

Clinical Outcomes of Ankle Distraction Arthroplasty Versus Supramalleolar Osteotomy for Treatment of Post-traumatic Ankle Arthritis in Young Adult Patients

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Abstract

Background

In the late stage of traumatic ankle arthritis, the pain symptoms are aggravated and the joint function is obviously limited. However, in the face of young patients with high activity requirements, there are still great challenges in how to preserve the joint and effectively treat traumatic ankle arthritis. Ankle distraction arthroplasty and supramalleolar osteotomy are both options for such medical condition, but the studies comparing their clinical outcomes have been scarce. The purpose of this study is to compare the clinical outcomes of ankle distraction arthroplasty and supramalleolar osteotomy in the treatment of severe traumatic ankle arthritis in young adult patients.

Methods

This was designed a retrospective study, enrolling 73 consecutive young adult patients who underwent ankle distraction arthroplasty (n=32) or supramalleolar osteotomy (n=41) for post-traumatic ankle arthritis from January 2017 to December 2020. All patients had at least 24-month follow-ups. The outcome measures were the comparisons of the pre- and postoperative visual analog scale (VAS) for pain relief, the American Orthopedic Foot & Ankle Society (AOFAS) ankle-hindfoot scores, angle range of motion (ROM), complications, patient-rated overall satisfaction and radiological evaluation of changes in ankle joint space width (JSW).

Results

Seventy-three patients (73 ankles) (100%) returned for final evaluation at an average of 32 months (range, 24 to 48 months) follow-up. At an average of 6 months follow-up, both groups achieved significantly improved VAS, AOFAS, ROM and JSW scores compared to those at baseline ($p < 0.05$), but not significantly differed between groups (all $p > 0.05$). Either, both groups did not differ in the tibial anterior surface angle (TAS), talar tilt angle (TT), tibial lateral surface angle (TLS), except for the correcting the load-bearing line of the ankle and hindfoot. However, at the last follow-up, patient satisfaction and ankle function scores in the ankle distraction arthroplasty group showed a downward trend, while the function scores in the supramalleolar osteotomy group showed an increasing trend, which was statistically significant.

Conclusions

Both ankle distraction arthroplasty and supramalleolar osteotomy are effective treatment options for the severe post-traumatic ankle arthritis in the young adult patients. From the long-term follow-up, however, supramalleolar osteotomy is better than ankle distraction arthroplasty in ankle score and patient satisfaction evaluation.

Level of evidence: Level III, retrospective comparative series.

Introduction

Ankle arthritis is an important cause of pain and functional limitation and ultimately leads to limited mobility and dysfunction [1]. At present, the number of patients with traumatic ankle arthritis is also gradually increasing [2]. It has been estimated that 20%–40% of patients with acute ankle trauma like ankle sprain would develop chronic sprain, leading injury or even rupture of the lateral ligaments of the ankle, causing chronic lateral ankle instability and the secondary post-traumatic ankle arthritis [3][4][5]. The recent reports showed that the young patients were the predominant for this arthropathy and the incidence seemed on the rise [6][7]. But a suitable treatment modality for young adult patients is very challenging. Currently, there is well-established consensus that ankle arthrodesis is the standard treatment for the end-stage traumatic ankle arthritis, which typically presents with persistent swelling around the ankle with pain, loss of normal bone structure of the tibiotalar joint surface and basic loss of function [8][9]. Ankle arthroplasty in the treatment of end-stage ankle arthritis can preserve the ankle range of motion, but at the expense of removing the tibiotalar articular surface [10]. Although the symptoms of ankle arthritis can be relieved in the short term, there are many complications in the later stage [11]. For young patients whose conservative treatment is ineffective, alternative treatment methods should be selected as far as possible for ankle arthrodesis or replacement and it is very important to preserve the range of motion of the joint to a certain extent. Although both ankle distraction arthroplasty and supramalleolar osteotomy can delay the development of the disease as an alternative to the treatment of severe traumatic ankle arthritis, but with respective advantages and disadvantages. By far as we know, there are no studies directly comparing the outcomes of both surgical methods.

Considering the increasing importance of evidence-based data on decision-making for the surgical option for this increasingly growing arthropathy in the young patients, it is necessary to clarify the respective advantages and disadvantages of surgical methods to facilitate the effective management. Given that, we designed this study, with aims to compare the clinical outcomes between ankle distraction arthroplasty and supramalleolar osteotomy for severe ankle arthritis, in terms of pain relief, functional recovery and postoperative complications.

Materials And Methods

This was a retrospective study. The study protocol was approved by the institutional review board of the Third Hospital of Hebei Medical University and all patients provided the written informed consent.

The inclusion criteria were age <60 years; stage 4 post-traumatic ankle arthritis classified as Takakura-Tanaka classification, ankle pain and swelling lasting >6 months and failure of conservative treatment; absence of past any surgical procedure around the ankle; complete pre- and postoperative data and imaging examinations, and the follow-up of at least 24 months.

The exclusion criteria were recent infection around the ankle; history of ankle fracture; other serious deformities or diseases of the foot and ankle, such as clubfoot or diabetic foot; incomplete medical

record data or lost to follow-up or follow-up period <24 months. Additionally, surgery is contraindicated for those with congenital collagen deficiency; bodyweight >120 kg; severe heart disease; lesions affecting liver and kidney function; severe diabetes; central nervous system diseases; or others.

The above criteria identified 73 consecutive patients who underwent either ankle distraction arthroplasty (n=32) or supramalleolar osteotomy (n=41) for treatment of Takakura-Tanaka stage 4 post-traumatic ankle arthritis after failure of conservative treatment from January 2017 to December 2020.

Among ankle distraction arthroplasty group, there were 19 men and 13 women, with an average age of 39.8 ± 11.8 years; left ankle was affected in 14 and right in 18 patients; 21 had a clear history of ankle trauma and 11 with unknown etiology. Among supramalleolar osteotomy group, 27 were men and 14 were women, with an average of 41.1 ± 10.9 years; left ankle was affected in 17 and right in 24 patients; 29 had a clear history of ankle trauma and 12 with unknown etiology. Preoperative evaluation of all patients included a detailed history ankle arthritis, presence of comorbidities, physical examination, and imaging examination. The ankle joint space width (JSW), tibial anterior surface angle (TAS), talar tilt angle (TT) and tibial lateral surface angle (TLS) were measured. CT was performed to evaluate the condition of the subtalar and tibiotalar joints.

Operative procedures

The supramalleolar osteotomy group received prophylactic intravenous antibiotics 30 minutes prior to skin incision. After anesthetic induction, the patient was placed in supine position then a tourniquet was placed at the proximal extremity. A 4-cm longitudinal incision was made in the middle of the anterior ankle to expose the ankle joint cavity and assess whether there was contact between the ankle and tibial joint surfaces. Intraoperatively, lip-like hyperplasia of the tibial joint surface and hyperplasia of the lateral talar surface can be observed, and the passive movement of the ankle was limited. The proliferative bone was removed, and the ankle was moved passively until the range of motion was close to normal. Patients with achilles tendon contracture or gastrocnemius tension should be treated with achilles tendon extension or gastrocnemius muscle release. If the range of motion of the ankle cannot be improved after extension or release, the posterior joint capsule of the ankle needs to be incised. The joint cavity was washed with normal saline and the surgical incision was sutured. A Kirschner wire was used as an osteotomy guide 4–5 cm above the ankle joint. After the osteotomy direction was confirmed on X-ray fluoroscopy, the medial, anterior, and posterior cortices were cut from the anterolateral side parallel to the articular surface of the distal tibia, and the contralateral cortices and periosteum were retained to form a hinge when the osteotomy was opened and were inserted into the wedge-shaped bone block to increase the stability. After satisfactory correction of the varus deformity, a Kirschner wire was used for temporary fixation. Autogenous or allogeneic bone was implanted at the osteotomy site. An anatomical steel plate was used to fix the osteotomy end and afterwards the incision was closed.

The ankle distraction arthroplasty group underwent the same preoperative preparation and the same ankle debridement procedure as the supramalleolar osteotomy group. The ankle joint was placed in a

neutral position and the annular external fixator was placed in a suitable position with the extension rod directly opposite the ankle joint activity center. A 2.0-mm-diameter Kirschner wire was used to drill 8 cm below the knee joint, and then two Kirschner wires were drilled 5 cm above the ankle joint and parallel to the knee joint; one Kirschner wire was fixed in front of the calcaneal tubercle, and the other one was fixed in the metatarsal base of the anterior foot. Each ring was reinforced with a threaded needle.

Postoperative rehabilitation

The incision was routinely dressed and intravenous prophylactic antibiotics were administered. The Kirschner wire hole was wiped with iodophor every day to prevent sinus tract infection. To promote functional recovery of the ankle and prevent postoperative stiffness, both groups began early postoperative rehabilitation exercises. From postoperative day 1, patients were instructed to exercise the toes and quadriceps femoris to prevent lower-extremities deep venous thrombosis. At 1 week postoperatively, the ankle was radiographed from the anteroposterior and lateral aspects. In the ankle distraction arthroplasty group, the ankle joint cavity was gradually stretched by about 0.5 mm every day and adjusted every 12 hours until the ankle joint space was pulled out by 5 mm. The ankle was full loaded by 7 days postoperatively. At 3 months postoperatively, the external fixator was removed and ankle rehabilitation training was commenced.

Outcome Measures

All patients were assessed by independent investigator preoperatively and at 6 months and the last follow up postoperatively. Routine radiological examination comprised anteroposterior and lateral radiographs or CT of the ankle. A goniometer was used to measure the ankle angle (TAS, TT, and TLS) and compare them between preoperative and postoperative recorded values. Ankle range of motion was measured, including the ranges of varus, valgus, dorsiflexion, and plantarflexion.

The American Orthopedic Foot & Ankle Society (AOFAS) ankle-hindfoot score was used to objectively evaluate the pain, ankle function, gait, and force line of the affected ankle and was rated as excellent (90–100 points), good (75–89 points), fair (50–74 points), or poor (0–50 points). Visual analog scales (VAS) scores for used for evaluate pain. At the last visit, patients were asked to rate their overall satisfaction with their surgical results as excellent, good, fair, or poor (Table 1). To reduce errors and ensure the accuracy of data, all measurements were independently performed by three investigators, and the average of the three results for any measurement was used in the analysis.

Results

The average follow-up duration was 32 months, ranging from 24 months to 48 months. 6 months after operation, pain and swelling around the ankle were significantly improved in 95% of patients in both groups. Only a small percentage of patients experience minor complications. However, at last follow-up,

patients in the ankle distraction arthroplasty group had more complaints, which will be described in detail later. All patients underwent ankle x-rays and CT results after surgery. At the last postoperative follow-up, the imaging results showed that the osteotomy area of all patients was bony union.

Satisfaction evaluation

At 6 months after the operation and at the last follow-up, among ankle distraction arthroplasty group, the patient satisfaction ratings were as follows: The extent of satisfaction was rated as excellent by 15 (46.9%) and 10 (31.3%) patients, good by 10 (31.3%) and 11 (34.4%), fair by 5 (15.6%) and 9 (28.1), and poor by 2 (6.3%) and 2 (6.3%). Among supramalleolar osteotomy group, the satisfaction was rated as excellent by 20 (48.8%) and 24 (58.5%) patients, good by 15 (36.6%) and 16 (39.0%), fair by 4 (9.8%) and 0, poor by 2 (4.9%) and 1 (2.4%). At 6 months after the operation, the excellent and good rate was not significantly different between two groups (78.2% versus 85.4%, $p=0.422$). But, at the last follow-up, the satisfaction of ankle distraction arthroplasty group (65.6%) was significantly lower than that of supramalleolar osteotomy group (97.5%), which was statistically significant ($p\leq 0.05$).

Ankle function and imaging

At final follow-up, the ankle range of motion and ankle space of the two groups were significantly improved compared with those before operation, but there was no significant difference between the two groups ($P>0.05$) (Table 2). There were no significant differences regarding the final postoperative imaging parameters of TAS (92.1 ± 3.9 vs 86.2 ± 4.1 , $P=0.074$), TT (2.8 ± 2.0 vs 3.2 ± 1.3) and TLS (82.1 ± 6.5 vs 81.2 ± 2.5 , $P=0.524$) (Table 3); but supramalleolar osteotomy performed significantly better than ankle distraction arthroplasty in correcting talus varus deformity and restoring lower limb alignment, namely the absolute difference between postoperative and preoperative parameters (TAS, 11.9 ± 3.6 vs 1.5 ± 2.2 , $P<0.001$; TT, 3.7 ± 2.3 vs 1.3 ± 1.6 , $P=0.003$; TLS, 5.9 ± 3.3 vs 2.8 ± 1.9 , $P=0.001$).

Ankle function and pain score

The mean AOFAS and VAS pain scores were significantly improved postoperatively compared with preoperatively in both groups (both $P < 0.001$). The ankle distraction arthroplasty had a similar mean AOFAS score (85.8 ± 6.4) and VAS pain score (1.4 ± 1.3) as the supramalleolar osteotomy group (AOFAS score 88.2 ± 7.2 , VAS pain score 1.1 ± 1.4) at 6 months after the operation. At the last follow up, the AOFAS and VAS scores of the ankle distraction arthroplasty group were (79.7 ± 5.9) and (3.1 ± 1.4) respectively; the AOFAS and VAS scores of the supramalleolar osteotomy group were (92.1 ± 4.5) and (0.9 ± 1.2) respectively; the scores of patients in the supramalleolar osteotomy group were better than those in the ankle distraction arthroplasty group, which was statistically significant ($p\leq 0.05$).

Complication

In the 6 months postoperative, the surgical incision healed well in the two groups. The tibial osteotomy area did not have any complications such as bone nonunion, incision infection or poor healing, ankle instability, and there was no loosening or falling off of the internal fixation. No significant difference for complication prevalence rate was found between both groups (28.1% vs 17.1%, $P=0.257$).

At the last follow up, there were eleven complications in the ankle distraction arthroplasty group, including persistent chronic ankle pain in three patients who finally underwent ankle arthrodesis at 31 months after the index operation, readjustment of the external fixator due to an accident in one patient, ankle stiffness and swelling in seven patients. There were three complications in the supramalleolar osteotomy group, including one case of scar contracture, two patients presented with ankle pain and swelling. The number of complications in the supramalleolar osteotomy group was less than that in the ankle distraction arthroplasty group.

Discussion

Post-traumatic ankle arthritis is very common in clinical practice and is increasingly affecting young adult patients. But a suitable treatment modality for young adult patients is very challenging [6]. Various surgical treatment regimens have been used in clinical practice [9, 12][13][14][15][16]{Kim, 2021 #21;Lindsey, 2020 #25;Liu, 2020 #20;Ma, 2020 #26;Woo, 2020 #34;Zeininger, 2021 #18}, but the optimal option remains unclarified. The present study retrospectively analyzed 73 patients with severe post-traumatic ankle arthritis treated with either ankle distraction arthroplasty or supramalleolar osteotomy. The results suggest that both surgical methods can effectively treat traumatic ankle arthritis and relieve pain symptoms, especially in the early stage; However, in the long-term follow-up, the supramalleolar osteotomy was highly evaluated in ankle function score and patient satisfaction.

The pain in ankle arthritis is caused by fluid from the joint entering the subchondral bone due to pressure[17]. While ankle distraction arthroplasty could reduce the abnormal mechanical stress of the ankle through physical means, promote the intermittent flow of synovial fluid in the joint, proteoglycan metabolism, reduce inflammatory reaction, repair cartilage atrophy, and then enhance bone repair activity and increase the thickness of articular cartilage and therefore slow down the degeneration of ankle cartilage [18]. Ankle distraction arthroplasty can be a pre-treatment before ankle fusion or replacement surgery in young patients. This procedure has proved to be effective in relieving pain and restoring the ankle function [19][20][21][22][23]; Marijinissen et al [24] followed up 11 patients for at least 2 years after arthroplasty and reported significant improvements in pain and functional scores, suggesting that arthroplasty significantly relieve pain, preserve joint range of motion, and delay or reverse trauma. However, the relatively low effective rate, inconvenience and longer period of treatment may limit its more extensive use in practice [25]. Additionally, the gradually lowering postoperative satisfaction over time should be considered and for patients with obvious ankle valgus deformity, ankle joint distraction arthroplasty alone cannot correct the deformity.

In the early postoperative period, although ankle symptoms were significantly improved, and we did not find the significant difference in overall satisfaction rate and ankle function score. At the last follow-up, However, the tendency towards lower value in those treated by ankle distraction arthroplasty (excellent and good rate of 65.6% versus 97.5% for supramalleolar osteotomy). This may be caused by the higher rate of complications associated with ankle distraction arthroplasty, including sinus tract infection, fixation failure, difficulty in moving after surgery, and the need for frequent reviews and external fixation adjustments [19].

The superiority of supramalleolar osteotomy over distraction arthroplasty is the ability to correct the load line of the ankle and hindfoot and to correct the distal tibial deformity in the coronal and sagittal planes[26][27]. Supramalleolar osteotomy could transfer the stress to the cartilage area that is normal or not been seriously degraded by the means of adjusting the force line of the tibia. In this study, supramalleolar osteotomy proved to better correct talus varus deformity and restore the lower limb alignment, consistent with the previous findings [28][29], therefore, facilitating delaying the further development of ankle arthritis. Of note, patients with chronic ankle instability caused by severe injury or repeated multiple injuries may develop increased stress in the asymmetric joint spaces, forming painful asymmetric ankle arthritis and ankle point mismatch [30], thus additionally requiring osteotomy surgery to restore the lateral stability [31].

The second advantage of supramalleolar osteotomy is the relatively lower rate of postoperative complications, with postoperative ankle stiffness as the primary one. Others reported complications involved bone union issues at the osteotomy site, and surgical wound related issues, such as dehiscence and infection. In the present study, we reported an average overall complicate rate of 7.3% [32][33]. Despite the above-mentioned advantages, supramalleolar osteotomy was not overwhelmingly recommended, partly due to the need for a second operation to remove the internal fixation material.

In this study, osteophyte removal of the ankle joint and release of the achilles tendon or gastrocnemius muscle were performed. This surgical method can fully expose the ankle joint and completely remove the hyperplastic osteophyte and synovial tissue; although this surgical method is an adjuvant operation However, to a certain extent, it delays the development of the ankle joint, improves the range of motion of the ankle joint, restores the function of the ankle joint, and improves the success rate of the operation [34] [35]. This further ensures the effectiveness of surgical treatment. It is worth noting that damage to the superficial peroneal nerve should be avoided during the procedure.

This study suffered from several limitations. First, the retrospective design might impede the accuracy and precise in collecting the data and these data cannot be verified. The use of average values for some outcome measures conducted by 3 independent investigators might compensate for this limitation. Second, due to the limited use in our institution, we included only 73 eligible patients for data analysis, making the comparison not definitely conclusive. It is possible the true differences for some outcome variables are withheld to detect by such limited sample, namely the type I statistical error. Third, these operative procedures were completed by general orthopaedic surgeons (n=7) and foot and ankle

surgeons (n=4), in whom the experience can be different, thus affecting the results. Also, due to the very limited number of procedures for a certain surgeon, we could not make a direct comparison between them. Fourth, this is a single-center study, limiting the generalizability of our results to other settings. The well-designed large sample studies are warranted to verify our results and to provide a robust evidence for improving the management of this chronic bone condition.

Conclusions

This study demonstrated that both ankle distraction arthroplasty and supramalleolar osteotomy are effective treatment methods for the severe post traumatic ankle arthritis in the young adult patients. Especially in the early follow-up, it can significantly alleviate the persistent pain of the ankle and preserve the mobility of the ankle, It is an effective method to avoid arthrodesis and replacement. However, through long-term follow-up, it is found that the curative effect of supramalleolar osteotomy is better than distraction arthroplasty.

Declarations

Ethics approval and consent to participate

All authors confirm that this work was approved by our Institutional Review Board with ethical principles of research.

This work was performed at the Third Hospital of Hebei Medical University, Hebei, China.

Consent for publication

This work was performed at the Third Hospital of Hebei Medical University, Hebei, China.

Availability of data and materials

The patients' data were collected in the Third Hospital of Hebei Medical University. The data sets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Author contributions

Xinzhong Shao designed the study; Liang Cui and Shiwu Tao and Jianyong Zhao searched relevant literature and analyzed; Li Wang and Fengqi Zhang interpreted the data; Zongyu Yang wrote the manuscript, and Xinzhong Shao approved the final version of the manuscript.

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References

1. Bendall S, Halliwell P, Goldberg A, et al. Ankle Arthritis Networking: Getting the right treatment to the right patient first time. *Foot Ankle Surg.* 2021 Mar 18:S1268-7731(21)00043-6.
2. Lee S, Song K, Lee SY. Epidemiological study of post-traumatic ankle osteoarthritis after ankle sprain in 195,393 individuals over middle age using the National Health Insurance Database: A retrospective design. *J Sci Med Sport.* 2022 Feb;25(2):129-133.
3. Deleu PA, Leemrijse T, Chèze L, et al. Post-sprain versus post-fracture post-traumatic ankle osteoarthritis: Impact on foot and ankle kinematics and kinetics. *Gait Posture.* 2021 May;86:278-286.
4. Sidhu SP, Atwan Y, Cavanagh J, et al. High Energy Transsyndesmotic Ankle Fracture Dislocation - Injury Characteristics, Radiographic Outcomes, and Factors Affecting the Rate of Post-traumatic Arthritis in Logsplinter Injuries. *J Orthop Trauma.* 2021 Jul 20.
5. Yaning S, Huijuan W, Yuchao T, et al. Reconstruction of the lateral ankle ligaments using the anterior half of peroneus longus tendon graft. *Foot Ankle Surg.* 2019 Apr;25(2):242-246.
6. S Giannini, R Buda, C Faldini, et al. The treatment of severe posttraumatic arthritis of the ankle joint. *J Bone Joint Surg Am.* 2007 Oct;89 Suppl 3:15-28.
7. Hubbard T, Hertel J. Mechanical contributions to chronic lateral ankle instability. *Sports medicine (Auckland, N.Z.).* 2006; 36: 263-77.

8. Mark Glazebrook, Tim Daniels, Alastair Younger, et al. Comparison of health-related quality of life between patients with end-stage ankle and hip arthrosis. *J Bone Joint Surg Am*. 2008 Mar;90(3):499-505.
9. Ma N, Li Z, Li D, Hu Y, Sun N. Clinical evaluation of arthrodesis with Ilizarov external fixator for the treatment of end-stage ankle osteoarthritis: A retrospective study. *Medicine*. 2020; 99: e23921.
10. Coetzee JC, Raduan F, McGaver RS. Converting Ankle Arthrodesis to a Total Ankle Arthroplasty. *Orthop Clin North Am*. 2021 Apr;52(2):181-190.
11. Clough TM, Ring J. Total ankle arthroplasty. *Bone Joint J*. 2021 Apr;103-B(4):696-703.
12. Kim J, Suh D, Choi G, et al. Change in the weight-bearing line ratio of the ankle joint and ankle joint line orientation after knee arthroplasty and high tibial osteotomy in patients with genu varum deformity. *Int Orthop*. 2021 Jan;45(1):117-124.
13. Benjamin BL, Rajbir Hundal, Neil KB, et al. Ankle Arthrodesis Through an Anterior Approach. *J Orthop Trauma*. 2020 Aug;34 Suppl 2:S42-S43.
14. Liu X, Chang F, Zhang H, et al. Ankle distraction arthroplasty for the treatment of severe ankle arthritis: Case report, technical note, and literature review. *Medicine*. 2020; 99: e22330.
15. Bo JW, Mun CL, Sean Ng, et al. Clinical outcomes comparing arthroscopic vs open ankle arthrodesis. *Foot Ankle Surg*. 2020 Jul;26(5):530-534.
16. Angel Zeininger, Daniel Schmitt, Cherice Hughes-Oliver, et al. The effect of ankle osteoarthritis and total ankle arthroplasty on center of pressure position. *J Orthop Res*. 2021 Jun;39(6):1245-1252.
17. Dror Paley, Bradley ML, Rachana MP, et al. Distraction arthroplasty of the ankle—how far can you stretch the indications? *Foot Ankle Clin*. 2008 Sep;13(3):471-84.
18. Fragomen AT. Ankle distraction arthroplasty (ADA): A brief review and technical pearls. *J Clin Orthop Trauma*. 2021 Nov 18;24:101708.
19. Mitchell Bernstein, Jay Reidler, Austin Fragomen, S Robert Rozbruch, et al. Ankle Distraction Arthroplasty: Indications, Technique, and Outcomes. *J Am Acad Orthop Surg*. 2017 Feb;25(2):89-99.
20. Gianakos A, Haring R, Shimoazono Y, et al. Effect of Microfracture on Functional Outcomes and Subchondral Sclerosis Following Distraction Arthroplasty of the Ankle Joint. *Foot Ankle Int*. 2020 Jun;41(6):631-638.
21. Ploegmakers J, van Roermund P, van Melkebeek J, et al. Prolonged clinical benefit from joint distraction in the treatment of ankle osteoarthritis. *Osteoarthritis Cartilage*. 2005 Jul;13(7):582-8.
22. Smith N, Beaman D, Rozbruch S, et al. Evidence-based indications for distraction ankle arthroplasty. *Foot Ankle Int*. 2012; 33: 632-6.
23. van Valburg A, van Roermund P, Marijnissen A, van Melkebeek J, Lammens J, Verbout A, et al. Joint distraction in treatment of osteoarthritis: a two-year follow-up of the ankle. *Osteoarthritis and cartilage*. 1999; 7: 474-9.
24. Marijnissen A, Hoekstra M, Pré B, et al. Patient characteristics as predictors of clinical outcome of distraction in treatment of severe ankle osteoarthritis. *J Orthop Res*. 2014 Jan;32(1):96-101.

25. Nguyen M, Pedersen D, Gao Y, et al. Intermediate-term follow-up after ankle distraction for treatment of end-stage osteoarthritis. *J Bone Joint Surg Am.* 2015 Apr 1;97(7):590-6.
26. Lacorda J, Jung H, Im J. Supramalleolar Distal Tibiofibular Osteotomy for Medial Ankle Osteoarthritis: Current Concepts. *Clin Orthop Surg.* 2020 Sep;12(3):271-278.
27. Choi J, Kim K, Suh J. Low Tibial Valgization Osteotomy for More Severe Varus Ankle Arthritis. *Foot Ankle Int.* 2020; 41: 1122-1132.
28. Deleu P, Naaim A, Chèze L, et al. The effect of ankle and hindfoot malalignment on foot mechanics in patients suffering from post-traumatic ankle osteoarthritis. *Clin Biomech (Bristol, Avon).* 2021 Jan;81:105239.
29. Wu Y. Treatment options of ankle osteoarthritis by stage. *Zhonghua yi xue za zhi.* 2019; 99: 1608-1610.
30. Zhao H, Qu W, Li Y, Liang X, et al. Functional analysis of distraction arthroplasty in the treatment of ankle osteoarthritis. *J Orthop Surg Res.* 2017 Jan 26;12(1):18.
31. Lee H, Wapner K, Park S, et al. Ligament reconstruction and calcaneal osteotomy for osteoarthritis of the ankle. *Foot Ankle Int.* 2009; 30: 475-80.
32. Stamatis E, Cooper P, Myerson M. Supramalleolar osteotomy for the treatment of distal tibial angular deformities and arthritis of the ankle joint. *Foot Ankle Int.* 2003; 24: 754-64.
33. Zhao HLJ, Zhang Y. Clinical application of different types supramalleolar osteotomy for varus ankle osteoarthritis. *Chin J Anat Clin.* 2009; 24: 112-117.
34. Lampert C. The role of arthroscopy in diagnostics and treatment of arthritis of the ankle joint. *Unfallchirurg.* 2022 Jan 18.
35. Shimozone Y, Dankert JF, Kennedy JG. Arthroscopic Debridement and Autologous Micronized Adipose Tissue Injection in the Treatment of Advanced-Stage Posttraumatic Osteoarthritis of the Ankle. *Cartilage.* 2021 Dec;13(1_suppl):1337S-1343S.

Tables

Table 1

Clinical Rating Scale for Postoperative Ankle function.

Rating	Description
Excellent	Full range of motion equal to the contralateral ankle without pain. Un-restricted work or sports activity.
Good	Functional range of motion and stable ankle. Able to return to the previous level with minimal pain with work or sport activity
Fair	Functional range of motion, good stability, moderate level of pain, and/or stiffness with activities of daily living and sports activity.
Poor	Persistent instability or pain, the same or worse than before surgery.

Table 3

Comparison of ROM and JSW between the two groups at the last follow-up.

	Ankle Distraction Arthroplasty		Supramalleolar Osteotomy		t*	P*
	Preoperative	Postoperative	Preoperative	Postoperative		
Plantarflexion (°)	23.3±3.7	31.8±4.2	25.1±4.8	30.4±3.6	4.318	0.224
Dorsiflexion (°)	17.5±5.8	30.4±6.4	23.8±6.1	28.3±5.5	4.976	0.104
Varus (°)	23.6±6.0	32.1±4.5	22.7±4.2	29.1±3.1	3.393	0.290
Valgus (°)	19.8±4.1	28.4±3.7	20.0±3.4	27.2±2.8	3.686	0.378
JSW (mm)	1.37±0.34	2.31±0.46	1.41±0.32	2.40±0.39	4.784	0.425

*The T value and P value in this table represent the postoperative between-group comparison for the ROM and JSW parameters.

Table 3

Comparison of imaging angles between the two groups of patients.

	Ankle Distraction Arthroplasty		Supramalleolar Osteotomy		*t	*p
	Preoperative	Postoperative	Preoperative	Postoperative		
TAS (°)	84.7±5.7	86.2±4.1	80.2±4.6	92.1±3.9	1.063	0.074
TT (°)	4.5±2.1	3.2±1.3	6.3±3.4	2.8±2.0	0.544	0.161
TLS (°)	78.4±3.9	81.2±2.5	76.2±5.8	82.1±6.5	0.138	0.524

*The T value and P value in this table represent the postoperative between-group comparison for the radiographic parameters.

Figures



Figure 1

Ankle distraction arthroplasty group: Preoperative ankle joints in anteroposterior and lateral positions; The space of ankle joint was narrow, osteophytes were found in the anterior tibia and dorsal talus articular surface, the medial and lateral malleolus became sharp, the articular surface of talar dome was inclined to the medial side of the distal tibia, and the ankle was slightly varus.

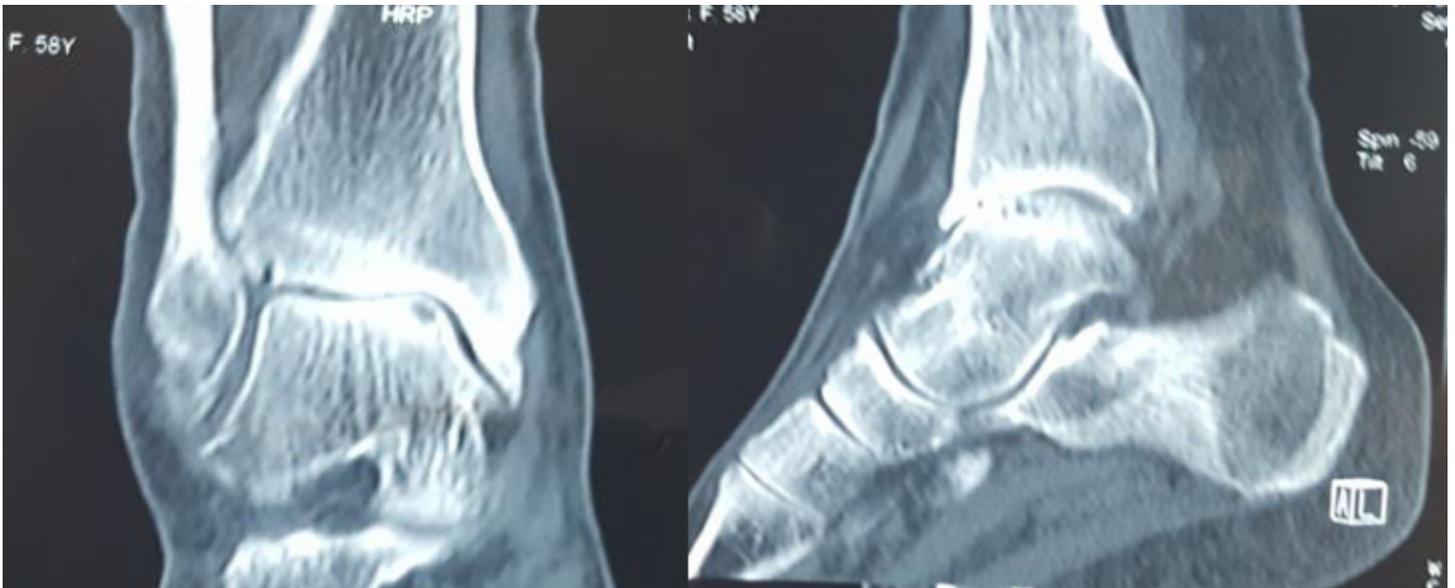


Figure 2

Ankle distraction arthroplasty group: CT coronal and sagittal images of ankle joint showed that the space of ankle joint was narrow, the osteophyte of anterior tibia was proliferated obviously, the space of medial ankle joint was occluded, the contact of subchondral bone was limited to the medial side, the bone of medial talus was sclerotic and cystic changes appeared, and the medial malleolus became sharp obviously.



Figure 3

Ankle distraction arthroplasty group: The osteophyte in front of the ankle joint was seen during the operation and completely removed.

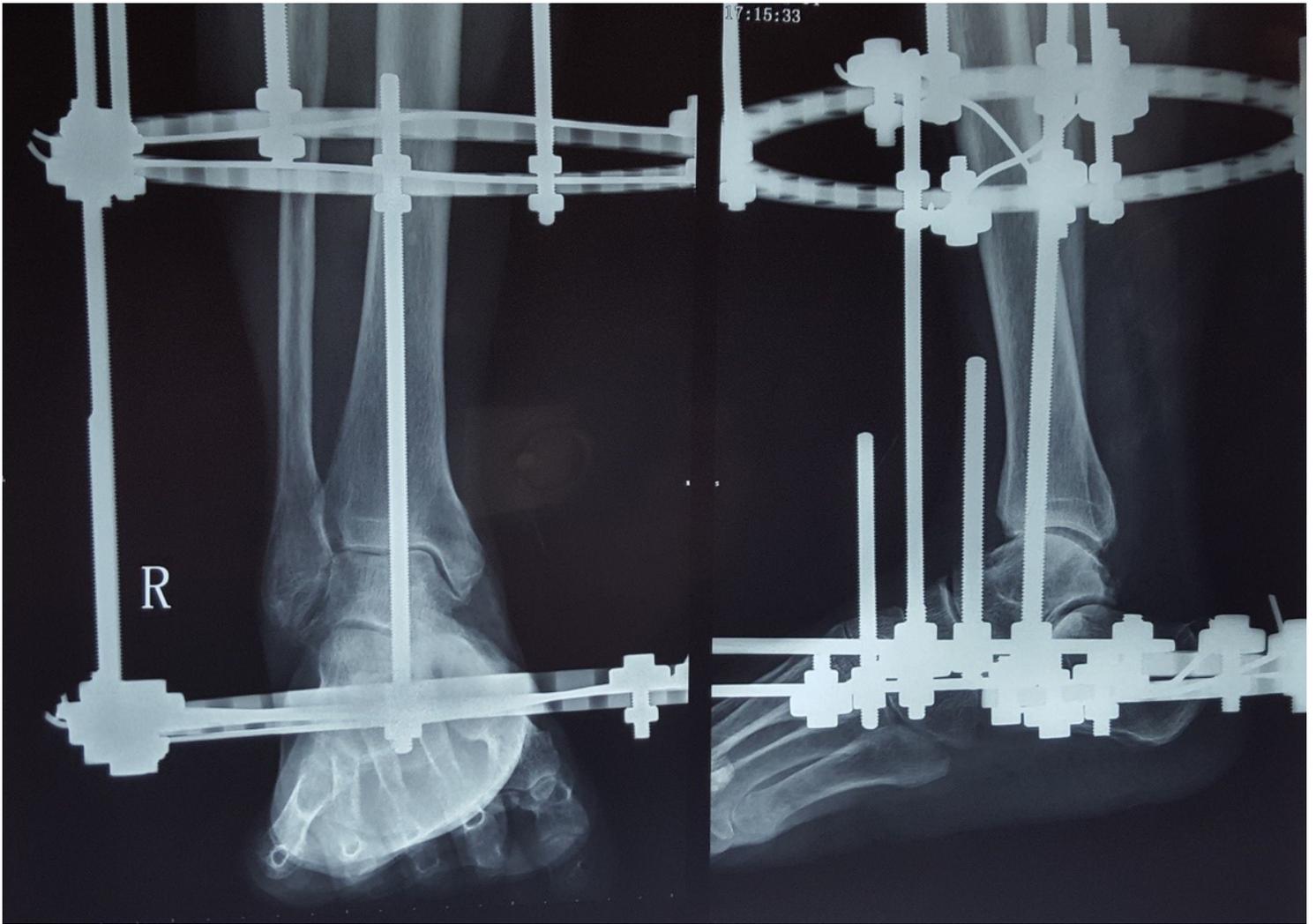


Figure 4

Ankle distraction arthroplasty group: Seven days after operation, the ankle joint X-ray showed that the ankle joint space was slightly widened, and the osteophytes on the front of the tibia had been removed.

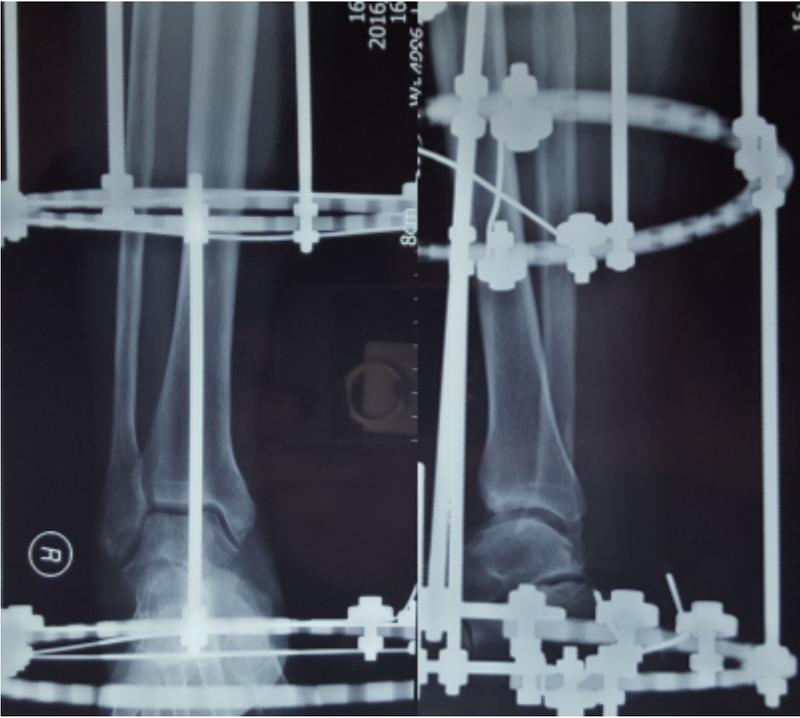


Figure 5

Ankle distraction arthroplasty group: The anteroposterior and lateral X-ray of ankle joint 1.5 months after operation showed that the ankle joint space was almost normal, and the anterior lip of ankle joint did not proliferate.



Figure 6

Supramalleolar osteotomy group: A is the preoperative lateral, anterior and calcaneal axis X-rays, showing ankle varus deformity and ankle arthritis; B. intraoperative localization of supramalleolar osteotomy and internal fixation; C 2 months after operation, the force line of ankle joint was good and the ankle joint space was clear.