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Ankle Arthrodesis Using Anatomically Contoured Anterior Plate

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ABSTRACT

Background: **More than 40 fusion techniques for the ankle joint have been reported. The purpose of this retrospective study was to review our preliminary clinical and radiographic results using an anatomically contoured anterior plate for ankle arthrodesis.** ***Materials and Methods:*** **Ten ankle arthrodeses with an anatomically contoured anterior plate performed by a single surgeon were reviewed with an average of 14 months followup. One underwent revision surgery due to screw loosening by reapplying the same plate. Plain radiographs were taken to help determine the stability of fixation and time of fusion. The AOFAS clinical rating system was applied to evaluate patients preoperatively and postoperatively.** ***Results:*** **Nine of ten patients achieved solid fusion radiographically and clinically at an average of 15 (range, 12 to 22) weeks. Bony healing was achieved after an additional 12 weeks for the patient who underwent revision fusion. There were no postoperative wound problems or infections. All patients reported an improvement in their pain level following successful fusion.** ***Conclusion:*** **The application of an anatomically contoured plate provides many advantages, including less soft tissue disruption by using a single anterior incision, ease of deformity correction, early rehabilitation, and high rate of union.**

Level of Evidence: IV, Retrospective Case Series

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INTRODUCTION

Disabling ankle arthritis from severe trauma, infection, and avascular necrosis of the talar body is a challenging problem. A stable, pain free ankle joint is desirable for the patient. Longer-term studies of total ankle arthroplasty have shown deterioration of clinical results,[7,9,11] and it is also relatively contraindicated to perform ankle replacement on those patients who have posttraumatic arthritis with infection or inadequate bone stock. Ankle arthrodesis remains an effective reconstructive procedure for the treatment of ankle arthritis and limb salvage since first described by Albert in 1882.[2] More than 40 different fusion techniques, which differ in surgical approaches, types of fixation and bone graft, have been described over the past 120 years. Each method has its own advantages and disadvantages. A high rate of successful fusion, up to 89%, is currently obtained with different types of internal fixation.[7,12] A popular internal fixation method of ankle fusion is partially threaded cancellous screws.[6,13] However, patients with a posttraumatic bone defect and/or poor bone quality after a long period of immobilization can require more rigid fixation. Dorsiflexion is the major stressor imparted to the fused ankle during normal gait,[18] therefore it can be rationalized that an anterior plate can provide more rigid fixation at the fusion gap. Our preference is an anatomically contoured anterior plate combined with compression techniques through an anterior approach to achieve ankle arthrodesis. The purpose of this retrospective study was to review our preliminary clinical and radiographic results in adults by using an anterior plate in ten patients. The surgical technique can be used for primary and salvage cases.

MATERIALS AND METHODS

From September 2004 to October 2006, ten arthrodeses were performed by the senior author (LAH) using an

anatomically contoured anterior plate (Synthes, Paoli, PA) through an anterior approach. The patients included six men and four women with an average age of 43.6 (range, 23 to 79) years. Average followup was 14 (range, 10 to 28) months.

All patients had disabling ankle arthritis of variable etiology. Preoperative diagnosis consisted of three patients with primary degenerative osteoarthritis, one with avascular necrosis of the talus, and six with post-traumatic osteoarthritis. Among the six patients with post-traumatic osteoarthritis, five had been complicated with infection following an open ankle fracture. Two of the five required a skin graft or flap. Half of the patients had bone defects located at the distal end of the tibia and the fibula, talus and medial malleolus. X-ray analysis and physical exam were used to diagnosis a painful arthritic ankle. The indications for surgery were severe pain with or without deformity which had not responded to conservative treatment. Three patients had not undergone any previous surgeries on the involved ankle, two had one operation, three had two operations, one had three operations, and one had four previous operations. Eight patients underwent primary arthrodesis by using an anatomically contoured anterior plate, one patient underwent secondary arthrodesis by reapplying the same plate due to distal screw loosening after primary fusion, and one patient underwent a third arthrodesis for nonunion after use of cortical and cancellous screws twice (Table 1).

All patients were evaluated by a reviewer who was not involved with the initial surgery. Plain radiographs (three views) were taken immediately following surgery, 6 weeks, 12 weeks, and 24 weeks postoperatively to aid in determining the stability of fixation and time of fusion. All films were analyzed by two independent observers (a radiologist and a foot/ankle orthopaedic surgeon) to confirm the status of the fusion. The AOFAS clinical rating system for ankle-hindfoot,[8] was utilized (Table 2). Two cases in our series were combined with subtalar fusion simultaneously, which made it impossible to evaluate hindfoot motion by using the AOFAS system.

Operative technique

The patient was placed in the supine position with a bump under the ipsilateral hip. A tourniquet was used. A standard anterior midline incision or previous anteromedial incision was performed over the ankle. The skin or grafted flap was carefully elevated. The interval between the anterior tibial tendon and extensor hallucis longus tendon was opened. With a combination of osteotomes, curettes and a power burr, cartilage was removed from the distal end of tibia, the talus, including the dome, the medial and lateral aspects of the talus, as well as the medial malleolus and the distal fibula. Osteophytes and degenerative scar tissue were also removed. For previously infected patients, the joint surface was thoroughly irrigated after debridement. The ankle joint was placed in a plantigrade position with 0 to 3 degrees of valgus. Cancellous bone was harvested from the iliac crest when necessary. For large bone defects cases, cancellous and cortical graft was taken. Three patients received ICBG, 6 received morselized bone graft. An anatomically contoured 6- or 7-hole 4.5-mm stainless steel plate (Synthes, Paoli, PA) was applied on the anterior aspect of the ankle. No bending was required. While placing the arthrodesis under axial compression a 4.5 mm cortex screw, angled distally approximately 30 degrees to the tibia shaft, was inserted through the most distal dynamic compression hole of the plate into the talus. Another 4.5-mm cortex screw, angled distally approximately 40 degrees to the tibia shaft, passed through the plate and the distal tibia into the talus. Both screw tips were threaded as far as possible into the talus without penetration of the subtalar joint.

The alignment and length of screws were confirmed with image intensifier. The other two or three screws were inserted into the tibia. A multilayer closure over a drain was performed. The leg was placed into a well padded posterior splint.

Postoperative care

Sutures were removed approximately 14 days after surgery. The leg was placed into nonweightbearing short leg cast for 6 weeks. If the internal fixation was radiographically shown stable at 6 weeks after surgery, patients were allowed to partial weight-bear with a cam boot 6 weeks postoperatively. Full weightbearing was permitted when fusion was confirmed radiographically and clinically. The cam boot or crutch was discontinued when the patient could bear full weight in the boot without pain, the ankle was stable, and evidence of fusion was shown on radiographs.

RESULTS

Fusion was achieved radiographically and clinically in nine cases at an average of 15 (range, 12 to 22) weeks. One patient with failed fusion after using compression screws twice also achieved bony fusion at 12 weeks postoperatively (Figure 1). One patient did not receive iliac bone graft during the first surgery, and the lower three screws had loosened at 12 weeks postoperatively. There was gross motion at the fusion site. The plate was re-applied and the fusion site supplemented with iliac crest bone. Bony healing was achieved after an additional 12 weeks (Figure 2). Trabecular bone bridging was radiographically evident in all patients and clinically no motion was evident at the ankle joint. One patient required 18 weeks, while another required 22 weeks to achieve clinical fusion. Both patients had an open ankle fracture complicated by previous infection and bony defects.

All patients reported an improvement in their pain level following successful fusion. Three patients reported occasional mild pain. One patient whose height was 160 cm and body mass was 138 kg reported moderate daily pain.

Table 1: Patient Data

Case	Sex	Age	Diagnosis	Previous procedure	Bone defect	Time to fusion (weeks)	Complication
1	M	79	degenerative osteoarthritis	ankle fusion with cortical and cancellous screw repeated fusion with canulated 6.5-mm screws	tibia, talus and fibula	12	none
2	M	57	degenerative steoarthritis.	none	none	12	none
3	M	34	post-traumatic osteoarthritis	ORIF open talus fx	none	12	none
4	F	33	post-traumatic steoarthritis.	ORIF open tibial pilon fx hardware removal and external fixator	medial malleolus	22	none
5	F	53	talus avascular necrosis	none	none	12	distal screws loose
6	F	23	post-traumatic osteoarthritis	ORIF open bimalleolar fx	none	12	none
7	M	66	degenerative osteoarthritis	none	none	12	none
8	M	30	nonunion of distal tibia post-traumatic osteoarthritis	ORIF open pilon fx gracilis and rectus abdominis free flap hardware removal and external fixator latissimus dorsi free flap and split-thickness skin graft	tibia	18	none
9	F	42	post-traumatic osteoarthritis	external fixator ORIF open ankle fx	medial malleolus	12	none
10	M	57	post-traumatic osteoarthritis	ORIF open ankle fx repair nonunion tibia with iliac crest bone graft and spinal mesh cage split-thickness skin graft	distal tibia	12	none

There were no postoperative wound problems or infections (Table 2).

DISCUSSION

The application of an anatomically contoured plate for ankle arthrodesis through an anterior approach meets three principles for bony fusion: (1) cancellous bone in intimate contact, (2) rigid internal fixation in compression through the fusion gap, and (3) viable autogenous bone grafting. The anterior approach for the ankle provides satisfactory visualization into the joint. Most surgeons are familiar with the anterior approach. We believe it allows easier removal of the cartilage from the ankle joint and correction of deformity, as well as more accurate placement of internal fixation.

Five of six patients (83%) with post-traumatic arthritis had been complicated with infection after open reduction and internal fixation (ORIF) of an open ankle fracture. Repeated debridements were performed on these patients. Two of them previously underwent skin graft or flap. There was extensive scar tissue around their ankle joints, but after anterior

Table 2: AOFAS Comparison of Preoperative Versus Postoperative Status

	Number of patients preop	Number of patients postop
Pain		
None		6
Mild, occasional		3
Moderate, daily	3	1
Severe, almost always present	7	
Function (activity limitations, support requirement)		
No limitation, no support		2
No limitation of daily activities, limitation of recreational activities, no support		6
Limited daily and recreational activities, cane	7	2
Severe limitation of daily and recreational activities, walker, crutches, wheelchair, brace	3	
Maximum walking distance, blocks		
>6		2
4-6	1	6
1-3	6	2
<1	3	
Gait abnormality		
None, slight		2
Obvious	3	6
Marked	7	2
Ankle-hindfoot stability		
Stable	8	10
Definitely unstable	2	
Alignment		
Good, plantigrade foot, ankle-hindfoot well aligned		9
Fair, plantigrade foot, some degree of ankle-hindfoot, malalignment observed, no symptoms	7	1
Poor, nonplantigrade foot, severe malalignment, symptoms	3	

placement of the stainless steel plate, there were no postoperative skin problems in these patients. Steinlauf et al. reported that anterior hardware placement would not interfere with wound healing or increase infection risk.[19] Our study also confirmed the previously reported experience that the placement of hardware along the anterior tibiotalar surface was safe and technically convenient.[14,17,19,20]

Besides maintaining compression at the tibiotalar interface, the plate provided good stability against plantarflexion-dorsiflexion movement at the fusion gap, allowing earlier partial weightbearing of the limb which could increase bony healing.[1,4] Screw fixation alone, which is suitable for low-risk patients with minimal deformity and adequate bone stock, was reported with favorable clinical union rates ranging from 93% to 100%.[6,13] However, Dohm et al. reported an unacceptable nonunion rate of 40% with this fusion technique.[5] Moreover, biomechanical evidence reported by Thordarson et al.[22,23] suggested that screw fixation is not reliable in patients with osteopenic bone, which is common in posttraumatic arthritis and failed arthrodesis.

Recently, Tarkin et al.[21] reported increased ankle arthrodesis construct rigidity with three 6.5-mm partially threaded cancellous screws and a supplementary 3.5-mm bent reconstruction plate. Biomechanical testing under three different decoupled loading conditions: plantarflexion/dorsiflexion, inversion/eversion, and rotation were conducted. Anterior plating increased construct stiffness by a factor of 3.5, 1.9, and 1.4 for the sagittal, coronal, and torsion modes, respectively. The plate acted as a tension band to resist plantarflexion moments, and ankle dorsiflexion was minimized by the buttress effect of the anteriorly placed plate. Less motion occurred at the tibiotalar interface in all three loading conditions with plate supplementation. Stable fixation in the present study was achieved with the 4.5 mm

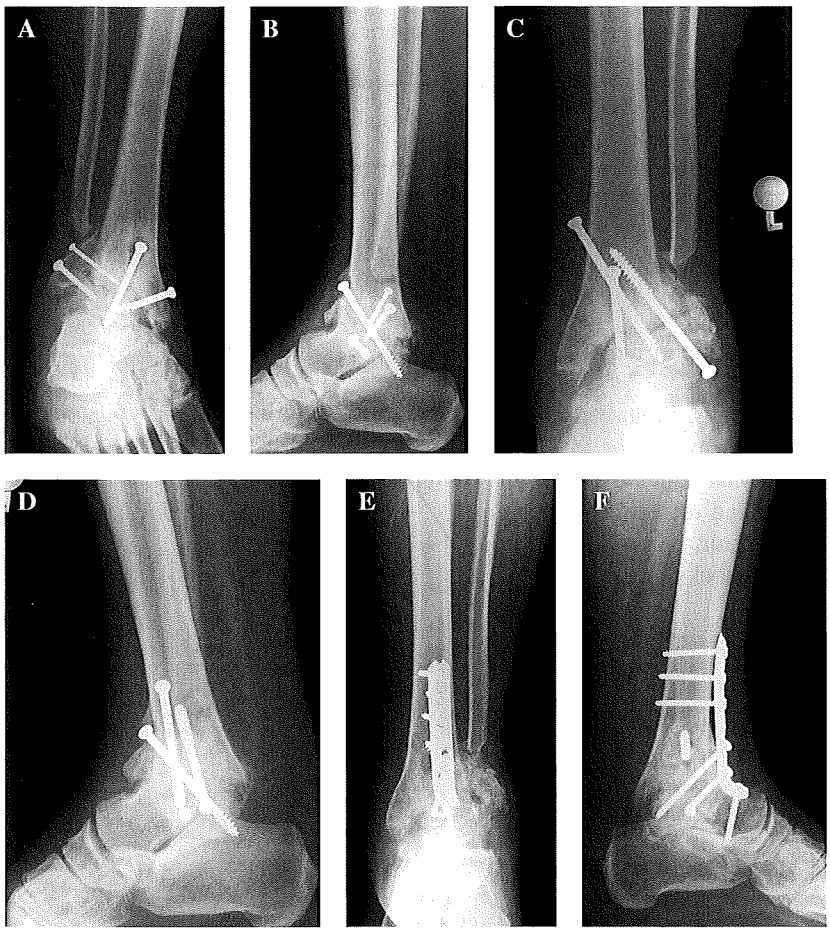

Fig. 1: A 79-year-old man with failed fusion using cannulated screws (A to D), 12 weeks postoperatively. A solid fusion with plantigrade alignment was achieved by using an anterior plate (E and F).

anterior plate alone. The mean fusion time was 15 weeks with 90% primary successful fusion rate in our series, which is comparable with other reports.

Since the plate is anatomically contoured, it is not necessary to bend the plate during the operation. After preparation of the fusion interface and correction of the deformity, the plate fits along the anterior aspect of the tibia and talus. The dome of the talus and/or distal tibia usually were deficient as a result of trauma or failed previous procedures. The plate was used as a reference for correction of the deformity and decreased the likelihood of malposition. By using cancellous screws or staple fixation, it could be difficult to achieve a well-positioned ankle arthrodesis in patients with failed fusion deformity and bone loss. Blade plates (BP) are reported as an excellent type of internal fixation for ankle fusion.[15,20,24] The disadvantages of BP are related to prominence of the plate when it was placed laterally or anteriorly. Iatrogenic fracture of the talus has also been reported.[20] In addition, BPs can require extensive preoperative modification or intraoperative bending. Biomechanical studies on sawbones have shown it has equal strength with crossed screws in resisting plantarflexion, varus and torsional loads, but has inferior stiffness during dorsiflexion and valgus loading.[13,16]

An anterior placed AO T-plate was reported to have a 94% fusion rate by Rowan et al.[17] The talar screws in the distal end of the AO plate pass horizontally in the talus, but can not provide rigid fixation for patients with a bone defect of the talus. An anterior tension plate with only two screws, one in the tibia and one in the talus respectively, yielded an 82% fusion rate.[14] It was only suited for application in patients with minimal deformity or bony destruction. Five of ten patients in our series had a bone defect. Nine patients had plantigrade postoperative alignment during followup. Eight of our ten patients were satisfied with this procedure and functioned well during daily activities without limitation. While wearing appropriate shoes, six patients could walk on level ground without pain. By using the anterior plate, we achieved solid fusion and plantigrade position of the fused ankle. This technique can be extended to include fusion of the subtalar joint by using two long angled screws after subtalar joint cartilage removal.

Fig. 2: The lower three screws loosened by 12 weeks postoperatively without iliac bone graft (A and B). The same plate was re-applied with iliac bone graft (C). Bony healing was achieved after an additional 12 weeks (D and E).

Apart from the advantages of an anatomically contoured anterior plate, the potential disadvantages should be considered. The plate and sagittally placed screws can provide excellent resistance to dorsiflexion-plantarflexion forces, but rotatory rigidity may be insufficient. The cam boot can provide additional protection to resist rotation force prior to solid fusion. In addition, CT was reported to be more accurate to assess successful union of a subtalar or triple arthrodeses compared with plain radiographs.[3] Although two independent observers evaluated all the X-ray films to confirm the successful ankle fusion, it is a weakness of this retrospective study.

CONCLUSION

The application of an anatomically contoured plate through an anterior approach provides many advantages, including minimal soft tissue disruption, ease of deformity correction, early rehabilitation, and a high rate of union. We believe it is easily reproducible and can be recommended for patients with failed fusion and posttraumatic arthritis with a previous history of infection and/ or poor bone quality.

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