# Comparative study of midterm results of a modified technique for ankle fusion versus an anterior T plate

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**Introduction**
Although many techniques are available to fuse the ankle, current recommendations favor the use of internal fixation with screws and/or plates. Despite the progress, the complication rate remains a major concern. This study is a prospective case series study that was carried out to assess the functional outcome of open ankle fusion using two different techniques: modified compression and sliding graft, and an anterior AO T plate.

**Patients and methods**
Between June 2004 and November 2007, 22 tibiotalar arthrodesis by the modified compression fixation and sliding graft technique were performed (group A), and an anterior T plate (group B); each group included 11 patients. The average age of the patients in group A was 32.9 years (26–53), whereas in group B, it was 32 years (25–54). There were 18 men and four women. Among these, 18 patients had post-traumatic arthritis, three had primary osteoarthrosis, and one had sciatic nerve injury.

**Results**
A rate of fusion achieved was 100 and 91% (groups A and B, respectively). Patients with a minimum follow-up period of 32 months after the arthrodesis were analyzed. The average follow-up period was 42 months (range, 32–58 months). Tibiotalar fusion was achieved in all the ankles at an average of 13 weeks (range, 10–19 weeks), 14.6 weeks (range, 13–21 weeks) (groups A and B, respectively).

**Conclusion**
Although arthrodesis of the ankle that uses lag screws for internal fixation is a safe and biomechanically stable method to obtain a solid ankle fusion and yields excellent results in most patients, there were no significant differences between both techniques of ankle fusion.

**Keywords:**
ankle fusion, AO T plate, compression technique, screws

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## Introduction

Despite appropriate acute treatment, many foot and ankles injuries result in post-traumatic arthritis. More than 40 open procedures have been described for ankle arthrodesis, most with high complication rates. From the early 1950s to the mid 1970s, external fixation was the dominant technique utilized. In the late 1970s and 1980s, internal fixation techniques for ankle arthrodesis were developed. In 1983, arthroscopic ankle arthrodesis was described for ankle arthrosis with minimal or no deformity. The open technique is still widely used for ankle arthrosis with major deformity and for complex cases that involve nonunion, extensive bone loss, Charcot arthropathy, or infection. The fusion rate in most recently published studies is 85% or greater, and may depend on the presence of infection, deformity, avascular necrosis, and nonunion. Compression fixation, when possible, remains the treatment of choice [1–3].

Although many techniques are available to for ankle fusion, current recommendations favor the use of internal fixation with screws and/or plates. Despite the progress, the complication rate remains a major concern [4]. Nonunion is one difficult problem, especially with difficult bone conditions, particularly the loss of bone stock on the talar side. Therefore, fusion of the tibiotalar joint is often extended to the talocalcaneal joint to provide sufficient stability.

To preserve the subtalar joint and to achieve a good fusion rate, a modified combined compression fixation technique and an anterior sliding graft were used in this series, comparing the results with another rigid compression technique: anterior AO T plating.

## Patients and methods

Between June 2004 and June 2007, we performed ankle arthrodesis on 22 patients, divided into two groups, 11 patients in each group. In group A, ankle fusion was performed using the new modified combined compression fixation technique and an anterior sliding graft was

used. In group B, an anteriorly placed T plate was used for ankle fusion.

Group A: 11 tibiotalar arthrodesis by modified compression fixation and sliding graft technique were performed. The average age of the patients was 32.9 years (25–53). There were eight men and three women; among these, eight patients had post-traumatic arthritis, two had primary osteoarthrosis, and one had sciatic nerve injury (Table 1).

### Surgical procedure

Through a longitudinal incision placed 1 cm medial to the midline, a zigzag incision was made through the extensor retinaculum, which facilitated repair when closing the wound. The interval between the extensor hallucis longus and the extensor digitorum longus was developed with the neurovascular bundle retracted medially. The capsule, periosteum, and synovium were incised in line with the skin incision. With the joint widely exposed, the tibial articular surface was denuded and avascular necrotic loose pieces of the talar body were removed. The joint surfaces were removed with osteotomes to expose the cancellous layer of subchondral bone. Most of the medial malleolus was excised with preservation of the lateral malleolus. The talus was then compressed manually under the tibia; the foot was kept in about 5–10° of planter flexion while the two crossing cancellous short-threaded 6.5 mm screws were inserted from the medial and lateral aspects of distal tibia delivered into the talus. This step was checked intraoperatively by image control. Then, anterior sliding arthrodesis was performed. To slide the graft, a 1.5 cm × 6 cm cut was made in the distal anterior portion of the tibia; this graft was snuggly fitted into a slot deeply gouged into the neck of the talus. Cancellous bone from the tibial graft site was then harvested and packed around the sliding graft; finally, the distal portion of the graft at the talar side was secured with a small 4-mm short-threaded cancellous screw. The sequence of delivery of the hardware minimized the likelihood of intraosseous screw collision. The strategic placement of the screws also prevents stress concentration, which may lead to stress risers in the distal tibia (Figs 1–3).

Postoperatively, a below-knee cast was used in all patients, changed after 6 weeks. Determination of when to place weight was made after radiographic evidence of healing of the graft and fusion of the joint.

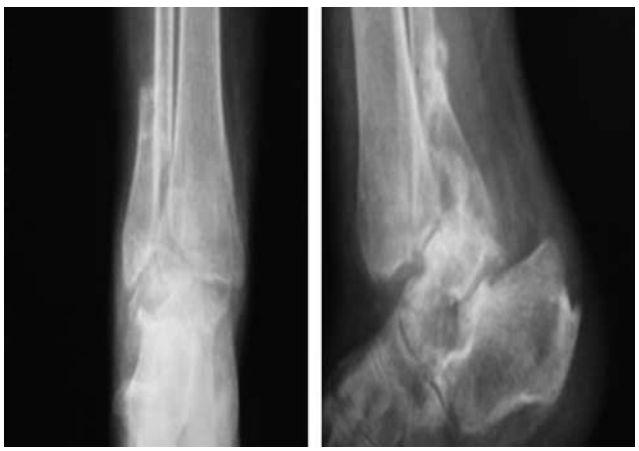
For group B, between 2004 and 2007, we performed ankle arthrodesis on 11 patients using an anterior AO T plate. There were 10 men and one woman, mean age at operation of 32 years (25–54).

Follow-up was retrospective and consisted of a review of all preoperative, perioperative, and postoperative medical records and of preoperative and postoperative radiographs for each patient. They were not seen outside their normal clinical follow-up.

**Table 1 Distribution of age, sex, and results of the two groups studied**

| | Sex | | Average age | Fusion rate (%) | Final Outcome | | |
|---|---|---|---|---|---|---|---|
| | Male | Female | | | Excellent | Good | Poor |
| Group A | 8 | 3 | 32 | 100 | 9 | 2 | 0 |
| Group B | 10 | 1 | 32.9 | 91 | 7 | 3 | 1 |

**Figure 1**



Preoperative radiographs of a post-traumatic neglected fracture dislocation.

**Figure 2**

Immediate postoperative radiographs showing the orientation of the screws and rigid stability of tibiotalar contact.

**Figure 3**

Fourteen-week follow-up radiographs (lateral view) showing solid fusion.

### Operative technique

As in group A, the approach and incision were the same.

The talus was then manually compressed under the tibia and held by a standard AO tibial T plate with two screws into the talus. The first screw to be positioned was the central tibial screw through the slot in the plate. It was placed proximally in the slot to allow additional compression of the talus under the tibia. Two cancellous screws were placed into the talus. The other tibial screws were then positioned. An intraoperative radiograph was required to ensure the correct placement of the screws.

The talar screws must be passed horizontally. If they are directed inferiorly, there may be a risk of penetration of the subtalar joint. In most cases, the original shape of the AO T plate was correct, and it did not require further contouring, which would tend to direct the talar screws inferiorly and sublux the body under the tibia. If there are large osteophytes or relative flattening of the body of the talus, it is necessary to cut a slot in the neck to seat the T portion of the plate (Fig. 4).

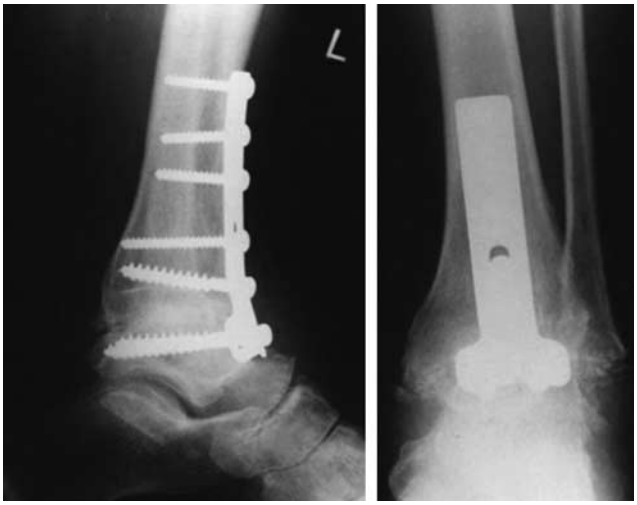
Our preferred plate is the AO tibial T plate. If there is incomplete bony apposition between the tibia and talus, a bone graft is used as an adjunct. A local graft from the excised malleoli was used.

Postoperatively, the patients were immobilized in a below-knee plaster cast until there was radiological evidence of fusion. They were allowed partial weight bearing for the first 6 weeks, increasing to full weight bearing as tolerated from 6 weeks onwards.

After the removal of the plaster, 50% of patients were then placed in a bivalved plastic ankle brace for a period of 6–8 weeks.

The Wilcoxon rank-sum test was used to determine any statistical significant difference between the two groups.

**Figure 4**




Radiographs taken 3 months after arthrodesis showing the typical position of internal fixation and sound union of a patient from group B.

## Results

In group A, the rate of fusion achieved was 100%. Patients with a minimum follow-up period of 24 months after the arthrodesis were analyzed. The average follow-up period was 32 months (range, 24–46 months). Tibiotalar fusion was achieved in all the ankles at an average of 13 weeks (range, 10–19 weeks).

All the cases were assessed radiologically and there was trabeculation across the talus and tibia; the sliding graft also showed trabeculation across the tibia and the talar neck.

Limb length discrepancies were also measured and shortening of an average of 0.8 cm was observed.

There was one case of a superficial wound infection, and no cases of broken screws or deep infection or nonunion were encountered in this series.

The results were considered excellent if the patient was able to return to full activity with a completely asymptomatic foot and ankle. If there was occasional discomfort causing no restriction in activities, the results were considered good; if pain was severe enough to limit activities or to require an analgesic, the results were considered poor. On the basis of these criteria, the results were excellent in nine patients and good in two.

The tibiopedal motion is defined as the arc of motion between maximum dorsiflexion and maximum planter flexion, the angles being those subtended by the long axis of the tibia and foot in the lateral projection. Seven patients, all with excellent results, had 15–20° of tibiopedal motion.

In group B, a rate of fusion of 91% was achieved. Only one patient developed nonunion and required another procedure. After 14 months, both talar screws were found to be broken and the ankle had not arthrodesed. At 15 months, the metal ware was removed and the ankle was fused using a noninstrumented graft. There were no technical difficulties or obvious surgical errors associated with the primary surgery.

One patient developed a stress fracture that occurred 9 months after the operation at the level of the most superior tibial screw. It healed in 2 months with immobilization and internal fixation was not removed.

There were two cases of superficial wound breakdown or infection. These were in patients in whom two incisions had been used. Infection involved the bridge of tissue between incisions. In one patient, *Staphylococcus aureus* was isolated and skin grafting was required 8 weeks after the operation. The other had a small area of wound breakdown that did not require a surgical intervention or admission to hospital.

In seven patients, radiographs suggested that the talar screws may have penetrated the subtalar joint, but only one patient had pain at this site.

In one patient, there was some mild residual pain over the plate, which was removed 2 years after the initial arthrodesis.

The results were excellent in seven patients, good in three, and poor in one. Tibiopedal range of motion was almost the same as in group A.

A nonsignificant statistical difference was found between the results of the two studied groups in terms of the fusion rate, time to fuse, and the final outcome.

## Discussion

Although inflammatory and osteoarthritis can occur, post-traumatic arthritis is the most common form of arthritis to affect the ankle. Post-traumatic ankle arthritis occurs in a generally younger, active population. The role and effectiveness of conservative/nonoperative treatment needs to be further determined. Surgical procedures include distraction arthroplasty, arthrodesis, or total ankle arthroplasty. Arthrodesis generally has a good outcome, but its limitations have been recognized. These limitations include the extended time required to achieve union, potential for nonunion, arthritis developed in adjacent joint, leg length discrepancy, and malalignment, and chronic edema, symptoms because of hardware, stress fractures, and continued pain. Although first-generation total ankle arthroplasty led to poor results, advancements in prosthetic design and surgical technique have revived optimism in terms of total ankle replacement as an alternative to arthrodesis. The key for the future of total ankle arthroplasty may not be related to the development of newer ankle components but rather in refining the criteria to determine who would best benefit from joint replacement versus fusion [5].

Arthrodesis of the ankle that uses lag screws for internal fixation is a safe and biomechanically stable method to achieve a solid ankle fusion; it generates good to excellent results in most patients. Prompt bone healing can be expected and allows a functional rehabilitation with full weight bearing. The surgical technique can be simplified further with the use of cannulated screws. Malalignment hazards while performing the ankle fusion are minimized by respecting the shape of the ankle mortise because no osteotomy of the lateral malleolus is performed. Generally, removal of the implanted material is not necessary. Major complications such as infection, stress fractures, or nonunion were not encountered in this series.

When evaluating the role of the ankle arthrodesis in the treatment of severe ankle arthritis, postoperative infection, nonunion, and the development of arthritis at the adjacent joints are major issues when considering treatment alternatives as reported by Zwipp *et al.* [6]. They followed up 72 patients for about 5 years. No patients developed a deep infection; union occurred in 99%. Secondary arthritis of the subtalar and talonavicular joints developed during the follow-up period in 17 and 11% of patients, respectively. Finally, they concluded that ankle arthrodesis with screws provides high rates of union, reliable pain relief, and favorable functional midterm results. Their results are comparable with those of this series, but actually our patients need longer time for follow-up to clearly evaluate the condition of adjacent joints.

Theoretically, long-term functional and radiographic degradation is predictable after ankle fusion [7,8], but sound evidence from the consecutive analysis of the same cohort is lacking. Trichard *et al.* [9] re-evaluated the same group of patients of the same series at 7 and 23 years of follow-up; they found that the functional outcome did not deteriorate significantly between 1984 and 2000. This long-term follow-up with successive assessments using the same evaluation criteria did show, however, the presence of undeniable degradation of the subtalar joint, but with little or no severe clinical expression at follow-up of 19 years. There was no need for complementary fusion between 4 and 23 years of follow-up.

Although tremendous strides have been made in total joint arthroplasty for the knee and hip, this modality is still evolving in the ankle. Some of the problems that increase the difficulty in total ankle replacement include a high prevalence of post-traumatic arthritis that causes poor anatomic access, a higher incidence of neuroarthropathy and vascular deficiency, and poor soft tissue coverage. This is associated with an increased incidence of perioperative complications, such as wound dehiscence and infection. The use of ankle arthroplasty as an alternative to the ankle fusion is expanding, but the results reported have been limited to those in case series. The clinical results of ankle arthroplasty and arthrodesis after an average follow-up period were almost the same. The arthoplasty patients in all reports showed more postoperative complications that required surgery than fusion patients. However, the arthroplasty group showed better pain relief and preservation of motion, and no complications in adjacent joints [10–13].

The use of external fixation for ankle arthrodesis offers an alternative to internal screw fixation when bone quality is suboptimal, when complex ankle pathology is present, and as a salvage procedure for complicated cases. Recent reports on the use of external ring fixation or a Taylor spatial frame have shown promising outcomes with the use of this method in complicated cases [14,15].

Reported ankle fusion healing times vary between 7 and 72 weeks. High nonunion rates have led to an increased use of bone graft and bone graft substitutes. We only use cancellous bone obtained from the tibia around the sliding graft, but many other authors encourage the use of locally generated bone slurry, or recombinant morphogenetic protein-2, or porous tantalum to accelerate the time of healing and avoid nonunion in high-risk ankle fusion [16–18].

Anterior plating for ankle fusion, either a T plate or small DCP, or double anterior plating, is the only technique found in the literature achieving a significant higher fusion rate as in the present study [19–21], but the compression screws method is more simple, easier, uses a smaller incision, and does not cause stress fractures, with almost no skin complications. Morgan *et al.* [22] reported fusion rates of 95% using transarticular screw fixation and

Maurer *et al.* [23] reported a 100% fusion rate using the same technique. Similarly, internal fixation with plates anteriorly has been described in the literature with good results. Rowan *et al.* [24] reported a 94% fusion rate in a series of 33 patients treated with an anterior AO T plate.

Our study is a comparative study involving a small number of patients in each group. Although patients were not randomized in the study, we chose to compare the outcome of two forms of internal fixation used for open ankle arthrodesis. The limitations of the study were the lack of randomization, the small number of patients in each group, and no specific definition criteria on the type of internal fixation to be used. The choice of screws versus screws plus plate fixation was entirely a clinicoradiological decision. Although the etiology in both groups was identical, the lack of randomization and the small sample size in both groups reduce the clinical significance of our statistical conclusions.

## Conclusion

Although arthrodesis of the ankle that uses lag screws for internal fixation is a safe and biomechanically stable method to achieve a solid ankle fusion, it generates excellent results in most patients; there were no significant differences between both techniques of ankle fusion.

## Acknowledgements

### Conflicts of interest

There are no conflicts of interest.

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