

Clinical Outcomes of Ankle Distraction Arthroplasty Versus Supramalleolar Osteotomy

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Research Article

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Abstract

Background

Post-traumatic ankle arthritis is increasing in young people and it is very important to preserve the ankle range of motion in young patients. This study aimed to compare ankle distraction arthroplasty versus supramalleolar osteotomy for post-traumatic ankle arthritis.

Methods

This retrospective study reviewed 32 consecutive patients who underwent surgery for post-traumatic ankle arthritis from January 2015 to December 2018 after failure of conservative treatment. Thirteen ankles that underwent ankle distraction arthroplasty were age-, sex-, and body mass index-matched with 19 ankles that underwent supramalleolar osteotomy. Patients returned for clinical and radiologic follow-up at an average of 32 (range, 24–48) months postoperatively. Outcomes were the comparison of the pre- and postoperative Visual Analog Scale (VAS) pain scores and American Orthopedic Foot & Ankle Society (AOFAS) ankle-hindfoot scores, complications, subjective patient-rated satisfaction, and ankle function.

Results

The VAS and AOFAS scores of the two groups were significantly improved at final follow-up compared with preoperatively ($p < 0.05$), but did not significantly differ between groups. The ankle distraction arthroplasty group had better postoperative ankle mobility than the supramalleolar osteotomy group. There was no significant difference between the two groups in the tibial anterior surface angle, talar tilt angle, tibial lateral surface angle, and other imaging parameters, but supramalleolar osteotomy was more effective in correcting the load-bearing line of the ankle and hindfoot. The complication rate was similar in both groups.

Conclusions

Ankle distraction arthroplasty and supramalleolar osteotomy both achieved good pain relief and improved function in patients with traumatic ankle arthritis.

Level of evidence: Level III, retrospective comparative series.

Introduction

Ankle osteoarthritis is an important cause of ankle pain and functional limitation. Although the ankle is the main weight-bearing joint of the human body, the incidence of ankle arthritis is lower than that of knee arthritis and hip arthritis [1]. Furthermore, primary ankle arthritis is rare, and mainly includes rheumatoid arthritis, neuropathic arthropathy, or infectious disease [2]. The maximum cartilage thickness is about 2.7 mm in the ankle and 3–6 mm in the weight-bearing areas of the hip and knee [3]; thus, the ankle transmits greater stress on very thin articular cartilage in a smaller weight-bearing area than the knee and hip, which leads to much greater local stress on the ankle than the knee and hip. Any abnormal alignment of the ankle leads to local stress concentration, and accelerates the degeneration of ankle cartilage and the formation of ankle arthritis [4]. However, the most common cause of ankle arthritis is trauma. An increasing number of people are participating in sports, which leads to an increasing incidence of ankle sprain. However, many people do not consider ankle sprain important and thus do not get this injury treated in a timely manner. About 20–40% of patients with acute ankle sprain develop chronic sprain; this leads to injury or even rupture of the lateral ligaments of the ankle, causing chronic lateral ankle instability [5], which eventually leads

to secondary changes in bone structure, namely traumatic ankle arthritis. In recent years, traumatic ankle arthritis has become more common in young people [6][7][8][9].

For patients with post-traumatic ankle arthritis for which conservative treatment is ineffective, ankle arthrodesis or replacement are not the only the treatment options, as other methods can be tailored to each patient's situation [10]. The main signs of end-stage ankle arthritis are persistent swelling around the ankle with pain, loss of normal bone structure of the tibiotalar joint surface, basic loss of function, and limitations of daily activities, which seriously affect daily life and work [11][12]. The gold standard treatment for end-stage traumatic ankle arthritis is ankle arthrodesis; this method effectively relieves ankle pain, improves ankle function, restores the force line, corrects deformity, and improves patient quality of life [12][13][14]. In addition, ankle arthroplasty has developed rapidly in recent years, and the clinical effect has been affirmed. However, the indications of ankle arthroplasty are narrow. Ankle arthroplasty is mainly used in older adults with relatively low activity levels who have a low body weight, normal talus joint, and relatively large amount of soft tissue around the ankle. Therefore, ankle replacement is not widely used in clinical practice [15][16].

For patients with non-end-stage traumatic ankle arthritis, the staging systems most widely used to guide clinical treatment are the modified Takakura classification [17][18] or Takakura-Tanaka classification [19], which divide the injury severity into four stages based on radiographic manifestations. Stage 1 has no joint space stenosis, but early sclerosis and osteophyte formation; stage 2 has a narrowed medial space of the ankle; stage 3a has a narrowed and inclined joint space, and subchondral bone contact on the medial side; stage 3b has a narrowed or tilted joint space, and subchondral bone contact in the whole talar fornix; stage 4 has a tilted joint space and bony contact in the talar fornix. Stage 1 is early-stage, stages 2 and 3 are middle-stage, and stage 4 is end-stage ankle arthritis. For patients with stage 1 ankle arthritis, the osteophyte and synovium can be removed by arthroscopic surgery or open joint debridement, and the intra-articular free body can be removed to relieve the impact on the anterior aspect of the ankle. The typical imaging manifestations of anterior malleolus impingement syndrome are anterior tibial osteophytes and limited ankle dorsiflexion [20].

Although there is currently no established optimal treatment for middle-stage ankle arthritis, the commonly used surgical methods are ankle distraction arthroplasty and supramalleolar osteotomy. However, there is no available information about functional recovery, postoperative complications, and indications of the two surgical methods. The purpose of this study was to describe the indications, postoperative ankle function, complications, imaging results, and surgical outcomes of ankle distraction arthroplasty and supramalleolar osteotomy.

Materials And Methods

This retrospective study reviewed 32 consecutive patients who underwent surgical treatment for Takakura-Tanaka stage 3 post-traumatic ankle arthritis after failure of conservative treatment from January 2015 to December 2018.

Ankle distraction arthroplasty was used in 13 patients (seven men, six women; average age 54.7 ± 12.8 years; five left ankles, eight right ankles; eight patients with a clear history of ankle trauma, five with unknown etiology). Nineteen patients were treated with supramalleolar osteotomy (nine men, 10 women; average age 59.4 ± 7 years; eight left ankles, 11 right ankles; 13 patients with a definite history of ankle trauma). The institutional review board approved the study, and all patients provided informed consent for study inclusion.

Inclusion criteria

Age > 18 years; ankle pain and swelling for > 3 months and failure of conservative treatment; Takakura-Tanaka stage 3 ankle arthritis; no other surgical treatment around the ankle; complete pre- and postoperative data and imaging examinations; good physical function and ability to tolerate surgery; provision of written consent and postoperative follow-up for at least 12 months.

Exclusion criteria

End-stage ankle arthritis; 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 pre- and postoperative case data and imaging examinations; follow-up duration < 1 year; serious medical or neuromuscular disease; mental illness that prevented cooperation with follow-up evaluation.

Contraindications

Congenital collagen deficiency; bodyweight > 120 kg; severe heart disease; lesions affecting liver and kidney function; severe diabetes; central nervous system diseases; other medical diseases.

Preoperative examination

Preoperative evaluation of all patients included a detailed history, physical examination, and imaging examination, including the ankle anteroposterior position, measurement of the tibial anterior surface angle (TAS), talar tilt angle (TT), tibial lateral surface angle (TLS), calcaneal axial X-ray to assess the force line of the lower limb, and assessment of the presence of varus or valgus of the calcaneus and talus. CT was performed to evaluate the condition of the subtalar and tibiotalar joints; MRI was performed to evaluate the cartilage condition of the ankle, presence or absence of talar necrosis, condition of the surrounding soft tissue, presence or absence of edema of the surrounding ligaments, and completeness of the lateral ligaments.

Operation procedures

The supramalleolar osteotomy group received prophylactic intravenous antibiotics 30 minutes preoperatively. After anesthetic induction, the patient was placed in supine position. A tourniquet was placed at the proximal extremity, which was routinely disinfected and draped with a sterile surgical towel. 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, there was lip-like hyperplasia of the tibial joint surface, hyperplasia of the lateral talar surface, and limited passive movement of the ankle. The proliferative bone was removed, and the ankle was moved passively until the range of motion was close to normal. 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. The incision was closed.

The ankle distraction arthroplasty group underwent 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 one was fixed in the metatarsal base of the anterior foot. Each ring was reinforced with a threaded needle.

Postoperative management

The incision was routinely dressed and antibiotics were administered. To promote functional recovery of the ankle and prevent postoperative stiffness, both groups began early postoperative rehabilitation exercises. The Kirschner wire hole was wiped with iodophor every day to prevent sinus tract infection. From postoperative day 1, patients were instructed to exercise the toes and quadriceps femoris to prevent deep venous thrombosis. At 1 week postoperatively, the ankle was photographed from the anteroposterior and lateral aspects. In the ankle distraction arthroplasty group, the external fixator was adjusted as needed; 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 external fixator was adjusted at any time based on the patient's condition). The ankle was half loaded by 1 month postoperatively, and completely loaded by 2 months postoperatively. At 3 months postoperatively, the external fixator was removed and ankle rehabilitation training was commenced. The supramalleolar osteotomy group performed the same functional exercises to prevent postoperative ankle stiffness and enhance the joint range of motion.

Efficacy evaluation

All patients were assessed by independent allied health staff preoperatively and at 6 and 24 months postoperatively. Patient demographic data, including age, sex, and BMI, were collected preoperatively. Patients were asked to rate their overall satisfaction with their surgical results as 'excellent', 'good', 'fair', or 'poor'.(Table 1)

Table 1
Clinical Rating Scale for Postoperative Ankle.

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.

All patients were followed up for at least 12 months, and routine radiological examination comprised anteroposterior and lateral radiographs of the ankle, and full-length lower extremity weight-bearing radiographs. A goniometer was used to obtain the ankle angle measurements (TAS, TT, and TLS) and compare them with preoperatively.

The range of motion of the affected foot and the healthy foot 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 severity, function, gait, and force line of the affected ankle as excellent (90–100 points), good (75–89 points), fair (50–74 points), or poor (0–50 points). Visual analog scales (VAS) pain scores were also recorded.

To reduce errors and ensure the accuracy of data, all measurements were conducted by three doctors at the same time, and the average of the three results was used in the analysis.

Results

Thirty-two patients (100%) returned for their final evaluation. The longest follow-up duration was 48 months (mean 32 months). Most patients were satisfied with the surgical outcome. A satisfactory curative effect was defined as substantial improvement in ankle pain and swelling compared with preoperatively, enabling the patient to carry out normal life activities, and an improved ankle range of motion. Ankle distraction arthroplasty was rated as excellent by six (46.2%) patients, good by four (30.8%), fair by two (15.4%), and poor by one (7.7%). Supramalleolar osteotomy was rated as excellent by 10 (52.6%) patients, good by eight (42.1%), and poor by one (5.3%). The subjective satisfaction of the supramalleolar osteotomy group was significantly better than that of the ankle distraction arthroplasty group ($P < 0.05$).

There were no significant differences between the two groups regarding age, sex, Takakura-Tanaka stage (all patients had stage 3 ankle arthritis), and follow-up duration (all $P > 0.05$). (Table 2)

Table 2
Comparison of the data of patients with ankle distraction arthroplasty and pupramalleolar osteotomy.

	Ankle Distraction Arthroplasty		Pupramalleolar Osteotomy		<i>p</i>
	n	%	n	%	
Age	54.7 ± 12.8		59.4 ± 10.7		0.801
Gender					0.719
Male	7	53.8	9	47.4	
female	6	46.2	10	52.6	
Side					0.837
Left	5	38.5	8	42.1	
Right	8	61.5	11	57.9	
Body mass index kg/m ²	28.15 ± 5.4		29.7 ± 6.3		0.940
Takakura-Tanaka Stage					
3-stage	13	100	19	100	
Time interval between onset and operation (years)	3.2 ± 4.3		4.1 ± 3.5		0.244
Operation time (minute)	78 ± 32		94 ± 28		< 0.001
Follow up time	30.8 ± 5.5		31.5 ± 7.4		0.601

At final follow-up, the ankle distraction arthroplasty group had significantly better ranges of varus, valgus, dorsiflexion, and plantarflexion motion than the supramalleolar osteotomy group (all $P < 0.05$)(Table 3). There were

no significant differences between the two groups regarding postoperative imaging parameters such as the TAS, TT, and TLS (all $P > 0.05$), but supramalleolar osteotomy was better than ankle distraction arthroplasty in correcting talus varus deformity and restoring lower limb alignment (Table 4). The ankle distraction arthroplasty had a similar mean AOFAS score (85.75 ± 6.4 points) and VAS pain score (1.42 ± 1.30 points) to the supramalleolar osteotomy group (AOFAS score 88.20 ± 7.2 points, VAS pain score 1.07 ± 1.21 points). The mean AOFAS and VAS pain scores were significantly improved postoperatively compared with preoperatively in both groups ($P < 0.05$). (Table 5)

Table 3
Comparison of ankle range of motion 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	37.8 ± 4.2	25.1 ± 4.8	30.4 ± 3.6	-3.001	0.039
Dorsiflexion (°)	17.5 ± 5.8	36.5 ± 6.4	23.8 ± 6.1	28.3 ± 5.5	-2.976	0.041
Varus (°)	23.6 ± 6.0	32.1 ± 4.5	22.7 ± 4.2	27.1 ± 3.1	-4.318	0.037
Valgus (°)	19.8 ± 4.1	28.4 ± 3.7	20.0 ± 3.4	25.2 ± 2.8	-3.486	0.047
The T value and P value in this table only represent the postoperative situation of the two groups of patients.						

Table 4
Comparison of imaging angles between the two groups of patients preoperative and postoperative.

	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	0.044
TT (°)	4.5 ± 2.1	3.2 ± 1.3	6.3 ± 3.4	2.8 ± 2.0	0.544	0.061
TLS (°)	78.4 ± 3.9	81.2 ± 2.5	76.2 ± 5.8	82.1 ± 6.5	0.638	0.524
The T value and P value in this table only represent the postoperative situation of the two groups of patients.						

Table 5
Comparison of clinical score between the two groups of patients preoperative and postoperative.

	Ankle Distraction Arthroplasty				Supramalleolar Osteotomy			
	Preoperative	Postoperative	t	p	Preoperative	Postoperative	t	p
Pain	21.7 ± 6.2	33.40 ± 3.1	-2.318	0.021	22.44 ± 5.8	34.71 ± 3.7	-2.920	0.015
Function	19.7 ± 7.8	42.08 ± 4.7	-2.890	0.004	19.17 ± 6.9	42.97 ± 6.1	-6.425	0.015
Force Line	5.7 ± 2.8	9.12 ± 0.8	-0.053	0.010	3.75 ± 3.4	8.94 ± 1.1	-2.041	0.002
Total (AOFAS)	50.71 ± 8.9	85.75 ± 6.4	-5.112	0.000	48.28 ± 5.7	88.20 ± 7.2	-10.389	0.000
VAS	5.6 ± 1.4	1.42 ± 1.30	-3.221	0.001	5.83 ± 1.2	1.14 ± 1.47	-1.261	0.021

There were five patients with six complications in the ankle distraction arthroplasty group, including sinus infection of the Kirschner wire and exudation of secretions in one patient, persistent chronic ankle pain in one patient, readjustment of the external fixator due to an accident in one patient, and ankle stiffness in two patients. The ankle range of motion improved substantially after rehabilitation training. One patient underwent ankle arthrodesis at 31 months after the initial operation due to pain and dysfunction.

There were three complications in three patients in the supramalleolar osteotomy group, including one case of scar contracture, one case of delayed healing of the surgical incision, and one case of delayed healing at the osteotomy site. The patient with delayed osteotomy healing received extracorporeal shock wave treatment and developed a continuous callus at 6.8 months postoperatively.

Discussion

Post-traumatic ankle arthritis is very common in clinical practice and is increasingly affecting younger patients [6]. The treatment methods for post-traumatic ankle arthritis include conservative treatment [4], arthroscopic surgery [14], osteotomy around the ankle [21], ankle distraction arthroplasty [22], ankle arthrodesis [14][23], total ankle arthroplasty [24], and combined internal and external fixation surgery [12]. However, the optimal treatment remains unclarified. The present study retrospectively analyzed 32 patients with Takakura-Tanaka stage 3 traumatic ankle arthritis treated with either ankle distraction arthroplasty or supramalleolar osteotomy at the Foot and Ankle Surgery Department in our hospital from January 2015 to December 2018. The present results suggest that ankle distraction arthroplasty better restored the ankle joint space and ankle mobility, while supramalleolar osteotomy better corrected ankle varus deformity, restored the lower limb alignment, and obtained a high degree of patient satisfaction. However, there was no significant difference between the two surgical methods in terms of overall ankle function recovery and postoperative complications.

Both surgical methods assessed in the present study are ankle-sparing surgeries. Ankle distraction arthroplasty was first proposed by Van Valburg et al. [25]. The basic principle is to reduce the abnormal mechanical stress of the ankle through physical means, promote the intermittent flow of synovial fluid in the joint, and reduce the ankle joint. The loaded articular cartilage has a certain self-healing ability that enables this method to treat ankle arthritis [22][26][27]. Ankle distraction arthroplasty is mainly suitable for ankles with good alignment and peripheral pain, but requires ankle joint movement; this method can also be used as a pre-treatment before ankle fusion or replacement surgery in young patients with an ankle range of motion of greater than 20°. The relative contraindications to ankle distraction arthroplasty are active infection around the ankle, coronal deformity of more than 10°, joint stiffness (range of motion < 20°), and insufficient bone mass around the ankle [20][28]. Ankle distraction arthroplasty significantly relieves pain around the ankle and restores ankle function [27][29][30][31]; during a 5-year follow-up period, the ankle joint activity increases, the tibiotalar space widens, and the degree of cartilage hardening is reduced. Marijinissen et al. [32] followed up 11 patients for at least 2 years after arthroplasty and reported significant improvements in pain and functional scores, suggesting that arthroplasty significantly relieves pain, preserves joint range of motion, and delays or reverses trauma. However, Mai et al. [33] reported that ankle distraction arthroplasty has limitations regarding the effective rate, convenience, and length of treatment. They found that postoperative satisfaction with ankle distraction arthroplasty decreases significantly over time; in particular, for patients with ankle arthritis with ankle valgus deformity, ankle joint distraction arthroplasty alone cannot correct the deformity, the treatment cycle is long, and the outcome is poor.

In addition to the common surgical risks, the complications of ankle distraction arthroplasty include sinus tract infection, fixation failure, difficulty in moving after surgery, and the need for frequent reviews and external fixation adjustments [27]. Therefore, the subjective patient-rated satisfaction of ankle distraction arthroplasty is lower than that of supramalleolar osteotomy. In the present study, the main advantages of ankle distraction arthroplasty were pain relief, restoration of range of motion, a small incision, and minimal intraoperative soft tissue damage; however, ankle distraction arthroplasty achieved inferior joint deformity correction compared with supramalleolar osteotomy.

Supramalleolar osteotomy is important in correcting the load line of the ankle and hindfoot and correcting the distal tibial deformity in the coronal and sagittal planes [34][35]. Varus or valgus deformity of the ankle leads to poor alignment between the ankle and hindfoot, which changes the local static and dynamic overload condition of the articular surface and accelerates the degeneration of articular cartilage [36][37]. Supramalleolar osteotomy transfers the stress to the cartilage area that is normal or has not been seriously degraded by adjusting the force line of the tibia; this restores the normal TAS and TLS, relieves ankle pain, and delays the development of ankle arthritis [20][38]. Some patients also need auxiliary fibular or calcaneal osteotomy [39][40][41][42]. 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 [43]. Such patients require restoration of the lateral stability of the ankle through surgery to treat traumatic ankle arthritis [44]. The ankle joint force line is effectively corrected after peri-ankle osteotomy, and the symptoms of ankle instability disappear when the stress becomes balanced [17]. For young patients with higher requirements for exercise, lateral ligament reconstruction may obtain greater postoperative satisfaction; this requires force line recovery of the bone structure, while ligament reconstruction can be used as a good supplementary measure [43]. The surgical indications for supra-ankle osteotomy include: 1) ankle varus deformity with medial ankle arthritis, 2) force line correction before ankle fusion, after surgery, and before ankle replacement [45]. Numerous studies have reported that supramalleolar osteotomy significantly improves the TAS, TLA, and VAS and AOFAS scores [18][46].

The complications of supramalleolar osteotomy are rare. However, the most common complication is postoperative ankle stiffness. Other reported complications include delayed healing at the osteotomy site, nonunion, wound dehiscence, and infection. In the present study, three of 19 patients had adverse reactions after supramalleolar osteotomy. Scar contracture and delayed wound healing were related to patient factors. One patient in the present study had delayed healing after osteotomy, giving an incidence of 5.3%, which is the same as the internationally reported incidence of this complication[46][47]; no auxiliary soft tissue surgery was performed on the patient in the present study. Supramalleolar osteotomy effectively corrects the rear foot force line, relieves ankle pain, and improves ankle function [35], but requires a second operation to remove the internal fixation material, which increases the surgical risk. There are many methods for osteotomy around the ankle, and personalized surgical treatment should be based on the specific condition of each patient [47][48][49][50].

Both ankle distraction arthroplasty and supramalleolar osteotomy achieved satisfactory postoperative results. However, the present study is limited by its retrospective design and small sample size. Our results require verification in a prospective large-sample comparative study.

Conclusions

This retrospective analysis of 32 patients with traumatic ankle arthritis clarified the indications, contraindications, postoperative results, and complications of ankle distraction arthroplasty and supramalleolar osteotomy. The final outcome did not significantly differ between the two groups. However, it is necessary for surgeons to understand the

surgical indications, comprehensively consider the type of ankle arthritis, and choose the best surgical treatment for each patient.

Abbreviations

Visual Analog Scale pain scores VAS

American Orthopedic Foot & Ankle Society AOFAS

Tibial Anterior Surface angle TAS

Talar Tilt angle TT

Tibial Lateral Surface angle TLS

Declarations

Ethics approval and consent to participate

This study was conducted with approval from the Ethics Committee of the Third Hospital of Hebei Medical University. Written informed consent to participate was obtained from all participants.

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 datasets 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 Li Wang inquired the EMR for variables of interest; Fengqi Zhang and Jianyong Zhao searched relevant literature and analyzed and interpreted the data; Zongyu Yang wrote the manuscript, and Xinzhong Shao approved the final version of the manuscript.

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Figures



Figure 1

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.

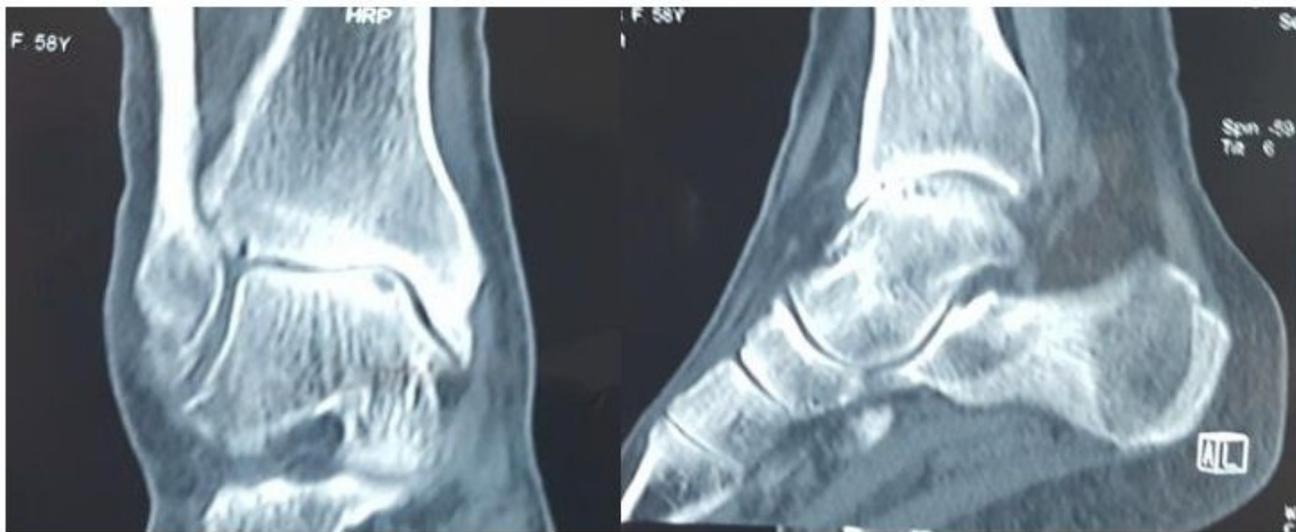


Figure 2

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

The osteophyte in front of the ankle joint was seen during the operation and completely removed.

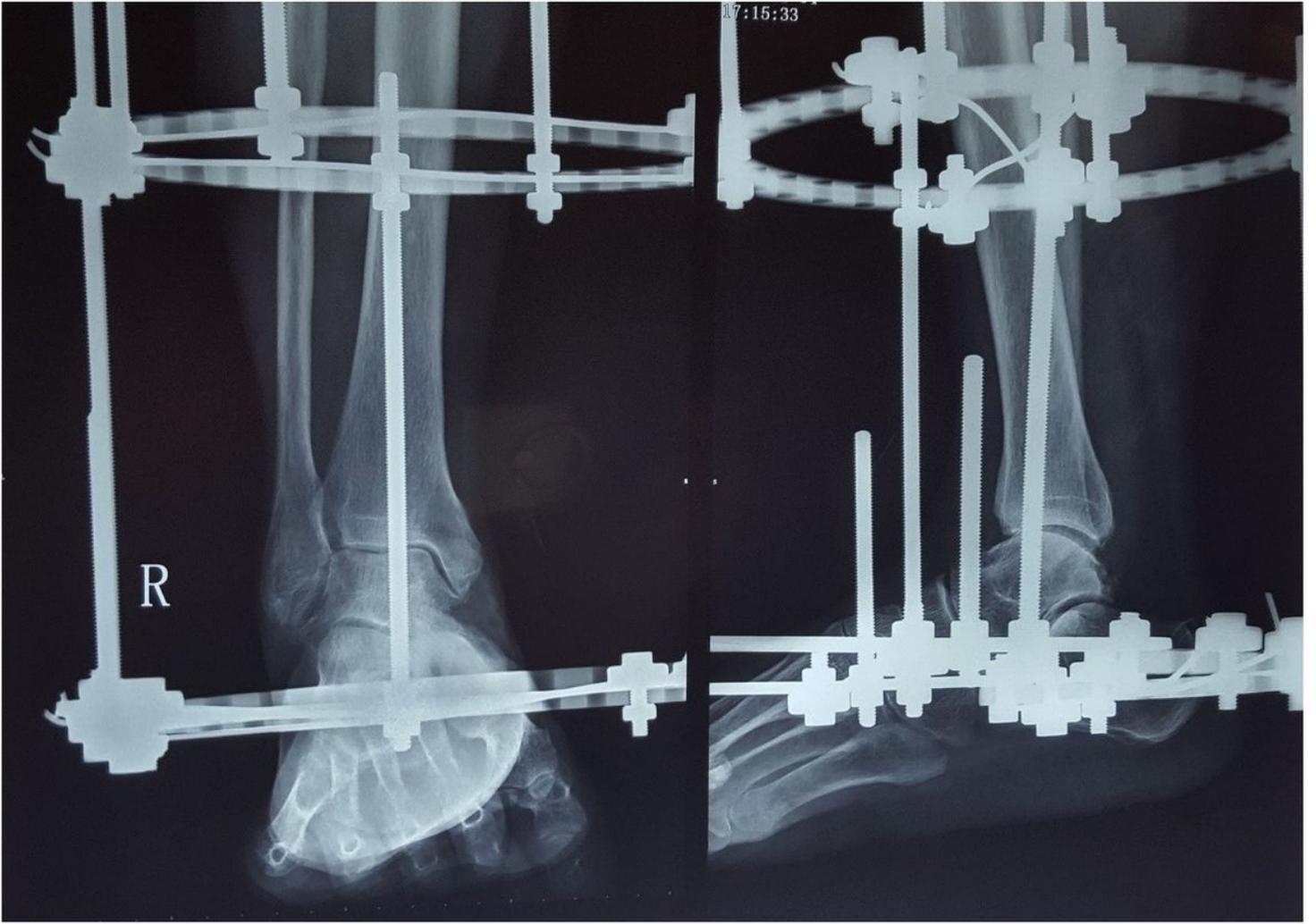


Figure 4

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

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

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.