

CLINICAL ARTICLE

A Better Treatment for Moderate to Severe Hallux Valgus: Scarf + Akin Osteotomy Combined with Lateral Soft Tissue Release in a Single Medial Incision

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Objective: Traditional lateral soft tissue release (LSTR) was conducted by an additional dorsal first web incision, as the malformed thick scar and neuritis were common after surgery. A new method of lateral soft tissue release in a single medial incision via dorsal flap over the first metatarsal (LSTR-SMI-DFFM) should be recommended. The objective is to investigate the clinical effectiveness and safety of scarf + Akin osteotomy (SAO) combined with lateral soft tissue release in a single medial incision via dorsal flap over the first metatarsal (LSTR-SMI-DFFM) for moderate to severe hallux valgus.

Methods: Patients who were performed surgery for hallux valgus from April 2014 to June 2020 were retrospectively reviewed. The visual analog scale (VAS) was recorded before surgery and during follow-up, as well as the forefoot score of the American Orthopaedic Foot and Ankle Society (AOFAS). Patient satisfaction was evaluated at the follow-up time. The preoperative and follow-up weightbearing X-ray were conducted in all patients. The radiological parameters of hallux valgus angle (HVA), intermetatarsal angle (IMA), and distal metatarsal articular angle (DMAA) were measured. Tibial sesamoid position (TSP) was also recorded according to seven-part grading system. The quantitative data were performed as mean ± standard deviation or median ± interquartile range. Student's *t* test was performed in HVA, IMA, and DMAA. The TSP, VAS, and AOFAS were statistical analyzed by Mann-Whitney *U* test. *p* value of <0.05 was considered significant.

Results: There were 123 feet conducted surgery in 96 patients. The AOFAS score improved a lot which was preoperative 39 to 100 at the follow-up time and VAS was 4 to 0 (*p* < 0.001). A total of 63 (51.2%) patients were very satisfied, 47 (38.2%) were satisfied, five (4.1%) were undecided and eight (6.5%) were not satisfied. The HVA, IMA, DMAA, and TSP were all decreased after surgery and were statistically significant (*p* < 0.001).

Conclusion: The SAO combined with a LSTR-SMI-DFFM for moderate to severe hallux valgus is effective and safe with pretty good clinical and radiographic results, as well as minimal complications. The corrections of AOFAS and VAS conformed to the minimum clinically important difference (MCID).

Key words: Akin osteotomy; hallux valgus; lateral soft tissue release; scarf osteotomy; single medial incision

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Introduction

The deformity of bone and imbalance of dynamic soft tissue result in hallux valgus, a deformity affecting the big toe.¹ There is a higher incidence of hallux valgus deformity in China with different causes, such as genetic susceptibility and ethnicity.² The incidence of hallux valgus deformity is about 30% in adult patients.³ The symptoms of hallux valgus can be alleviated by correcting the deformity in surgery, which has been reported through more than 100 surgical approaches.^{4,5} The most common procedure is scarf or chevron osteotomy combination with or without Akin osteotomy. The indication for chevron osteotomy is mild to moderate hallux valgus and scarf is suitable for moderate to severe hallux valgus. The scarf osteotomy is a Z-shaped osteotomy in the first metatarsal bone and it is very effective in correcting hallux valgus deformity.⁶ Due to the inherent stability and ease of internal fixation of scarf osteotomy, now it is popular in China. And the scarf osteotomy allows horizontal displacement, shortening, rotation, elevation, and lowering of the metatarsal head.⁷ The scarf osteotomy can maintain the length of the first metatarsal and allow an early mobilization after surgery. The metatarsal head was displaced in a plantar direction as part of the scarf osteotomy to reduce the possibility of transfer metatarsalgia. Scarf osteotomy can also bring good results and satisfaction.^{1,8} Akin osteotomy combined with the first metatarsal osteotomy was increasingly acknowledged.^{9,10} Akin osteotomy can effectively correct the enlargement of distal metatarsal articular angle (DMAA), and effectively assist metatarsal osteotomy, which significantly improves the efficacy and satisfaction rate and fully compensates for the deficiencies exhibited by scarf osteotomy.¹¹ It is a common deformity of hallux valgus affecting the first toe and soft tissue structures around the first metatarsophalangeal (MTP) joint, and it was suggested that the occurrence of hallux valgus was associated with soft tissue structures.¹² Therefore, lateral soft tissue release (LSTR) is frequently used as an adjuvant procedure during the surgical treatment. The adductor tendon is regarded as being a deformable force on the first MTP joint by attaching it to the lateral part of the base of the proximal phalanx of the first toe, bringing it into the valgus position. A LSTR is considered an important step in the surgical treatment for severe hallux valgus deformities.⁴ The LSTR is also necessary in scarf + Akin osteotomy (SAO). Sesamoids can be better reduced in their anatomic position with scarf + Akin osteotomy and LSTR. In addition, the combination of scarf + Akin osteotomy and LSTR can also maintain a long-term correction after hallux valgus surgery.¹³ There are some controversies about LSTR for that it is difficult to decide a thin line between sufficient and excessive release without comparative studies and more detailed terminology.

Traditional LSTR was conducted by an additional dorsal first web incision, as malformed thick scar and neuritis were common after surgery.¹⁴ There are many other procedures including trans-articular, trans-osteotomy, medial single incision, dorsal and plantar sub-periosteal elevation, and minimally invasive techniques in LSTR to minimize these complications.¹⁵⁻¹⁷

Currently, as with surgery in other regions, foot surgery is developing in a minimally invasive direction. The single medial incision *via* a dorsal flap over the first metatarsal or trans articular approach can be also used to release lateral soft tissue.¹⁸ The single medial incision can achieve a pleasant looking foot and great satisfaction according to most surgeons and patients. In addition, a single medial incision is also easy to perform the LSTR adequately.¹⁹⁻²¹ The SAO for moderate to severe hallux valgus was described by many studies with pretty good results. The LSTR was conducted in a single medial incision without changing the traditional medial incision of scarf + Akin osteotomy. However, the SAO combined with a LSTR in a single medial incision *via* dorsal flap over the first metatarsal (LSTR-SMI-DFFM) for moderate to severe hallux valgus has not been studied. The objective of this study was as follows: (i) report the clinical effectiveness and safety of SAO combined with LSTR-SMI-DFFM for moderate to severe hallux valgus, and (ii) propose the surgical skills or directions of this SAO combined with a LSTR-SMI-DFFM for correction of hallux valgus deformity. The result will provide more evidence to support the clinical application of the SAO combined with a LSTR-SMI-DFFM in the management of hallux valgus.

Material and Methods

Patients

The study design was a case review series study. Our ethics committee approved this study (Number 2020-2-4086). Patients who were performed surgery for hallux valgus from April 2014 to June 2020 were retrospectively reviewed. Inclusion criteria were: (i) ages ≥ 18 ; (ii) nonoperative treatment failed; (iii) hallux valgus angle (HVA) $\geq 20^\circ$ or intermetatarsal angle (IMA) $\geq 14^\circ$; and (iv) with LSTR-SMI-DFFM combined with SAO were included. The exclusion criteria were: (i) rheumatoid arthritis and osteoarthritis on the first metatarsophalangeal joint (MPJ); (ii) patients with severe cardiovascular diseases; and (iii) patients lost to follow-up.



Fig. 1 The medial incision is made parallel to the plantar surface of the foot, beginning 1 cm distal to the first metatarsophalangeal joint over the hallux valgus and continuing proximally along the inferior margin of the first metatarsal to the first metatarsocuneiform joint

Surgical Technique

1. All patients were taken in the supine position and used standard clinical techniques. A 7 cm single medial incision was made from 1 cm distal to the first MPJ continuing along the lower part of the first metatarsal (Figure 1). Then a blunt dissection as performed to expose the first intermetatarsal space and protect the nervus cutaneus. The lateral wound edge and the extensor tendons were pulled aside. Then the lateral capsule, the adductor hallucis muscle, the lateral metatarsal-sesamoid suspensory ligament and the transverse metatarsal ligament were exposed. After that, the adductor hallucis muscle including the adductor oblique and transversus was released. Next, the lateral metatarsal-sesamoid suspensory ligament, the deep transverse metatarsal ligament, and lateral joint

capsule were released. Neurovascular bundles of the first interspace should be treated with care.²² The effect of the release was that the MPJ could achieve varus angulation manually (Figure 2).

2. Scarf osteotomy was performed according to Duke HF and Rippstein,^{23,24} which is widely used nowadays.^{6,25} The scarf osteotomy was fixed with two 2.0 screws. One 2.0 cortical screw was also used in the Akin osteotomy (Figure 3).
3. The medial joint capsule was then closed and then the skin wound was closed. The medial joint capsule was tightened. All of patients with the single incisions were treated with a drainage tube in surgery, which was removed the day after surgery, to reduce postoperative swelling.

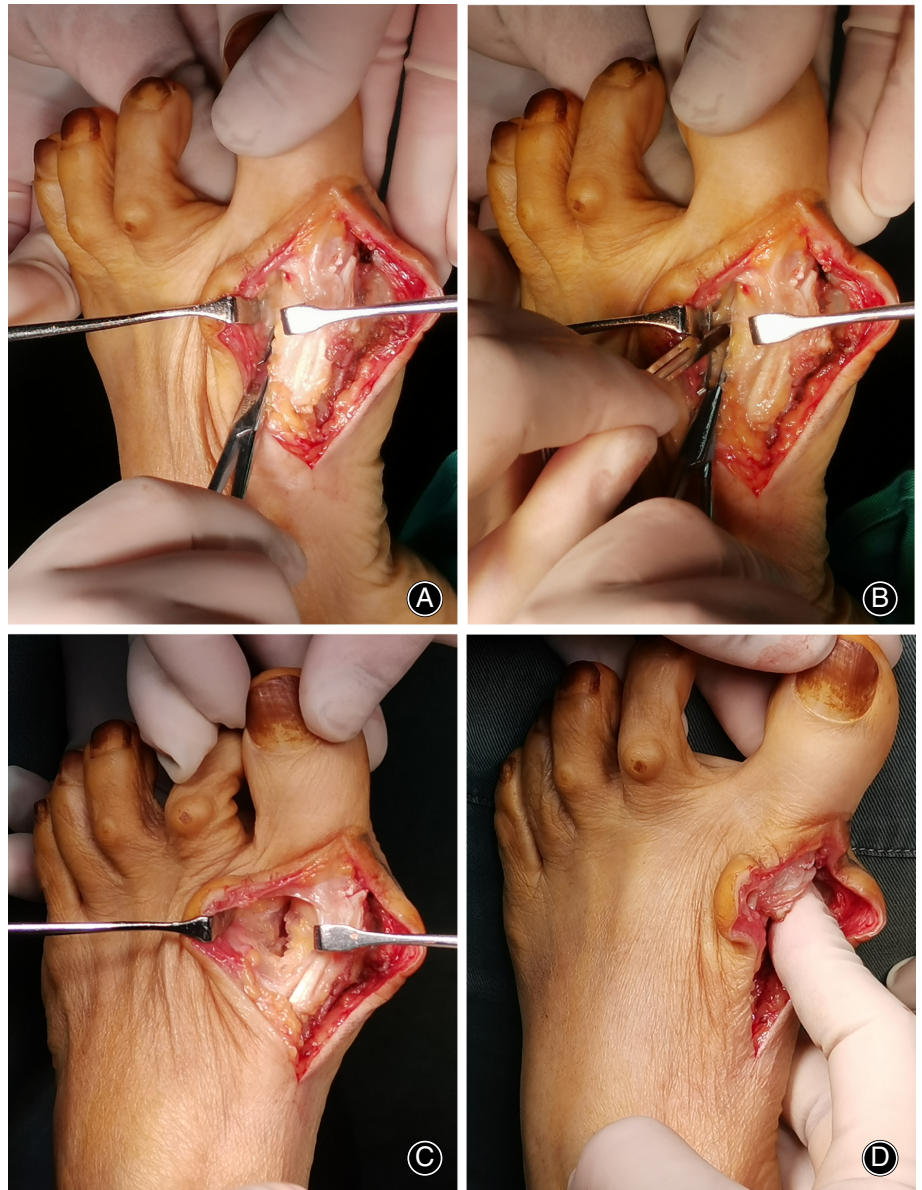


Fig. 2 Intraoperative photograph. (A) The intermetatarsal space with the hemostat placed under the deep transverse metatarsal ligament. (B) Release the adductor release from the lateral sesamoid. (C) Lateral soft tissue after release. (D) An adequate amount of lateral soft tissue release



Fig. 3 (A) Intraoperative photograph showing the scarf osteotomy. (B) Intraoperative photograph showing the Akin osteotomy. (C) Radiographs showing the preoperative deformity. (D) Radiographs showing the postoperative correction

TABLE 1 Preoperative and postoperative radiographic and clinical results

	Preoperative	Postoperative	Mean correction	t/Z value	p value
HVA	37.4° ± 8.5°	9.8° ± 7.4°	27.6°	32.370	<0.001 ^a
IMA	13.9° ± 3.4°	4.2° ± 2.4°	9.7°	33.970	<0.001 ^a
DMAA	23.4° ± 11.0°	12.0° ± 7.0°	11.4°	12.334	<0.001 ^a
TSP	5(5-6)	3(3-4)	2	-9.421	<0.001 ^b
VAS	4(4-5)	0(0-0)	4	-9.632	<0.001 ^b
AOFAS	39(35-55)	100(90-100)	61	-9.636	<0.001 ^b

Abbreviations: AOFAS, American Orthopaedic Foot and Ankle Society; IM, intermetatarsal, hallux valgus hallux valgus; TSP, tibial sesamoid position; VAS, visual analog scale.; ^aValues are given as the mean ± standard deviation, the statistical analysis was conducted using paired Student's *t*-test.; ^bValues are given as the median (interquartile range), the statistical analysis was conducted using a Wilcoxon rank-sum test.

Intraoperative Results

In the LSTR, the lateral capsule, the adductor hallucis muscle, the lateral metatarsal-sesamoid suspensory ligament, and the transverse metatarsal ligament should be exposed. Finally, close the medial joint capsule and the skin wound in turn. The medial joint capsule needs to be tightened.

Postoperative Care

After surgery, hallux was wrapped in the correction position. Patient can use the metatarsal offloading shoes to bear weight on the second day. After 6 weeks, the patients were allowed to carry weight on the auxiliary insole. Allow the toes to bear normal weight after 12 weeks. Patients can exercise after 6 months.

Clinical and Radiological Assessments

The visual analog scale (VAS) was recorded before surgery and during follow-up, as well as the forefoot score of the American Orthopaedic Foot and Ankle Society (AOFAS). As for satisfaction scale, it was recorded with "very satisfied," "satisfied," "undecided," or "not satisfied," respectively,

corresponding to 1 to 4.²⁶ The preoperative and follow-up weightbearing X-ray were conducted in all patients. The radiological parameters included the HVA, IMA, DMAA, and tibial sesamoid position (TSP).

Visual Analog Scale (VAS)

The VAS was used to show the pain level.²⁷ The VAS pain scoring standard (scores from 0 to 10) was as following: 0 means painless; 1-3 means mild pain that the patient could endure; 4-6 means patient was in pain that could be endured and be able to sleep; and 7-10 means patient had intense pain and was unable to tolerate the pain.

American Orthopaedic Foot and Ankle Society (AOFAS) Scores

AOFAS forefoot score were assessed before and at the last follow-up after the surgery.²⁸ The total score is 100 for the best, which includes pain (40 points), function (45 points), and alignment (15 points).

TABLE 2 Patient satisfaction and complications

Patient satisfaction	Number (%)	Complications (Number)
Very satisfied	63 (51.2)	Hallux varus (4), Recurrence (4)
Satisfied	47 (38.2)	Hallux varus (1), Metatarsalgia (1) and Recurrence (2)
undecided	5 (4.1)	Recurrence with infections (1), Metatarsalgia (1) and Irritation of hardware (1)
Not satisfied	8 (6.5)	Hallux varus (2), Recurrence with metatarsalgia (3) and Metatarsalgia (3)

Radiographic Evaluation

Anteroposterior and lateral weightbearing X-ray were performed before and after the surgery and at the last follow-up. The HVA is defined as the angle between the line from the center of the first metatarsal base to the center of the first metatarsal head and the line from the midpoint of the proximal articular surface of the proximal phalanx to midpoint of distal articular surfaces of the proximal phalanx.²⁹ The IMA is the angle of the line from the center of the first metatarsal base to the center of the first metatarsal head with the axis of the second metatarsal shaft.²⁹ The DMAA is the angle between the vertical line of distal articular surface of the first metatarsal and the line from the center of the first metatarsal base to the center of the first metatarsal head. Tibial sesamoid position (TSP) was also recorded according to seven-part grading system.³⁰

Minimum Clinically Important Difference (MCID)

Recently, the minimum clinically important difference (MCID), which is widely used in clinical evaluation, can be performed to determine whether a treatment leads to clinically significant improvement and the minimum change in

outcome measurements.³¹ It shows the importance of evaluation from the perspective of patients. The VAS and AOFAS scores in our study were compared with MRCID in other studies which also studied the hallux valgus.^{32,33}

Statistical Analysis

SPSS23.0 (Chicago, IL, USA) were used for statistical analyses. The quantitative data were performed as mean \pm standard deviation or median \pm interquartile range. Student's *t* test was performed in HVA, IMA, and DMAA. The TSP, VAS, and AOFAS were statistical analyzed by Mann-Whitney *U* test. *p* value of <0.05 was considered significant.

Results

Baseline and Follow-Up

There were 123 feet that underwent surgery on 96 patients. The average age was 60 ± 11 years. One hundred and six (86.2%) feet were women's feet. Radiographic assessment was the time of last follow-up with X-ray examination. Time of radiographic assessment was 7.2 months (6.2–73.9 months) and mean follow-up time for clinical outcomes was 41.6 ± 18 months. All 96 patients were followed up.

Clinical Evaluation and Radiological Assessment Results

After the surgery, the patient's pain and appearance of the foot have been well improved. The results of VAS and AOFAS before and after surgery were shown in Table 2, of which the differences were statistically significant ($p < 0.001$). The AOFAS score improved a lot which was preoperative 39 to 100 at the time of follow-up and the VAS was 4 to 0. There were 63 (51.2%) patients who said that they were very satisfied with score 1, 47 (38.2%) were satisfied with score 2, five (4.1%) were undecided with score 3, and eight

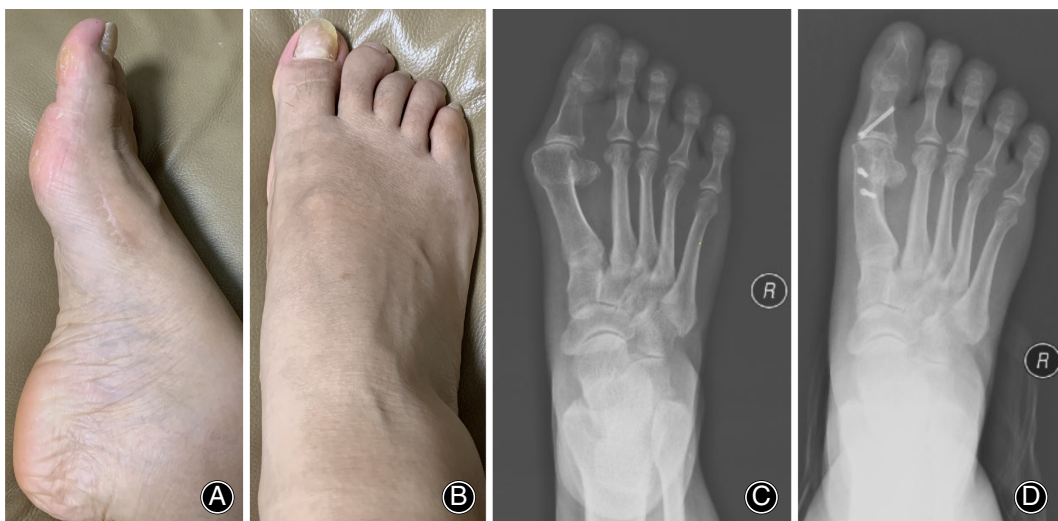


Fig. 4 Postoperative outcome of a patient 3 years after surgery. (A) The medial view of foot. (B) The frontal view of foot. (C) Radiographs showing the preoperative deformity. (D) Radiographs showing the postoperative correction

(6.5%) were not satisfied with score 4. The HVA, IMA, DMAA, and TSP all decreased after surgery and were statistically significant. ($p < 0.001$, Table 1)

Complications

A HVA $\geq 20^\circ$ indicated the recurrence of hallux valgus.³⁴ Ten (8.1%) of the 123 feet were found with recurrence. Transfer metatarsalgia was found in eight (6.5%) feet. The transfer metatarsalgia can be relieved by taking modified shoes or a brace. There was one (0.8%) foot with postoperative incision infections, which was treated with oral antibiotics and local wound care, and 2 weeks later the wound healed well. Irritation of hardware was found in one (0.8%) foot and was removed 8 months after surgery. Hallux varus was found in seven (5.7%) feet and were all treated conservatively. For the treatment of hallux varus, the adhesive orthosis bandage was used, and the deformity could be basically recovered as well as with good outcome (Table 2). Table 2 also showed the relationship between patient satisfaction and complications.

A Case-Report Result

A 38-year-old woman with a severe hallux valgus deformity in the right foot and a severe pain in the forefoot had SAO combined with LSTR-SMI-DFFM. After surgery, the deformity was adequate corrected with a postoperative HVA (4.8), IMA (4.6), DMAA (2.3), and TSP (2) compared to preoperative HVA (35), IMA (10.8), DMAA (38.9), and TSP (5) (Figure 4). The postoperative functions were good and the orthopaedic effect was satisfactory.

Discussion

The role of LSTR in the correction of moderate and severe hallux valgus is very important. Two incisions can be selected for a LSTR. One is the traditional incisions was through the dorsal first web and the other is *via* a single medial incision. We have achieved pretty good clinical and radiographic results with minimal complications in the SAO combined with a LSTR-SMI-DFFM for moderate to severe hallux valgus.

Characteristics and Surgical Skills

In the past, dorsal first web incision was frequently used. Because dorsal first web incision could release the lateral soft tissue adequately with a directed view. Some studies proposed the risk of avascular necrosis when the soft tissue was released through the first dorsal web.^{35,36} Recently, single medial incision is becoming more and more popular in a LSTR and has been described in some studies.^{15,19} It can avoid some problems that are caused by dorsal first web incision. And it can also bring better cosmetic results. Drainage tube was used to reduce postoperative swelling and was removed the day after surgery. Overall, there was no additional complication associated with a single incision, which is consistent with other studies.

In the implementation of a LSTR, dorsal cutaneous nerve should be protected. The lateral soft tissue can be well exposed by pulling the dorsal skin externally with a drag

hook. During the surgery, the release can be judged according to the passive movement of the big toe.

SAO Combined with a LSTR

The SAO has been widely used in correcting hallux valgus.^{6,11} It was common that phalangeal pathology was found in hallux valgus deformity, especially the moderate and severe hallux valgus. The deformity affects the progress of HVA and IMA by expanding the traction of the big toe joint. Phalanx can be rectified by Akin osteotomy, which is not directly affected by the IMA. It can achieve pretty good correction in hallux valgus deformity in a SAO. The effect and satisfaction can be improved by LSTR, and the series of deficiencies exhibited by a SAO can also be compensated by the LSTR.¹⁵

In our study, we found the SAO combined with a LSTR could correct the HVA, IMA, DMAA effectively, especially the HVA, which has a low risk of recurrence. HVA and IMA were basically returned to the normal range. And after 41.6 months of follow-up, the HVA and IMA had little change. In addition, a LSTR is of great importance for the reduction of sesamoid position, which is associated with the recurrence of hallux valgus. In clinical outcomes, patients got pain relief, pretty good appearance, and pretty good postoperative VAS and AOFAS scores. In terms of complications, there is also a very low incidence of complications, such as recurrence, hallux varus, transfer metatarsalgia, incision infections, and irritation of hardware. Those results in our study were consistent with other studies.^{6,8,9}

Technical Advantages and Treatment Experience

A LSTR can be conducted in a single medial incision *via* a trans-articular approach or a dorsal flap over the first metatarsal. When comparing the two surgical skills to release the lateral soft tissue, we prefer choosing a single medial incision *via* a dorsal flap over the first metatarsal. In our study, all patients performed the SAO combined with a LSTR-SMI-DFFM. The postoperative outcomes, including clinical and radiological, were better than those before surgery, and they were also statistically significant. No added complications existed, such as marginal wound necrosis and a scar of the medial incision, which is not easy to find (Figure 4). So, it is effective and safe to conduct the SAO combined with a LSTR-SMI-DFFM. Qasim *et al.*¹⁹ treated hallux valgus by using scarf with or without Akin osteotomy though a single medial incision *via* a trans-articular approach for a LSTR. The results were with very low incidence of complications and very high patient satisfaction in this study. However, it is a retrospectively case review series study without functional score assessment. Jung *et al.*¹⁵ had studied chevron osteotomy + Akin osteotomy with a LSTR in a single medial incision *via* a dorsal flap over the first metatarsal. It was with very favorable radiographic and clinical outcomes. The MCID of AOFAS score in hallux valgus surgery was 7.9 to 30.2 in the study of Chan *et al.* in hallux valgus.³² Sutton *et al.* studied VAS in hallux valgus and calculated MCID scores ranged from 1.8 to 5.2 points.³³ In our study, the correction of AOFAS and VAS were 61 and 4, which is better than MICS. So, from the patient's point of view, the effect is positive. The experience is

that the lateral joint capsule and lateral ligaments should fully release by transverse and longitudinal with sharp knife and intraoperative examination can be performed after the release to show an adequate amount of lateral soft tissue release (Figure 2). The lateral soft tissue could be exposed clearly when dorsal flap was retracted laterally and the extensor tendon was retracted medially. Attention should be taken to protect the vessels and nerves in the process above.

So, we believe that the SAO with a LSTR-SMI-DFFM could be a pretty good choice for moderate to severe hallux valgus. We hope more orthopaedic surgeons understand and implement the LSTR-SMI-DFFM. In the future, more studies can provide the good effects of the SAO with a LSTR-SMI-DFFM.

Strengths and Limitations

There are some strengths in the study, including large cases and enough follow-up time. There are also some limitations in this study. Firstly, it is a retrospective study with non-comparative group. Randomized controlled studies are needed in the subsequent studies. Secondly, the sample size is not large enough, and more samples are needed for further study. Thirdly, the short follow-up time is also a limitation and longer follow-up data should be performed in future study. Finally, the proficiency of surgical methods of different surgeons may affect the results and has inherent deficiencies.

Conclusions

In our study, we have achieved pretty good clinical and radiographic results with minimal complications. The corrections of the AOFAS and VAS conformed to the MCID. The SAO combined with a LSTR-SMI-DFFM for moderate to severe hallux valgus is effective and safe. While further controlled studies are needed, such as prospective controlled studies where one group conducts SAO combined with a LSTR-SMI-DFFM and the other with SAO combined with a traditional LSTR by an additional dorsal first web incision.

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Author Contributions

WYX, HL, and SZZ performed data analysis, as well as writing the manuscript. GCL and YSY contributed to the collection of data and manuscript editing. HLX edited the manuscript and was the guarantor of this article. The author(s) read and approved the final manuscript.

Ethics Statement

Institutional review board: We certify that all subjects provided informed consent to participate in the study, and this study was approved by the institutional review board of our institution (2021PHB134-001).

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