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All-Suture Anchor–Enhanced Capsulorrhaphy Versus Simple Longitudinal Capsulorrhaphy in the Treatment of Moderate-to-Severe Hallux Valgus: a retrospective cohort study

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Abstract

Background

The ideal surgical technique for treating moderate-to-severe hallux valgus (HV) is unclear. Surgical methods that effectively restore the balance of soft tissues around the first metatarsophalangeal (MTP) joint are necessary. This study compared osteotomy combined with either all-suture anchor–enhanced capsulorrhaphy (AEC) or simple longitudinal capsulorrhaphy (SLC).

Methods

Ninety-five patients with moderate-to-severe HV were divided into the AEC group or the SLC group. Demographic data, clinical scores, and radiological parameters collected before surgery, at 3 months after surgery, and at the last follow-up were retrospectively analyzed, and complications and recurrence were monitored.

Results

All patients showed significant improvement in clinical scores and radiological parameters ($p < 0.05$). The AEC group exhibited better HV correction than the SLC group, as well as significantly better distal metatarsal articular angles and joint congruency ($p < 0.05$).

Conclusion

Both AEC and SLC were safe and effective techniques for correcting moderate-to-severe HV, although AEC exhibited a greater corrective ability and achieved better joint congruency.

Levels of Evidence:

Level III.

Introduction

Hallux valgus (HV) is a common forefoot deformity, usually classified as mild, moderate, or severe according to the hallux valgus angle (HVA) and intermetatarsal angle (IMA).[1, 2] For patients with moderate-to-severe HV who exhibit symptoms but have not yet developed metatarsophalangeal arthritis, surgical treatment usually requires both correction of bony structures and balanced reconstruction of the first metatarsophalangeal joint (MTP1) and surrounding soft tissues.[3]

For osseous surgery, the distal Chevron osteotomy combined with the Akin osteotomy is widely used and has proven to be effective.[4–7] However, pure bone surgery cannot achieve durable periarticular soft tissue balance. The core of soft tissue surgery lies in the release of the lateral structure and the tightening and strengthening of the MTP1 medial collateral ligament (a part of the capsule).[3] Since Goldfarb et al. emphasized the importance of medial capsule surgery in 1980, a variety of simple capsulorrhaphy techniques (e.g., longitudinal, V-Y, inverted L, and U-shaped capsulotomies) have been used and are considered safe and effective.[8–10] However, simple capsulorrhaphy, often used to treat mild-to-moderate HV, may not be sufficient in terms of suture strength. Many scholars have obtained better correction in the medial capsule of the MTP1 joint by using autologous or artificial materials.[11] In recent years, the all-suture anchor has

been introduced into soft tissue surgery for HV correction due to its excellent biomechanical strength, histocompatibility, and firm fixation ability. Preliminary reports have demonstrated that it can significantly strengthen the medial joint capsule.[12] However, few studies on this topic have been published.

Here, we report the findings of our comparative study of osteotomy combined with either all-suture anchor–enhanced capsulorrhaphy (AEC) or simple longitudinal capsulorrhaphy (SLC), in which we evaluated the corrective effect of these two techniques when used to treat moderate-to-severe HV by comparing clinical function scores and radiological parameters. Our findings provide an evidentiary basis to inform the selection of clinical surgical techniques.

Patients and methods

This study was a retrospective cohort study, performed at a single medical facility. A total of 121 patients with moderate-to-severe HV deformities admitted from October 2018 to November 2024 were reviewed and treated by open Chevron and Akin osteotomy combined with MTP1 medial capsulorrhaphy surgery. All patients signed an informed consent form before participating in the study. The study was conducted as a proof-of-concept study in accordance with the Declaration of Helsinki and was approved by the local ethical review board.

The inclusion criteria were (1) unilateral deformity or bilateral deformities with only one foot operated on, (2) moderate-to-severe HV deformity (HVA > 30 or IMA > 11), (3) age over 18 years, and (4) a minimum follow-up period of 6 months.

The exclusion criteria were (1) history of other forefoot surgery or major trauma, (2) metatarsophalangeal arthritis, (3) rheumatoid arthritis, gout, or severe osteoporosis, (4) symptoms caused by severe skin diseases, peripheral vascular diseases, or nervous system diseases, and (5) foot infections.

Of the 121 patients reviewed, 10 required simultaneous bilateral orthopedic surgery, and 16 were lost to follow-up due to failure to meet the minimum follow-up time (at least 6 months). Ultimately, 95 patients met the inclusion criteria.

The enrolled patients were divided into two groups: (1) the all-suture AEC group (AE group; n = 49), and (2) the SLC group (SL group; n = 46). Demographic data, including sex, age, body mass index (BMI), affected side, and follow-up time, were collected. The Manchester–Oxford Foot Questionnaire (MOXFQ), American Orthopedic Foot & Ankle Society (AOFAS) Hallux MTP–IP Scoring Scale, and Visual Analogue Scale (VAS) were used for clinical scoring. The MOXFQ comprises three domains (Pain, Walking & Standing, and Social Interaction) plus an Index score and was scored using Likert's five-point method.[13–15] Patients were evaluated using the three scoring methods before operation, 3 months after operation, and at the last follow-up. The radiological parameters HVA, IMA, and distal metatarsal articular angle (DMAA) were measured via weight-bearing X-rays before operation, 3 months after operation, and at the last follow-up. HVA > 15° was regarded as recurrence. Possible complications included wound infection, suture knot reaction, loosening of internal fixator, and hallux varus.

Surgical technique

A longitudinal incision of approximately 5 cm was made on the medial side of the MTP1 joint, and a sharp dissection was made into the joint cavity. The abductor hallucis tendon and lateral joint capsule were released through the joint cavity, and the medial osteophyte of the first metatarsal was appropriately removed. At this time, the AE group required the use of a 1.7-mm all-suture anchor (Rejoin Medical, Shijiazhuang, China) or a JUGGERKNOT™ 1.8-mm Soft Anchor (DePuy Synthes Mitek, Raynham, MA, USA), which was vertically placed in the center of the metatarsal head.

Osteotomy

A modified Chevron metatarsal osteotomy was performed outside the joint capsule (proximal to the anchor insertion point) using a 0.4 mm × 20 mm oscillating saw (Stryker, Kalamazoo, MI, USA) to advance the bone block, leaving enough cortical bone for rigid internal fixation. After the correction was completed, a K-wire was used to form a temporary fixation, and two 3.5-mm headless cannulated screws (Wego Orthopaedic, Weihai, China) were used to achieve bicortical fixation as much as possible. Then, the temporary fixation K-wire was withdrawn, the excess bone block was cut off, and the excess joint capsule was trimmed. All affected feet underwent proximal phalanx Akin osteotomy, fixed with 3.0-mm headless cannulated screws (Wego Orthopaedic, Weihai, China) or nickel–titanium alloy staples (Seemine International Medical Corporation, Lanzhou, China).

Capsulorrhaphy

In the AE group, anchor lines were reserved at both ends, and the MTP1 joint was corrected to 0° or even mild varus by manipulation. The joint capsule was closed with absorbable intermittent suture and then stitched by anchor lines in a U-shape. The lines were tightened and knotted to correct and reinforce the medial structures. The anchor knot was buried in the bone tunnel where the anchor was inserted as much as possible, and the incisions were closed by suture (Figs. 1 and 2).

In the SL group, SLC was performed on the medial side of the MTP1 joint capsule, parallel to the axis of the MTP1 joint.

Postoperative management

An elastic bandage was used after operation, with gauze placed between the first and second toes. Early weight bearing was encouraged, and all patients could wear forefoot decompression shoes on the second day after operation. Sutures could be removed at 2 weeks after operation, and loose shoes could be worn for walking at 1 month after operation.

Statistical analysis

IBM SPSS Statistics software (version 29.0) was used for the statistical analysis. Continuous variables were expressed as mean ± SD, while categorical variables were described in terms of number (N) and percentage (%). The Mann–Whitney U test was used for comparisons between groups, a paired *t*-test was used for comparisons within groups, and the $\chi 2$ test was used to compare categorical variables. A value of $p < 0.05$ was considered statistically significant.

Results

There were no significant differences between the two groups in terms of age, sex, BMI, or affected side *(*$p = 0.660$, 0.948, 0.456, and 0.591, respectively), with an overall mean follow-up time of 12.41 ± 6.04 months, which was also not significantly different between the two groups *(*$p = 0.535$) (Table 1).

In terms of the MOXFQ, the Index score of the AE group improved from 57.44 ± 13.18 preoperatively to 12.12 ± 5.43 at 3 months postoperatively ($p < 0.05$) and 9.79 ± 5.61 at last follow-up ($p < 0.05$). The Index score of the SL group improved from 53.30 ± 11.40 preoperatively to 12.36 ± 5.90 at 3 months postoperatively ($p < 0.05$) and 9.50 ± 5.39 at last follow-up ($p < 0.05$). Both groups also showed a statistically significant improvement in the Pain, Standing & Walking, and Social Interaction domains. No statistically significant difference was observed between the groups in terms of the Index score or the three domains at the last follow-up ($p = 0.902$, 0.129, 0.442, and 0.800, respectively). The AOFAS Hallux MTP–IP Scoring Scale and VAS pain score results were significantly improved in both groups at 3 months postoperatively and at the last follow-up ($p < 0.05$), with no statistically significant difference between the groups at the last follow-up ($p = 0.797$, 0.234) (Table 2).

In terms of imaging, the HVA, IMA, and DMAA of all patients were improved at 3 months after operation and at the last follow-up. In the AE group, the mean HVA was 40.7° (range, 30°–55°) preoperatively, 4.7° (range, 0°–10°) at the 3 month follow-up, and 6.8° (range, 2°–22°) at the last follow-up. The mean IMA was 18.2° (range, 12°–22°) preoperatively, 6.7 (range, 3°–10°) at the 3 month follow-up, and 8.9° (range, 4°–12°) at the last follow-up. The mean DMAA was 22.5° (range, 15°–31°) preoperatively, 3.4° (range, 0°–15°) at the 3 month follow-up, and 4.8 (range, 0–20) at the last follow-up. In the SL group, the mean HVA was 43.6° (range, 30°–55°) preoperatively, 8.5° (range, 5°–12°) at the 3 month follow-up, and 11.9° (range, 6°–23°) at the last follow-up. The mean IMA was 17.1° (range, 12°–22°) preoperatively, 6.0° (range, 3°–10°) at the 3 month follow-up, and 8.0° (range, 4°–15°) at the last follow-up. The mean DMAA was 23.5° (range, 15°–32°) degrees preoperatively, 5.5° (range, 2°–10°) at the 3 month follow-up, and 7.3° (range, 2°–12°) at the last follow-up. The extent of correction in terms of HVA ,DMAA and joint congruency was greater in the AE group than in the SL group, and at the last follow-up, there was a significant statistical difference between the two groups ($p < 0.05$) (Table 3).

In terms of recurrence and complications, five patients (10.8%) in the SL group and one patient (2.0%) in the AE group experienced recurrence, with no statistical difference between groups ($p = 0.077$). In the AE group, one patient (2.0%) experienced a wound infection at 2 weeks after operation; one patient (2.0%) experienced hallux varus at 6 months after operation, which disappeared after further surgical correction; and two patients (4.1%) experienced screw loosening, which required reoperation to remove the internal fixation one year after operation.

Discussion

In this study, all patients with moderate-to-severe HV underwent open distal Chevron osteotomy, Akin osteotomy, and soft tissue surgery. We retrospectively compared the corrective effects of two different MTP capsule suture techniques used in conjunction with the same osteotomy technique. There were no statistically significant differences between the two groups in terms of the MOXFQ score, AOFAS Hallux MTP–IP Scoring Scale, or VAS pain score reported at 3 months post operation or at the last follow-up, indicating that both techniques provided significant clinical benefits, including improved appearance, reduced pain, and enhanced walking and standing function. Radiographical assessment showed significant correction of HVA, IMA, and DMAA in all patients at 3 months post operation and at final follow-up. Notably, the degree of correction of HVA and DMAA in the AE group was significantly greater than that in SL group at these two time points, suggesting that the AEC technique provides greater mechanical stability and joint alignment (Fig. 3).

Previously, Wei et al. analyzed U-capsulotomy versus inverted L-capsulotomy, and Sever et al. analyzed longitudinal capsulotomy versus inverted L-capsulotomy, demonstrating the safety and effectiveness of medial capsulotomy.[9, 10] However, numerous studies have shown that medial soft tissue augmentation of the MTP1 joint requires strength and long-lasting stability,[16, 17] and Gould et al.[12] reported that AEC was superior to inverted L-capsulotomy and capsulorrhaphy in correcting HVA in the short-term postoperative period. However, postoperative follow-up data on the use of the AEC technique to treat HV are scarce. In our study, longitudinal capsulotomy combined with anchor application was easily performed. Intraoperative X-rays demonstrated that the HVA was corrected and the joint congruency was improved after tightening the anchor suture (Fig. 4).

According to published reports, the HV recurrence rate is approximately 2.7%–16%. The peak period of recurrence is 6 weeks to 6 months after operation, and some patients experience recurrence during longer-term follow-up.[18] Under normal physiological conditions, bones can heal completely within 6 weeks to 3 months after surgery, while the soft tissue repair process may take longer under weight-bearing conditions. Tomoyuki et al. demonstrated radiographical and histological evidence that anchor augmentation of the medial capsule reduces postoperative recurrence.[19] In our study, there was no recurrence at the 3 month follow-up in either group, but by the last follow-up, five patients (10.9%) in the SL group and one patient (4.1%) in the AE group had experienced recurrence. None of the patients with recurrence had pain symptoms, and the clinical scores were still significantly improved compared with those before operation. Long-term follow-up observation was required in the later period, and there was no statistically significant difference between the

two groups. According to the pathogenesis of HV proposed by Perera et al.[20], deterioration of the strength of the medial joint capsule is the primary and critical pathological change driving the development of deformity. We speculate that reinforcing the medial soft tissue with material of sufficient strength can delay this degeneration. Equally importantly, the anchor strengthening technique can improve congruency and stability in the medial joint capsule, thus resisting deformity recurrence. The potential ability of AEC to reduce recurrence rates needs to be further evaluated in studies with long-term follow-up.

In addition to recurrence, possible complications of surgery include wound infection, delayed healing or non-healing due to knot reaction, and loosening and breakage of the internal fixation. In our study, one patient with anchor insertion experienced a postoperative wound infection, and the wound had still not healed at 3 weeks after surgery. The wound did heal well after 2 weeks of re-debridement and anti-infection treatment. No knot reaction or anchor loosening occurred; embedding the knot into the bone tunnel may be the key to avoiding knot reactions. The population most susceptible to HV comprises elderly women. With osteoporosis, there is a possibility of anchor loosening after insertion. The anchor insertion point is the site of the previous osteotomy to remove osteophytes, where the cancellous bone can provide excellent expansion and serve as an anchor insertion point with high holding power. No anchor loosening was observed during the entire postoperative follow-up period. A suture anchor can provide higher mechanical strength than absorbable sutures, providing the repaired joint capsule with continuous support under long-term weight-bearing conditions. The circumferential suture technique used in our study effectively dispersed tension without tissue dissection.

Limitations of this study included the retrospective design and lack of randomization and blinding, which may have introduced bias. The short mean follow-up period (12.41 ± 6.04 months) and small sample size limit the universality of the results. Studies with longer-term follow-up periods and larger samples are needed to further assess recurrence rates and long-term efficacy.

Conclusion

In this retrospective study, we found that open Chevron and Akin osteotomies combined with either all-suture AEC or SLC were safe and effective surgical approaches for moderate-to-severe HV. However, all-suture AEC achieved a greater degree of correction and better joint congruency.

Abbreviations

MTP, MTP1. The First Metatarsophalangeal.

HV, HVA. Hallux Valgus.

IMA. Intermetatarsal Angle.

DMAA. Distal Metatarsal Articular Angle.

AEC. All-suture Anchor–enhanced Capsulorrhaphy.

SLC. Simple Longitudinal capsulorrhaphy.

BMI. Body Mass Index.

MOXFQ. The Manchester–Oxford Foot Questionnaire.

VAS. Visual Analogue Scale.

AOFAS. American Orthopedic Foot & Ankle Society.

Declarations

Ethics approval and consent to participate

Ethical approval for this study was obtained from Ethics Committee of the Second Affiliated Hospital of Soochow University (approval number: JD-HG2026-004). All patients provided their consent by signing an informed consent document.

Competing interests

The authors declare no competing interests.

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Author Contribution

Ke Xu and Bo Jiang provided the experimental design. Ke Xu and Zeding Du wrote the main manuscript text . The collection of experimental data were conducted by Ke Xu and Nan Yi. Jiaju Zhao and Bin Chen analyzed and interpreted the data. Bo Jiang made the final revisions. All authors reviewed the manuscript.Ke Xu and Zeding Du contributed equally to this study.

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Data Availability

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

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Tables

Table 1. Demographic data of the patients in two groups

	AE group（n=49）	SL group（n=46）	*P value*
Age（years）	49.90±14.18	50.93±16.48	0.66
Gender(Male/Female)	12/37	11/35	0.948
BMI（kg/m²）	23.13±3.50	23.57±3.45	0.456
Side(Right/Left)	25/24	26/20	0.591
Average Follow-up Time（mouths）	12.02±5.91	12.83±6.22	0.535

Table 2. Clinic Scoring of the patients in two groups

	AE group(n=49)			**SL group(n=46)**			
	Preoperative	**3-mouth Postoperative**	**Last Follow-up**	**Preoperative**	**3-mouth Postoperative**	**Last Follow-up**	**P* values
MOXFQ							
Index	57.44±13.18	12.12±5.43	9.79±5.61	53.30±11.40	12.36±5.90	9.50±5.39	0.902
Pain	51.85±14.19	12.34±5.14	9.85±5.09	55.39±14.67	11.52±5.28	8.85±5.70	0.129
Walking &Standing	52.35±17.22	11.12±4.93	7.98±4.96	55.50±14.90	12.61±5.30	9.57±5.22	0.442
Social Interaction	53.19±9.45	11.85±2.74	9.04±3.04	54.22±8.06	11.94±3.15	9.14±3.41	0.8
VAS	5.61±1.2	0.58±0.91	0.61±0.67	5.50±1.06	0.41±0.61	0.45±0.62	0.797
AOFAS Score	52.48±7.73	88.24±5.37	90.30±5.07	53.89±7.64	89.28±4.80	90.36±5.47	0.234

*P value is comparison between groups at the last Follow-up

Table 3. Radiological data of two groups

	AE group(n=49)	SL group(n=46)	*P* values
HVA(°)			
Preoperative	40.7±7.7	43.6±7.9	0.084
3-mouth Postoperative	4.7±3.2	8.5±2.6	<0.05
Last Follow-up	6.8±3.8	11.9±3.6	<0.05
IMA(°)			
Preoperative	18.3±3.2	16.9±3.3	0.076
3-mouth Postoperative	6.7±2.4	5.9±2.1	0.144
Last Follow-up	8.8±2.7	8.0±3.1	0.053
DMAA(°)			
Preoperative	22.5±5.2	23.5±5.9	0.422
3-mouth Postoperative	3.4±2.8	5.5±2.1	<0.05
Last Follow-up	4.8±3.3	7.3±2.2	<0.05
Joint Congruency (Yes/No)			
Preoperative	30/19	31/15	0.531
3-mouth Postoperative	45/4	38/8	0.176
Last Follow-up	44/5	34/12	0.044

Figures

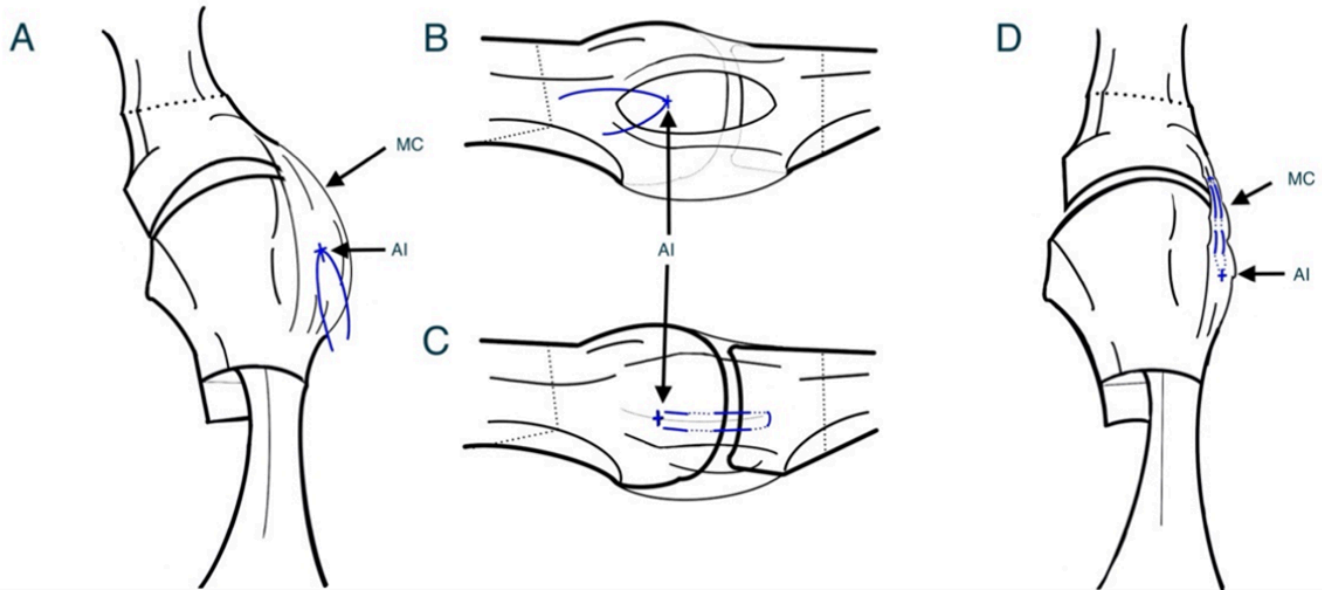

Figure 1

All-Suture Anchor Enhanced Capsulorrhaphy

AI, Anchor insertion point; MC, Medial capsule. After osteotomy and fixation: (A, D) comparison of horizontal position before and after anchor enhancing; (B, C) comparison of sagittal planes before and after anchor enhancing.

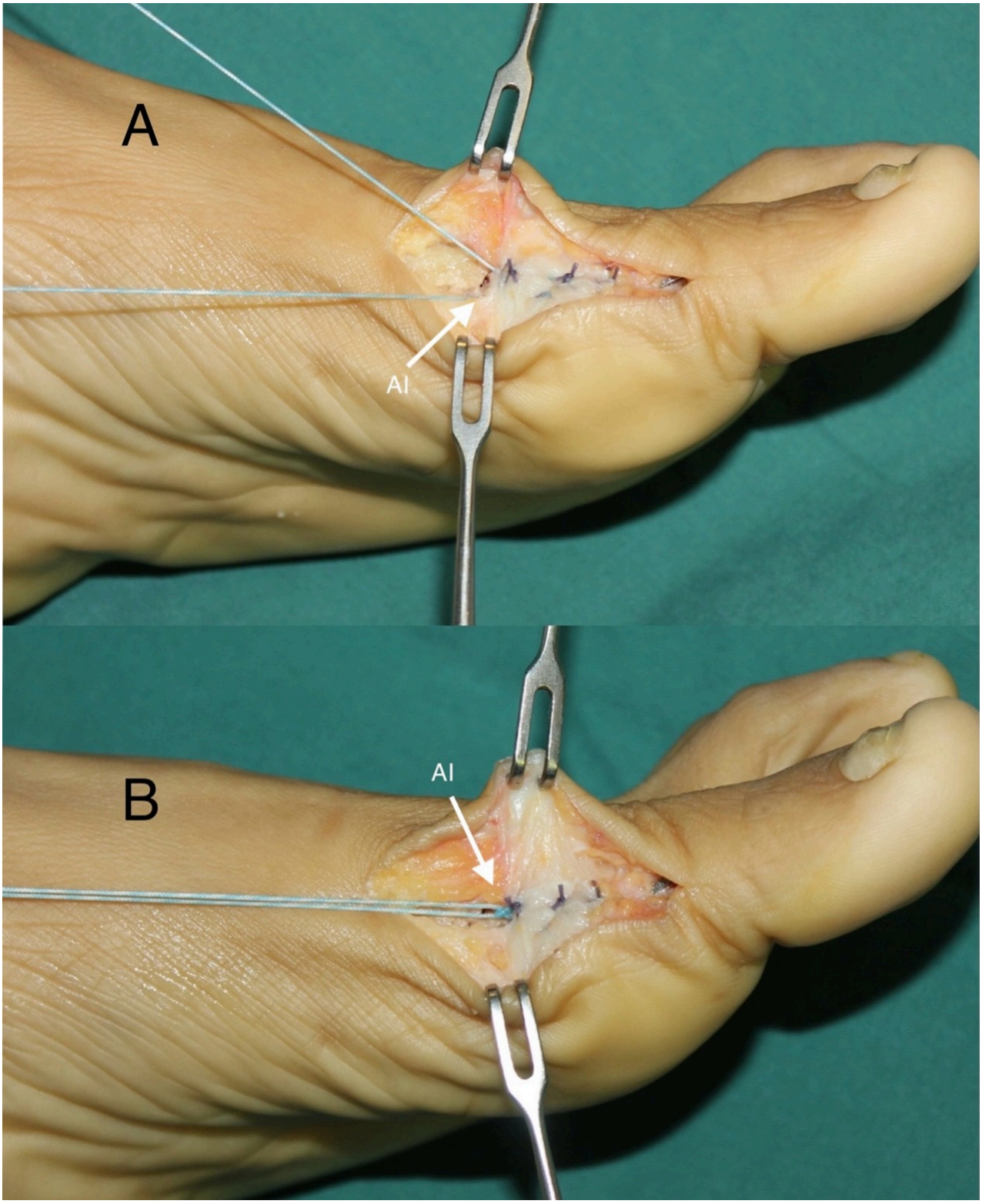

Figure 2

Intraoperative sagittal observation before and after anchor enhancing

Figure 3

Effected foot weight-bearing AP X-ray

Left foot with severe HV of a 53-year-old female patient who received the Chevron/Akin osteotomy and AEC surgery. (A) Pre-operation. (B) One-year postoperative follow-up. The white lines indicate the congruency of the joint surfaces. The red line represents the axis of the first metatarsal bone. The yellow line represents the axis of the first proximal phalanx.

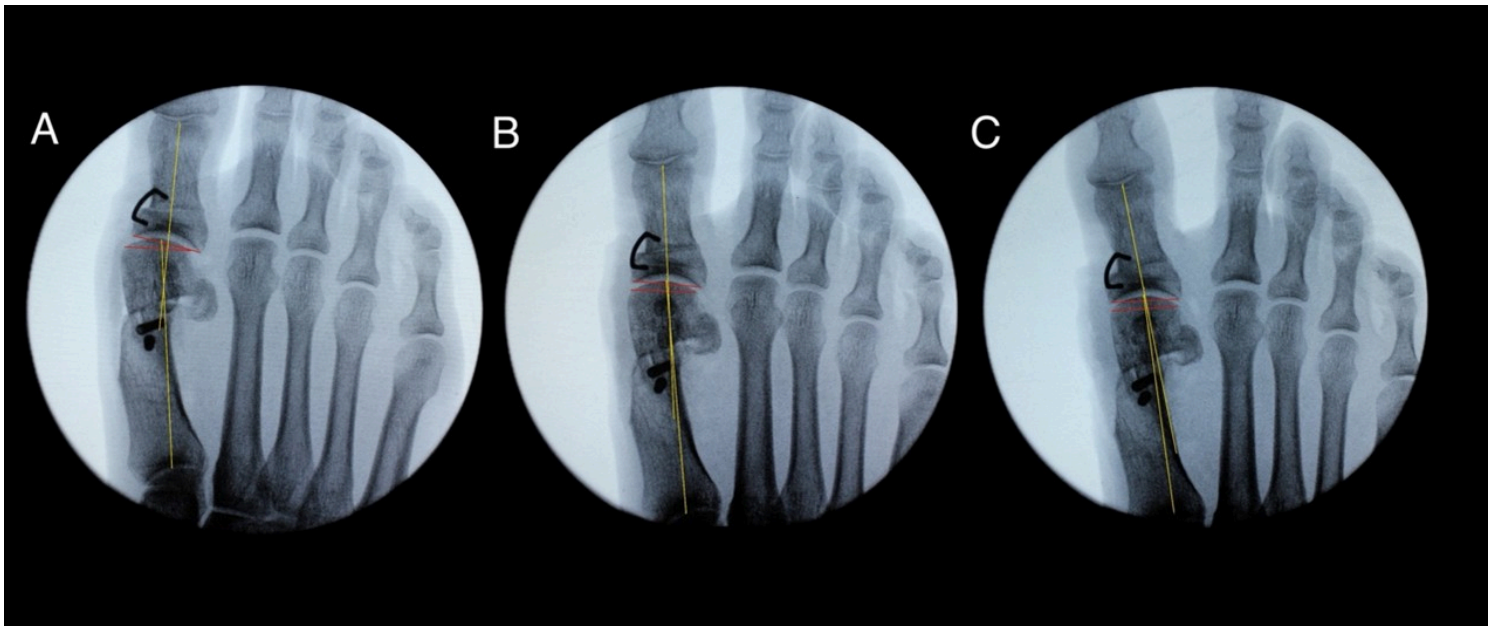

Figure 4

Intraoperative AP view

(A) After osteotomy and fixation, MTP1 joint congruency was still unsatisfactory, and HVA was not fully corrected. (B) After simple suture capsulorrhaphy, MTP1 joint congruency and HVA achieved satisfactory improvements. (C) After AEC,

MTP1 joint congruency and HVA achieved complete correction.