative and final follow-up American Orthopedic Foot & Ankle Society (AO-FAS) hallux MTP-interphalangeal (IP) functional scores, and patient satisfaction after the surgery were evaluated. Regarding the radiographic parameters, the hallux valgus angle (HVA) and IMA were measured on standing foot anteroposterior (AP) radiographs.

We defined recurrence of hallux valgus as a final HVA of more than 20° or an increase in the HVA of more than 10° on the standing foot radiograph measured at 3 months postoperatively and at the final follow-up evaluation.16-18)

Fig. 1. Schematic diagram of proximal chevron metatarsal osteotomy with fixation using Kirschner-wires (K-wires) in the K-wire group (A) and K-wires with a screw in the K-wire and screw fixation group (B).
10.3% (12 feet) were satisfied with some reservation; and 5% (6 feet) were dissatisfied. In the KWS group, which included 56 feet, 55.4% (31 feet) were very satisfied; 37.5% (21 feet) were satisfied; 7.1% (4 feet) were satisfied with some reservation; and none of the patients were dissatisfied. In summary, 85% in the KW group and 93% in the KWS group were more than satisfied with the operative outcome ($p = 0.290$).

Radiographic Outcomes
The mean HVAs of the KW and KWS groups decreased from $34.7^\circ \pm 8.4^\circ$ (range, $26.3^\circ–43.1^\circ$) and $38.5^\circ \pm 7.4^\circ$ (range, $31.1^\circ–46.0^\circ$), respectively, preoperatively to $9.1^\circ \pm 9.3^\circ$ (range, $–12.4^\circ$ to $28.5^\circ$) and $9.2^\circ \pm 5.8^\circ$ (range, $–10.2^\circ$ to $26.0^\circ$), respectively, at the final follow-up evaluation ($p < 0.001$). The mean IMAs of the KW and KWS groups decreased from $14.5^\circ \pm 2.7^\circ$ (range, $11.8^\circ–17.2^\circ$) and $18.0^\circ \pm 3.2^\circ$ (range, $14.8^\circ–21.2^\circ$), respectively, preoperatively to $6.4^\circ \pm 3.7^\circ$ (range, $2.7^\circ–10.1^\circ$) and $5.3^\circ \pm 2.8^\circ$ (range, $2.5^\circ–8.1^\circ$), respectively, at the final follow-up evaluation ($p < 0.001$). The mean IMA of the KW group increased from $5.1^\circ$ at the 3-month postoperative follow-up visit to $6.4^\circ$ at the final follow-up ($p < 0.001$). However, the mean increase in the IMA of the KWS group was not significant, i.e., from $5.0^\circ$ to $5.3^\circ$ at the final follow up ($p = 0.280$). The mean decrease of IMA at the final follow-up of the KW and KWS groups showed significant difference ($p = 0.034$). Clinical and radiographic outcomes are summarized in Table 2.

Postoperative Complications
Radiographically, hallux valgus recurrence was noted in 6.0% (7/117 feet) of cases in the KW group and 3.6% (2/56 feet) of cases in the KWS group. However, the difference was not statistically significant ($p = 0.504$). Revision surgery was not performed for hallux valgus recurrence per patient request for any patients in either group. Two complications of hallux varus occurred in each group, and 3 (2.6%) and 1 case (1.8%) of neuralgia of the SPN occurred in the KW and KWS groups, respectively ($p = 0.750$). In 1 patient with a postoperative hallux varus complication in

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Table 2. Clinical and Radiographic Outcomes

| Variable | KW group (n = 117) | KWS group (n = 56) | p-value | p-value |
|----------|-------------------|-------------------|---------|---------|
|          | Preop             | Postop            |         | Preop   | Postop  |         |
| Clinical |                   |                   |         |         |         |         |
| VAS      | 6.3 ± 1.9         | 1.6 ± 1.2         | < 0.05  | 5.7 ± 1.4 | 0.5 ± 0.8 | < 0.05 |
| AOFAS    | 59.4 ± 10.5       | 88.9 ± 5.6        | < 0.05  | 58.2 ± 9.3 | 95.3 ± 4.8 | < 0.05 |
| Radiographic |               |                   |         |         |         |         |
| HVA      | 34.7 ± 8.4        | 9.1 ± 9.4         | < 0.05  | 38.5 ± 7.4 | 9.2 ± 5.9 | < 0.05 |
| IMA      | 14.5 ± 2.7        | 6.4 ± 3.7         | < 0.05  | 18.0 ± 3.2 | 5.3 ± 2.8 | < 0.05 |

Values are presented as mean ± standard deviation.
KW: Kirschner-wires (K-wires) only for pin fixation, KWS: combined K-wires and screw fixation, Preop: preoperative, Postop: postoperative, VAS: visual analog scale, AOFAS: American Orthopedic Foot & Ankle Society, HVA: hallux valgus angle, IMA: intermetatarsal angle.

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Fig. 2. Kirschner-wire (K-wire) migration was observed in the K-wire group during follow-up. (A) Anteroposterior foot radiographs of a representative case: preoperative, immediate postoperative, and 6-week postoperative images, from left to right. The rightmost image displays 3-cm pin pullout proximally with metatarsal shortening. (B) Lateral foot radiographs from the same case at the corresponding time point, from top to bottom.
the KW group, salvage surgery was performed. Neuralgia of the SPN of the hallux was spontaneously resolved at the final follow-up visit in all patients.

Pin irritation occurred in 5 cases in the KW group (5/117 feet, 4.3%) and in 1 case in the KWS group (1/56 feet, 1.8%) (p = 0.403). One patient with pin irritation in the KW group underwent removal at 3 months postoperatively because of pin migration (Fig. 2). One patient in the KWS group had 1 pin removed due to repeated pin migration, but stability was maintained by the remaining K-wire and the screw (Fig. 3). One case of superficial wound infection occurred in each group. All superficial wound infection complications resolved after administration of antibiotic treatment (Table 3).

**DISCUSSION**

Proximal metatarsal osteotomy has been widely used to...
correct moderate to severe hallux valgus deformity. Proximal osteotomy can be performed using various operative methods, such as the crescentic osteotomy popularized by Mann and Coughlin \(^{19}\) chevron and reverse-chevron osteotomy, Ludloff osteotomy, Mau osteotomy, and scarf osteotomy. Among different metatarsal osteotomy techniques, our experience is that PCMO has an advantage of greater corrective ability through rotation, translation, and supination of the osteotomized metatarsal bone simultaneously. Although other authors have reported good clinical and radiographic outcomes for moderate-to-severe hallux valgus by PCMO using K-wire fixation in previous studies, \(^{14,20}\) it is our experience that PCMO fixation with 2–3 K-wires can be unstable, even at the time of fixation, and a risk of correction loss exists when the K-wire loosens and pulls out. Therefore, we performed PCMO with 2 K-wires and 1 headless cannulated screw to enhance fixation with combined elastic (K-wire) and rigid (screw) stability. \(^{21}\)

The recurrence rate after operative treatment for moderate-to-severe hallux valgus deformity is reported to range from 3% to 25% in the literature. \(^{16,18,22,23}\) To decrease the recurrence rate, it is very important to secure and maintain the stability of the osteotomy site. It is also important to consider the bone quality when performing bone fixation, as osteopenic bones have an especially high tendency for pin pullout. \(^{24,25}\) In this study, we compared radiographic and clinical outcomes between the KW and KWS groups. Both groups had satisfactory outcomes according to radiographic and clinical parameters. However, a statistically significant difference was observed in the IMA at 3 months postoperatively and the final follow-up for the KW group. Although this difference was within 2°, if a threshold angle of recurrence exists, even a small difference could be significant. Furthermore, the rate of hallux valgus recurrence was 6.0% in the KW group and 3.6% in the KWS group, although the difference was not significant \((p = 0.504)\). This outcome suggests that the use of a combination of K-wires and an additional screw is beneficial for fixation of the osteotomy site and can help reduce recurrence.

Several methods exist for fixation of the metatarsal osteotomy site such as the use of K-wires, screws, and a plate and screws. Some literatures showed the merits of the K-wire fixation method such as technical simplicity and relatively good clinical outcome. \(^{14,20}\) Petroutsas and Trnka \(^{9}\) introduced using BOLD Compression screws during Ludloff osteotomy for hallux valgus and reported good outcomes. Crosby and Bozarth \(^{9}\) reported no statistically significant difference among 3 different fixation groups after PCMO, including pins, screws, and no fixation. In addition, the authors reported disadvantages including the long operation time and high cost when using screws. However, the study was limited in that the follow-up period of the patients was short, and the correction angle was not considered during the follow-up period. Anderson and Davis \(^{7}\) suggested that fixation with a cannulated screw after osteotomy can provide firmer fixation. Bozkurt et al. \(^{11}\) reported that cannulated screw fixation was superior to K-wire fixation in a biomechanical study. However, biomechanically combined fixation using K-wires and screws in a proximal crescentic osteotomy can offer a simple and effective method to improve mechanical stability. This approach can also be utilized in the standard Ludloff osteotomy to replace the second screw when the purchase is poor, without significant loss of fixation strength. \(^{21}\) Thus, the rigidity provided by the screw and the elasticity provided by the K-wire can prevent failure of the osteotomy site to a large degree. \(^{21}\) Moreover, the static stability provided by screw fixation prevents metatarsal shortening due to axial metatarsal migration. Therefore, we suggest that combined fixation is biomechanically and clinically superior to K-wire fixation alone.

This study has some limitations. First, we did not perform the 2 techniques during the same period. The preoperative AOFAS and pain VAS scores of the 2 groups showed a statistically significant difference, and the preoperative HVA and IMA of the 2 groups also showed a statistically significant difference. Second, the numbers of patients in the 2 groups were different. Third, we did not perform the bone mineral density test due to various age groups of patients.

In summary, most clinical and radiographic parameters in both groups were significantly improved. However, no statistically significant increase was found in the IMA between the 3-month postoperative and final follow-up evaluations in the KWS group. Although the recurrence rate in the KWS group was lower, the difference was not statistically significant. The results suggest that the combined fixation method used in the KWS group can provide additional stability. However, further biomechanical studies would help clarify the effect.

Although the pin fixation group and the combined screw fixation group both showed good clinical and radiographic outcomes with minimal complications after PCMO for moderate to severe hallux valgus, the KWS group showed a statistically insignificant increase in the IMA and a tendency toward a lower recurrence rate. Therefore, we recommend the combination of 2 or 3 K-wires and screw fixation for PCMO to enhance fixation stability and prevent potential hallux valgus correction loss.
CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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