The Treatment of Severe Posttraumatic Arthritis of the Ankle Joint

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Introduction

Posttraumatic ankle arthritis consists of a progressive alteration of the hyaline cartilage, sclerosis of the subchondral bone, and osteophyte and loose-body formation as a result of an ankle injury. It may develop after nonoperative or surgical repair of an ankle injury in the form of cartilage damage, lateral malleolus malunion with shortening and valgus deformity, tibial plafond disruption and cartilage damage, malunion or necrosis of the talus, or joint instability[1-5].

The aim of the current study was to present our treatment guidelines for severe posttraumatic stage-2 or 3 ankle arthritis[6] on the basis of the results for a series of 190 patients.

Materials and Methods

One hundred and ninety patients ranging from seventeen to seventy years of age who had stage-2 or 3 posttraumatic ankle arthritis (Table I) were managed between 1994 and 2004.

Surgical strategies were decided according to the stage of arthritis, the age of the patient, the quality of joint alignment, and the range of motion of the adjacent foot joints (the midtarsal, Lisfranc, and subtalar joints) according to the algorithm described in Table II.

All patients were examined clinically and radiographically, and the American Orthopaedic Foot and Ankle Society (AOFAS) clinical rating score[7] was calculated both preoperatively and at the time of follow-up. The AOFAS score was graded as excellent (80 to 100), good (70 to 79), fair (60 to 69), or poor (≤59). Patients who were managed with allograft were also studied with computed tomography and magnetic resonance imaging. A cartilage biopsy was performed during hardware removal at 1.5 years of follow-up.

Surgical Strategies

Stage-2 Arthritis with Preserved Ankle Anatomy: Arthroscopic Débridement and Ankle Arthrodiastasis (Fig. 1)

Twelve patients ranging from twenty-one to forty-eight years of age were managed with arthroscopic débridement and arthrodiastasis with an external fixator[8]. Standard arthroscopic approaches were used, and débridement of degenerated cartilage and fibrous tissue was performed. In seven cases, chondral damage of the talus was treated with microfracture[9].

A monolateral hinged ankle external fixator (Orthofix, Bussolengo, Italy) was applied to maintain the joint in distraction (Figs. 2-A, 2-B, and 2-C).

Postoperatively, the external fixator was maintained for four weeks, during which time partial weight-bearing was allowed and active and passive motion of the ankle joint was encouraged. The external fixator was removed at four weeks, and weight-bearing and physiotherapy progressed over the next four weeks.

Stage-2 Arthritis with Supramalleolar Malalignment: Supramalleolar Osteotomy (Fig. 3)

Eight patients ranging in age from seventeen to forty-five years were managed with supramalleolar osteotomy[10]. Through a stan-

TABLE I Ankle Arthritis Classification System

Stage 0	Normal joint or subchondral sclerosis
Stage 1	Presence of osteophytes without joint-space narrowing
Stage 2	Joint-space narrowing with or without osteophytes
Stage 3	Subtotal or total disappearance or deformation of joint space

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TABLE II Decision-Making Algorithm

Arthritis Stage	Age	Ankle Joint Condition		Surgical Procedure
Stage 2	≤50 years or >50 years (to delay/enable use of prosthesis or to delay arthrodesis)	Preserved ankle anatomy		Arthrodiastasis and arthroscopic débridement
		Supra-articular malalignment		Supra-malleolar osteotomy
		Intra-articular malalignment		Joint reconstruction
Stage 3	≤50 years	Preserved or restored ankle anatomy	<25° of motion in other foot joints, arthritis in other foot joints/refusal of patient to have arthrodesis	Ankle allograft
	>50 years			Ankle prosthesis
	Any age		>25° of motion in other foot joints/no arthritis in other foot joints	Arthrodesis
	Any age	Nonrestorable ankle anatomy, chronic infection, neurological disorders, severe osteoporosis		Arthrodesis

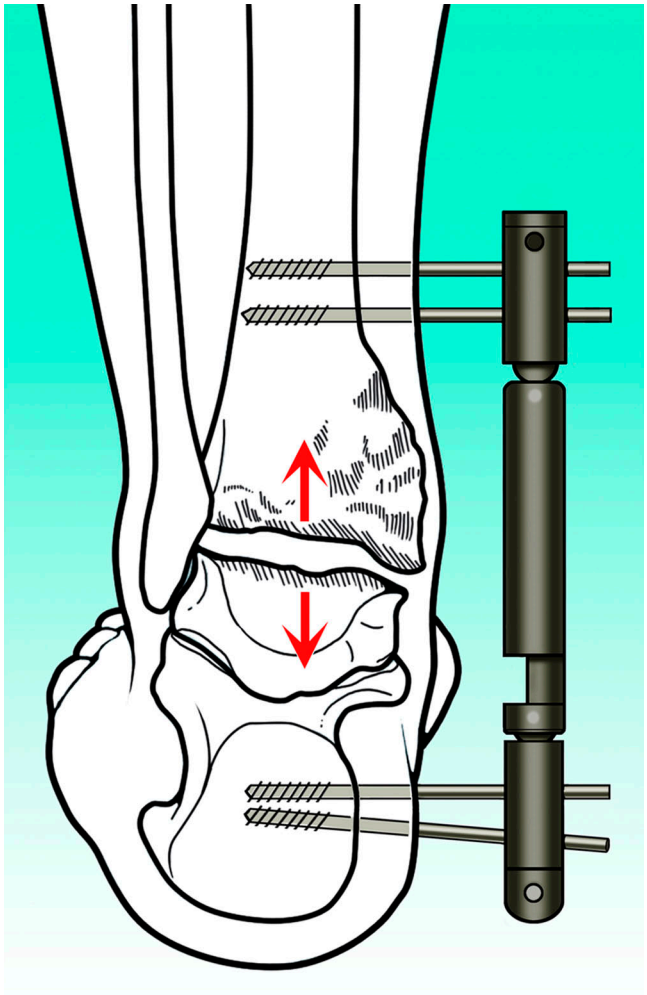

Fig. 1
Illustration of an arthrodiastasis procedure.

dard approach to the distal part of the tibia, a corrective osteotomy of the deformity was performed, usually 4 cm proximal to the articular surface. In six patients the osteotomy gap was filled with a wedge of allograft bone to restore alignment (Figs. 4-A, 4-B, and 4-C), and in the other two patients a closing-wedge osteotomy was performed. Fixation was achieved either with a plate and screws or with two Kirschner wires.

Postoperative treatment consisted of plaster cast immobilization for six weeks without weight-bearing. This was followed by partial weight-bearing in a fracture boot that permitted the patient to perform active and passive ankle motion exercises. When there was radiographic evidence of bone healing (at an average of twelve weeks), full weight-bearing was permitted.

Stage-2 Arthritis with Intra-Articular Malalignment: Joint Reconstruction (Fig. 5)

Forty-two patients ranging from nineteen to fifty-six years of age were managed with ankle reconstruction[11] with use of a lateral approach to the ankle joint. In twenty-five cases, malunion of the lateral malleolus was corrected by creating a fibular suprasyndesmotic osteotomy and lengthening the fibula. A bone graft, harvested directly from the lateral side of the tibia, was interposed in the fibular defect and was stabilized with a plate and screws (Figs. 6-A, 6-B, and 6-C). In seventeen patients, the fibular shortening was associated with lateral tibial plafond depression and the fibular lengthening was combined with elevation and bone-grafting of the articular surface (Figs. 7-A, 7-B, and 7-C). Associated procedures included medial malleolar revision to treat a malunion (eleven patients) and repair of a chronic tear of the deltoid ligament (nine patients). In twenty-five patients, Achilles tendon lengthening was also performed to correct tendon contraction produced by the prolonged state of deformity and to obtain at least a neutral position of the ankle once the deformity was corrected.

Fig. 2-A

Radiograph of the ankle of a thirty-five-year-old woman with stage-2 arthritis with preserved ankle anatomy.

Fig. 2-B

Photograph made at the time of arthroscopy following the placement of the external fixator and distraction.

Postoperative treatment consisted of plaster cast immobilization for three weeks without weight-bearing, followed by non-weight-bearing in a fracture brace for six weeks to permit daily active and passive range-of-motion exercises. Partial weight-bearing was then permitted for the next four weeks. After there was radiographic evidence of bone-healing (at an average of twelve weeks), full weight-bearing was permitted.

Stage-3 Arthritis with Preserved or Restored Ankle Anatomy in Patients Less Than Fifty Years of Age and with <25° of Motion in Other Foot Joints and Arthritis in Other Foot Joints or in Patients Who Refused Arthrodesis: Allograft (Figs. 8-A and 8-B)

Eighteen patients ranging from nineteen to fifty years of age were managed with a fresh bipolar shell osteochondral allograft[12-14]. The allograft was harvested from a cadaver donor and was preserved in a chondroprotective antibiotic solution at 4°C for as long as fourteen days. A patient was selected from a special waiting list when an appropriate graft became available. The choice of the patient was based on a patient-to-allograft match obtained by means of computed tomographic scanning. Surgery involved preparation of the allograft by using designed jigs to obtain articular surfaces

Fig. 2-C

Radiograph made after two years of follow-up. Note that the arthritis shows no evidence of progression.

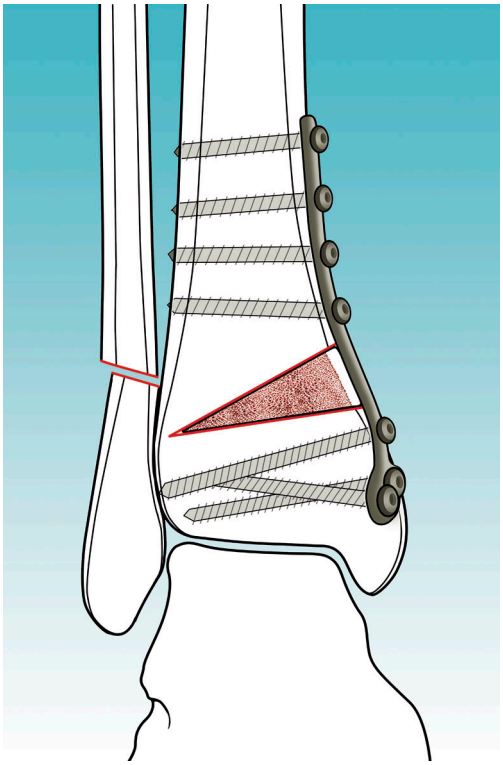

Fig. 3

Illustration depicting an opening-wedge supramalleolar osteotomy. Note the use of allograft to fill the defect.

Fig. 4-A

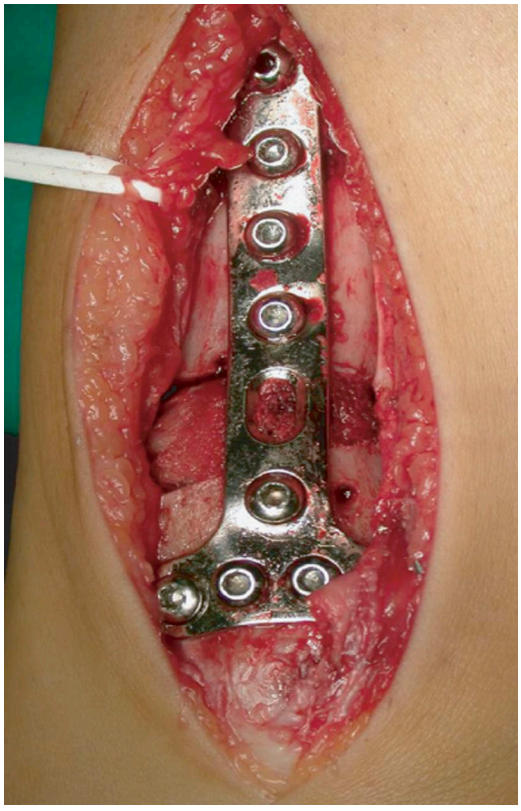

Fig. 4-B

Fig. 4-C

Figs. 4-A and 4-B A twenty-five-year-old man with stage-2 arthritis and varus malunion (Fig. 4-A) was managed with supramalleolar osteotomy and bone-grafting with plate-and-screw fixation (Fig. 4-B). **Fig. 4-C** At seven years of follow-up, the patient had an excellent radiographic result.

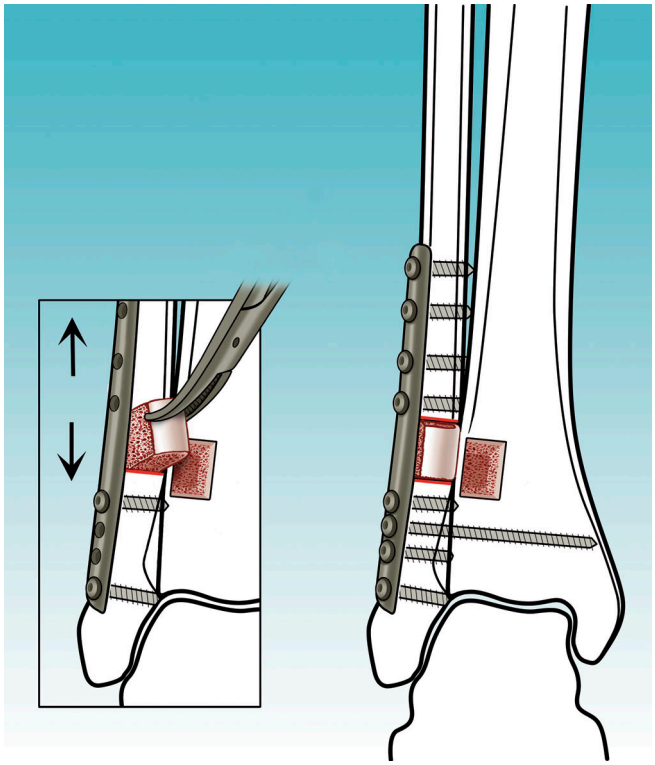

Fig. 5

Illustrations depicting ankle reconstruction with fibular lengthening.

Fig. 6-A

Fig. 6-B

Fig. 6-C

Figs. 6-A and 6-B A thirty-four-year-old man who had fibular shortening (Fig. 6-A) was managed with fibular lengthening and joint realignment (Fig. 6-B). **Fig. 6-C** At six years of follow-up, the patient had an excellent radiographic result.

Fig. 7-A

Fig. 7-B

Fig. 7-C

Figs. 7-A and 7-B A forty-five-year-old woman with tibial plafond depression (Fig. 7-A) was managed with elevation of the depressed articular fragment and the placement of a bone graft beneath it (Fig. 7-B). **Fig. 7-C** At six years of follow-up, the patient had an excellent radiographic result.

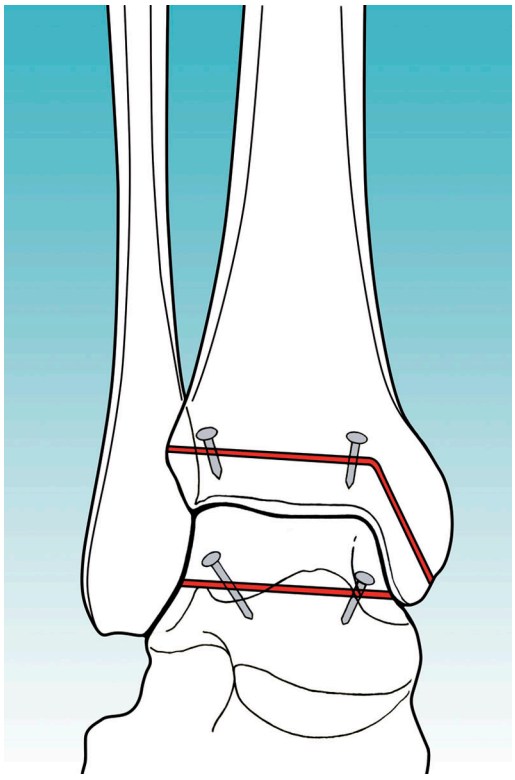

Fig. 8-A

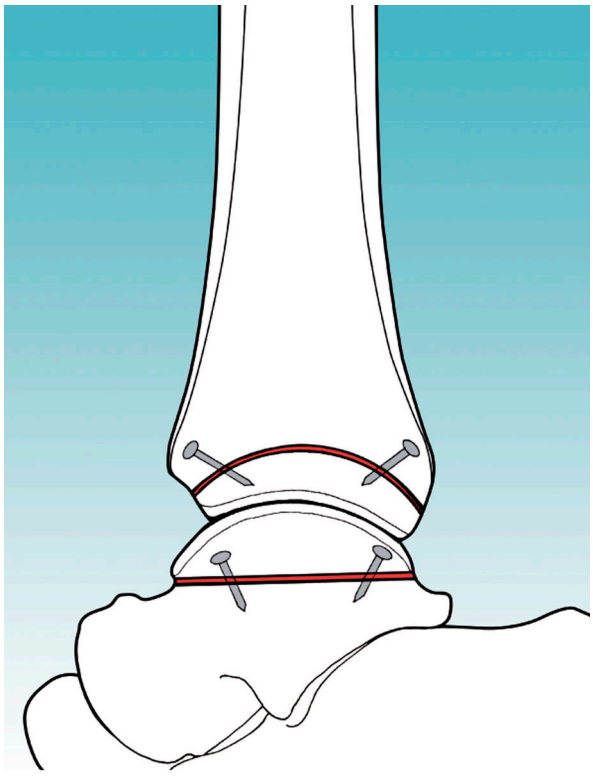

Fig. 8-B

Illustrations showing frontal (Fig. 8-A) and sagittal (Fig. 8-B) views of a fresh bipolar shell osteochondral allograft.

Fig. 9-A

Figs. 9-A through 9-F A thirty-eight-year-old man with stage-3 arthritis and fairly well-preserved ankle joint alignment was managed with a fresh bipolar shell osteochondral allograft. **Fig. 9-A** Preoperative radiographs.

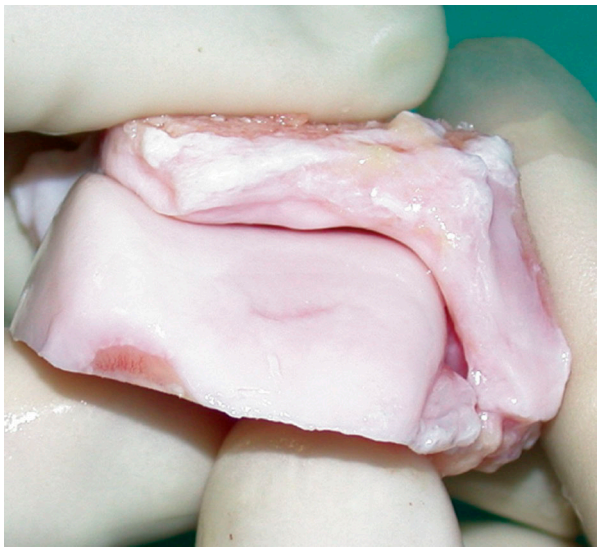

Fig. 9-B

The anterior aspect of a fresh bipolar shell osteochondral allograft harvested from a cadaver donor.

with a 1-cm thickness of subchondral bone for both the tibial and talar components. With use of a 2-cm incision technique, the patient's ankle was exposed and 1 cm was resected from both articular surfaces with the same jig that was used for the graft. Then the graft was implanted and was fixed with twist-off screws (Figs. 9-A through 9-F).

Postoperative treatment consisted of non-weight-bearing in a cast-boot for four months. Active and passive range of ankle motion was performed after two weeks. Partial weight-bearing was permitted after four months, while full weight-bearing was permitted after there was evidence of bone-healing (at an average of eight months).

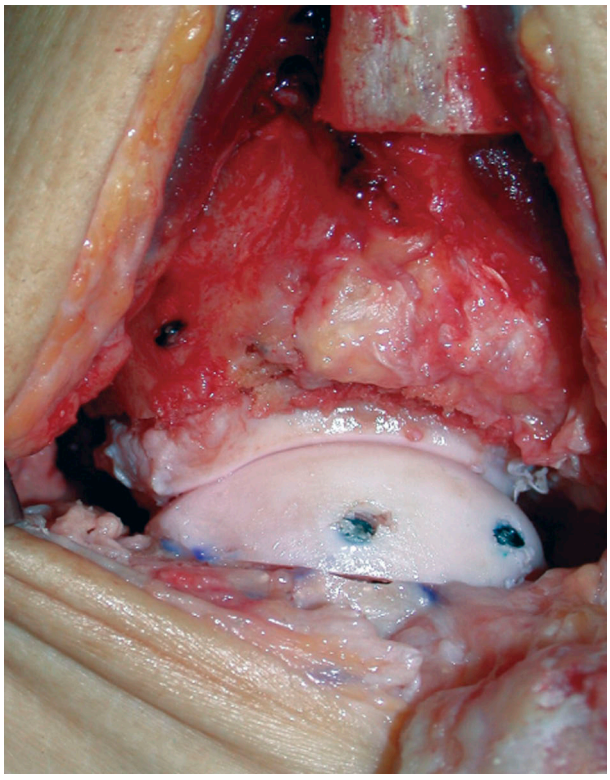

Fig. 9-C

The lateral aspect of a fresh bipolar shell osteochondral allograft fixed with twist-off screws.

Stage-3 Arthritis with Preserved or Restored Ankle Anatomy in Patients More Than Fifty Years of Age or with <25° of Motion in Other Foot Joints or in Patients Who Refused Arthrodesis: Ankle Prosthesis (Fig. 10)

Fifty-two patients ranging in age from fifty-one to seventy

years were managed with three different designs of total ankle replacement: twenty patients received an LCS implant (New Jersey Low Contact Stress; Endotec, South Orange, New Jersey), twenty received a STAR implant (Scandinavian Total Ankle Replacement; Waldemar-Link, Hamburg, Germany), and twelve received a BOX implant (BOX Total Ankle Replacement; Finsbury Orthopaedics, Leatherhead, United Kingdom)[15,16].

A standard anterolateral or anteromedial approach was used. Tibial and talar surfaces were prepared with use of specific instrumentation, ensuring correct evaluation of alignment of the axis of the tibial component in both the frontal and sagittal planes and minimizing the amount of bone resection. During preparation of the talus, special care was taken not to damage the subchondral bone. After prosthesis implantation, other procedures that were performed in-

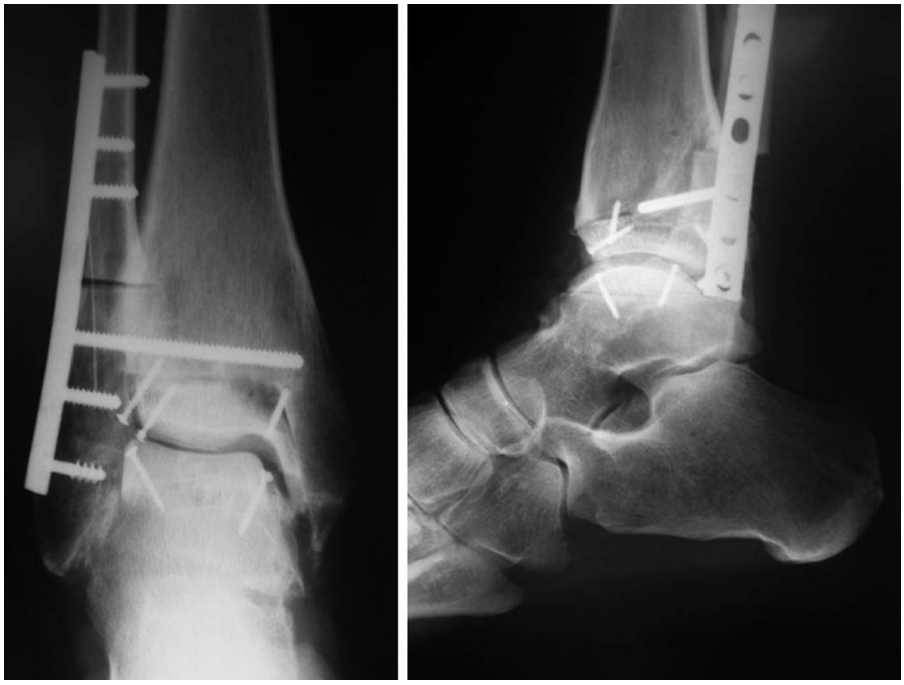

Fig. 9-D

Postoperative anteroposterior and lateral radiographs showing the fresh bipolar shell osteochondral allograft.

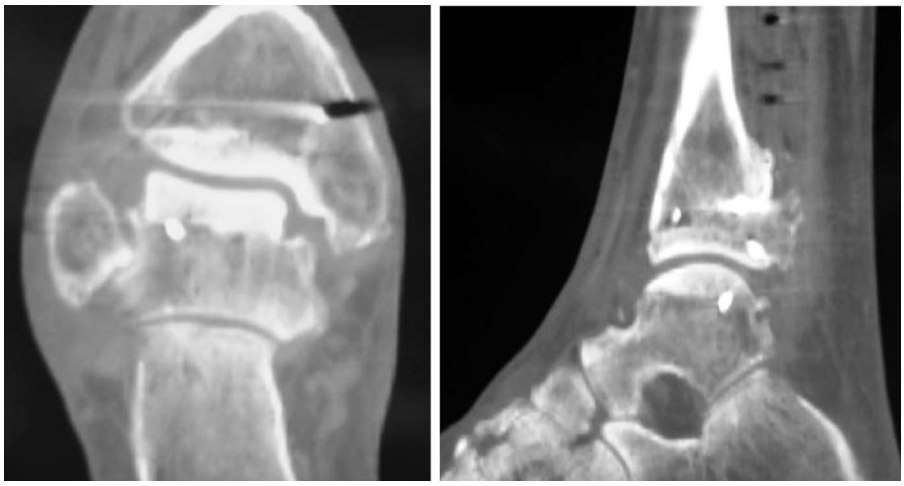

Fig. 9-E

Computed tomography scans made after eight months of follow-up, showing good osseointegration of the fresh bipolar shell osteochondral allograft.

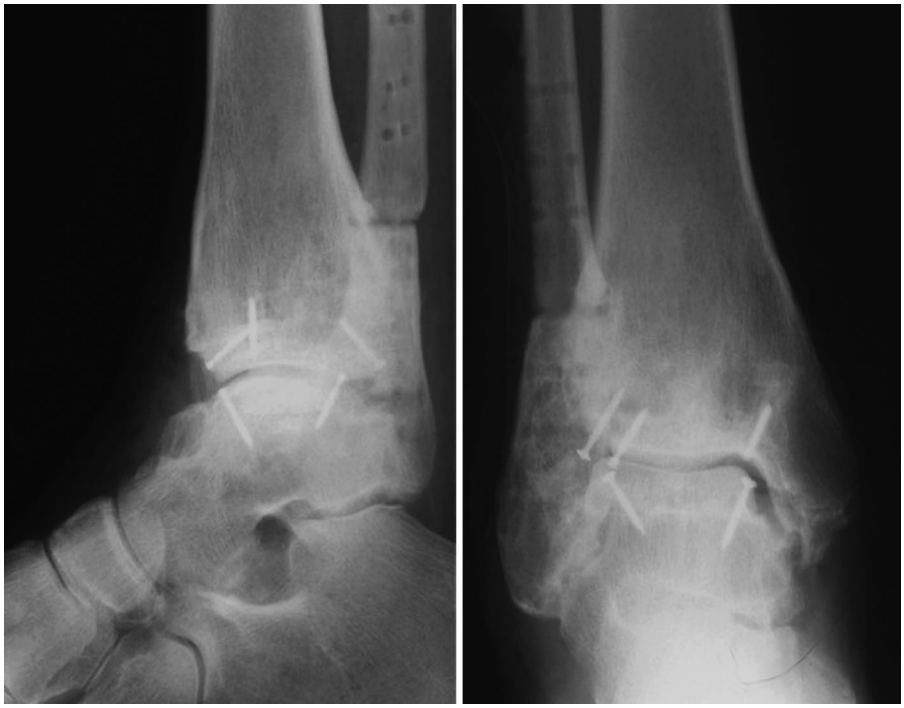

Fig. 9-F
Radiographs demonstrating an excellent result at two years of follow-up.

cluded Achilles tendon lengthening (thirty-eight patients), ligament reconstruction (six), correction of deformity of the foot (eight), and reduction of previous mortise widening with a syndesmotic screw (five).

Postoperative treatment consisted of plaster cast immobilization without weight-bearing for two weeks, followed by the use of a fracture brace without weight-bearing for two weeks. Active and passive ankle motion was begun at two weeks. After four weeks, partial weight-bearing was permitted in the fracture brace for four weeks, and full weight-bearing was begun after eight weeks (Figs. 11-A and 11-B).

Stage-3 Arthritis with Preserved or Restored Ankle Anatomy and >25° Range of Motion in Foot Joints, No Arthritis in Other Foot Joints, or Nonrestorable Ankle Anatomy: Arthrodesis (Fig. 12)

Fifty-eight patients ranging from eighteen to fifty-eight years of age were managed with ankle arthrodesis according to the method of Merle d'Aubigné[17]. Through a lateral approach, a fibular osteotomy was performed 2 cm proximal to the ankle joint. Two parallel cuts were performed, one through the distal part of the tibia and one through the talar dome, with resection of the arthritic articular surfaces and exposure of the cancellous bone. The foot was positioned in 5° to 10° of valgus and 5° to 10° of external rotation. In thirty-six patients with good range of motion of the midtarsal joint, the ankle was positioned in 90°, whereas in twenty-two patients with midtarsal joint arthritis, the ankle was positioned in 10° of dorsiflexion. Fixation was obtained primarily with one hydroxyapatite-

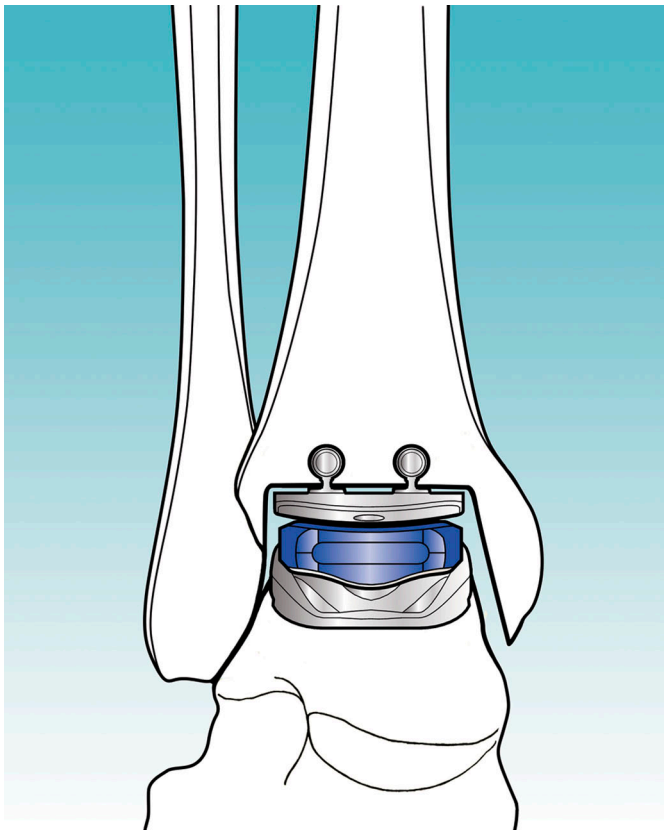

Fig. 10
Anteroposterior-view illustration of the three-component ankle prosthesis.

Fig. 11-A

Figs 11-A and 11-B A fifty-nine-year-old woman with stage-3 arthritis with preserved ankle alignment was managed with total ankle replacement. **Fig. 11-A** Preoperative radiographs.

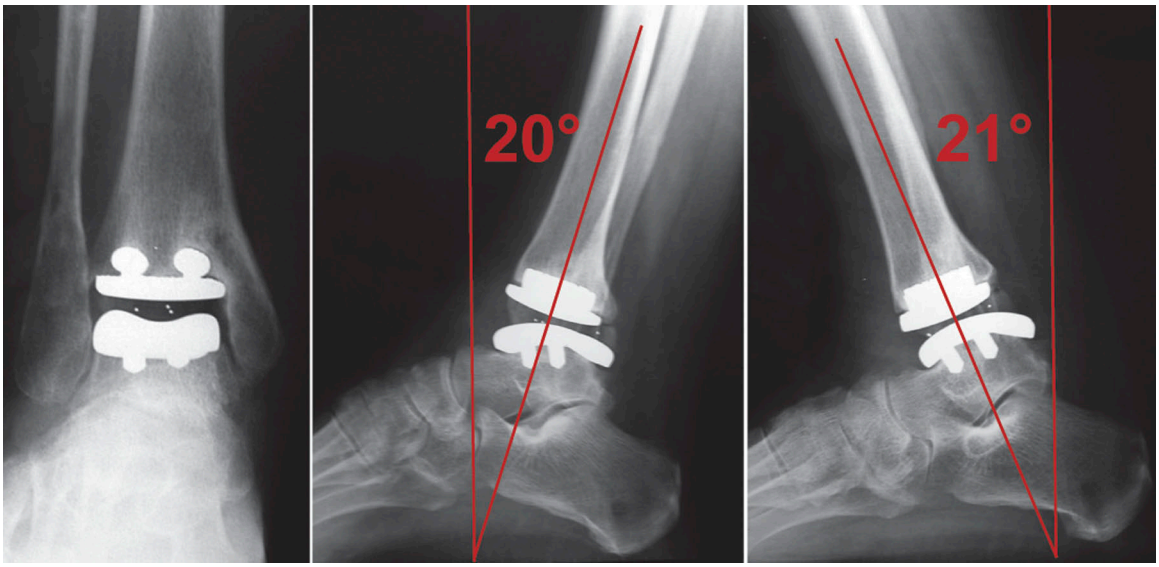

Fig. 11-B

Radiographs made two years postoperatively. The lateral weight-bearing radiographs show a very good range of motion of the implant.

coated 6.5-mm cancellous screw[18] (Fig. 13) inserted from the anterolateral aspect of the tibia into the body of the talus (Figs. 14-A and 14-B).

Postoperative treatment consisted of plaster cast immobilization for six weeks without weight-bearing, followed by an additional six weeks in the cast with complete weight-bearing. Full unprotected weight-bearing was allowed after bone-healing was evident radiographically, usually by twelve weeks.

Statistical Analysis

All continuous data are expressed in terms of the mean and the standard deviation of the mean. The data in the groups

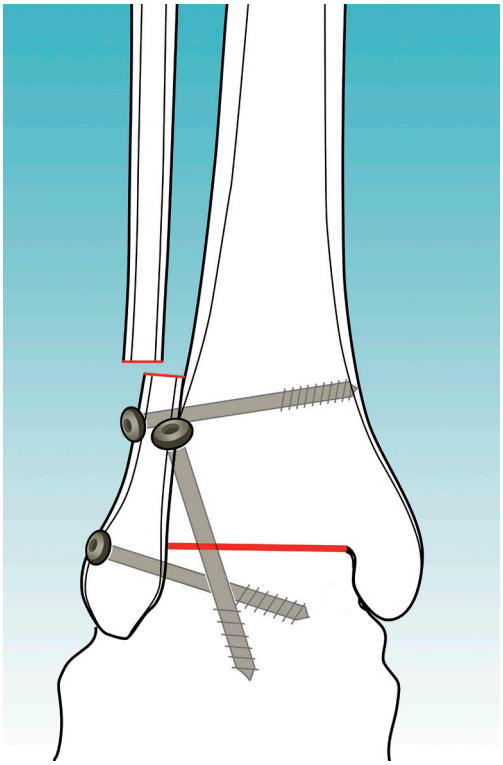

Fig. 12
Illustration depicting the arthrodesis technique used.

were compared with use of the t test (in groups with at least twenty patients) or the Wilcoxon test evaluated with the Monte Carlo method for small samples. The level of significance was set at $p < 0.05$.

Results

After a mean duration of follow-up of five years (range, two to ten years), 190 ankle joints had been fused or salvaged; among these joints were 108 excellent, fifty-seven good, and thirteen fair results according to the AOFAS score. The remaining twelve joints had a poor result and underwent reoperation (Fig. 15).

The sixty-two patients with stage-2 arthritis presented with a mean preoperative AOFAS score of 35.5 ± 8.9. At the time of the latest available follow-up (mean, five years), the mean score was 80.5 ± 11.4 ($p < 0.05$). Fifty-five patients had a satisfactory clinical result with no need for additional surgical treatment, despite radiographic evidence of slight progression of arthritis over time. Of the seven ankles that had a poor result in this group, three had undergone reconstruction and four had undergone unsuccessful arthrodiastasis. These ankles were treated with arthrodesis or total ankle replacement at an average time of four years after the first intervention.

The eighteen patients with stage-3 arthritis who were managed with an allograft had a mean AOFAS score of 28.3 ± 12.3 preoperatively and 83.3 ± 11.2 at the time of the most recent available follow-up (minimum, two years) ($p < 0.05$). Two patients had a poor result, necessitating an arthrodesis in one patient and revision surgery in the other. A cartilage biopsy at the time of hardware removal confirmed >90% chondrocyte viability in the cases of sixteen patients. All of the sixteen successful allografts demonstrated mild to moderate arthritis of the transplanted surfaces radiographically at the time of follow-up, although these changes could not be correlated with pain, reduced motion, or loss of function.

In the group of fifty-two patients with stage-3 arthritis who were managed with total ankle arthroplasty, the mean AOFAS score improved from 30.3 ± 14.3 preoperatively to 84.4 ± 10.4 at the time of the most recent available follow-up ($p < 0.05$). Three patients with a poor result underwent revision surgery (arthrodesis).

Among the fifty-eight patients with stage-3 arthritis who were managed with arthrodesis, the mean AOFAS score was 28.8 ± 11 preoperatively and 77.5 ± 8 at a mean of seven years postoperatively ($p < 0.05$). No revision surgery was performed. A review of the radiographs showed progression of arthritis in the ipsilateral midtarsal and/or subtalar joint in twenty of these fifty-eight patients.

Discussion

The most appropriate treatment for severe posttraumatic ankle arthritis is still controversial[19,20].

Ankle salvage procedures can be effective[8-11] for the treatment of stage-2 arthritis. Although the optimal results observed at the time of short-term follow-up deteriorated slightly over time, only seven of our sixty-two patients with stage-2 arthritis had had additional surgery after a mean duration of follow-up of seven years. Nevertheless, even in the patients who underwent additional surgery, the use of ankle salvage allowed us to delay arthrodesis or an ankle substitution procedure, such as the insertion of an allograft or prosthesis, probably because the ankle anatomy was restored at least to some degree.

The ankle allograft technique that we used is promising[12-14] for the treatment of stage-3 arthritis in patients younger than fifty years of age, although longer follow-up is required

Fig. 13
The hydroxyapatite-coated cancellous screw.

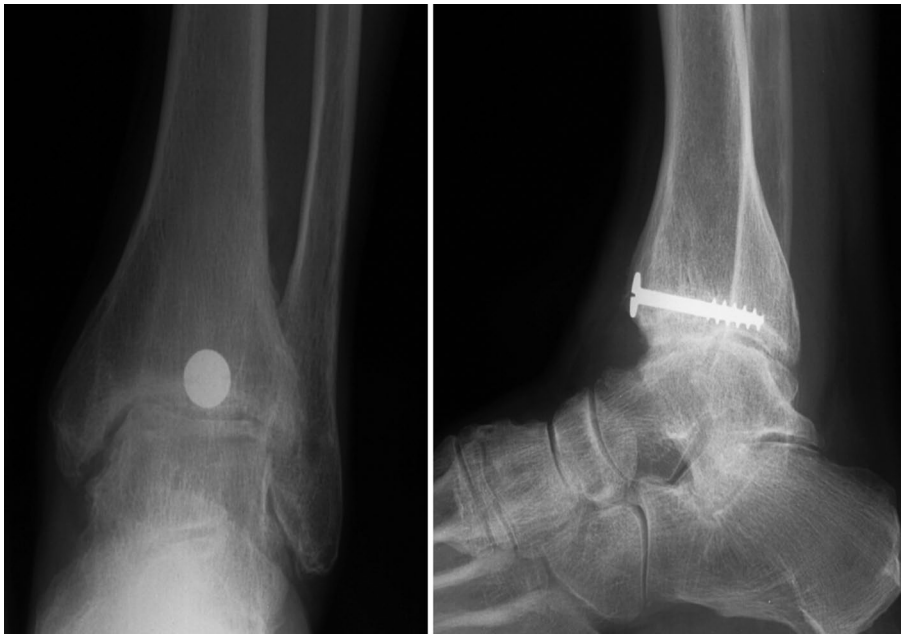

Fig. 14-A

Figs. 14-A and 14-B A fifty-five-year-old man with stage-3 arthritis and >25° of motion in the other foot joints was managed with arthrodesis. **Fig. 14-A** Preoperative radiographs.

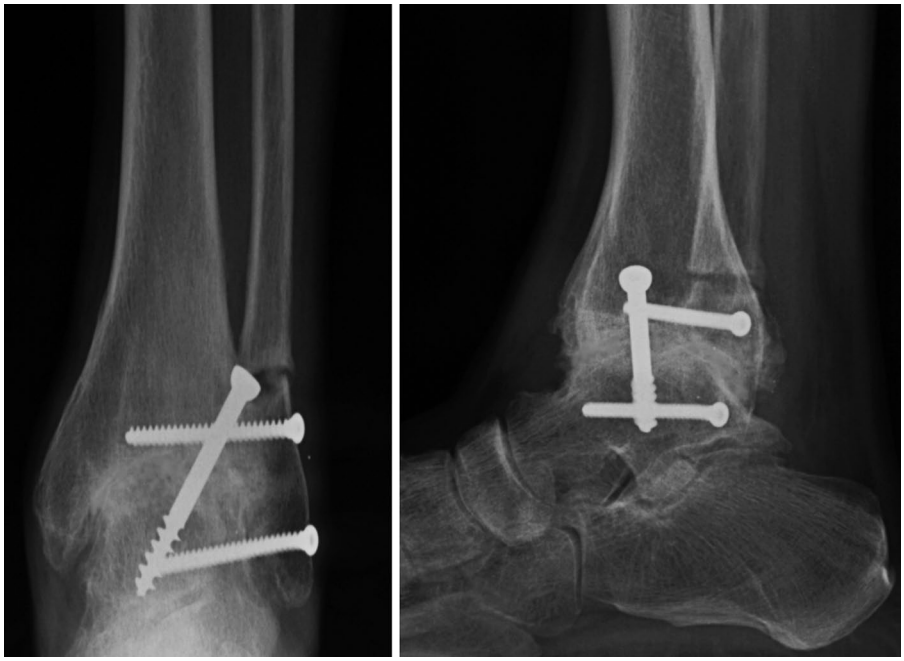

Fig. 14-B

At five years, the patient had an excellent radiographic result.

to confirm the good results observed in this review. Good osseointegration of the graft was demonstrated radiographically, and good cartilage quality was confirmed by means of histologic analyses of biopsy specimens in sixteen cases. The disadvantages of this procedure are a technically demanding surgical technique and a long recovery period.

While we used three different implants[21-23] over the course of the present study, total ankle replacement demonstrated satisfactory results with a very limited failure rate of 5.8% in older patients[24] with grade-3 arthritis.

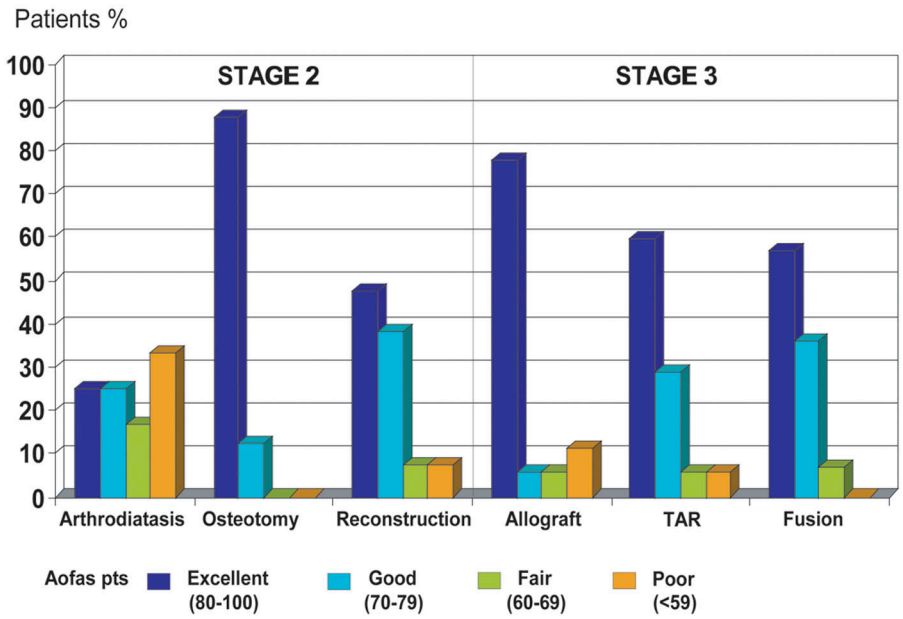

Fig. 15

Bar graphs showing the AOFAS score for each procedure.

In patients managed with ankle arthrodesis, the AOFAS score was lower because of the loss of ankle joint motion. Otherwise, these patients had very limited pain at the time of follow-up, and a low complication rate was observed following the treatment of stage-3 arthritis associated with very compromised anatomical conditions. Arthrodesis of the ankle, which completely sacrifices ankle motion, is often hard for patients to accept, but if correct information is given about the good function to be expected after successful surgery and if the arthrodesis is achieved in a good position with at least 25° of motion in the other foot joints[25], it should be considered a valuable and reliable option at any age. ■

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