Acta Orthop. Belg., 2006, **72**, 716-721

ORIGINAL STUDY

Comparative study of ankle arthrodesis using cross screw fixation versus anterior contoured plate plus cross screw fixation

Gopikrishna KAKARALA, Daniel T. RAJAN

From King's College Hospital, London, United Kingdom

Arthrodesis of the ankle joint is still the traditional treatment for symptomatic osteoarthritis. This comparative study was done to assess the functional outcome of open ankle fusion using either cross screw fixation (group A) or anterior contoured plate and cross screw fixation (group B) in a consecutive series of 22 patients. All the patients had the same inclusion criteria. All the patients in both groups underwent the same operative technique and were operated by the same surgeon. Mean follow-up was 26.8 months. The mean time to fusion was 18.8 weeks in group A and 16.8 weeks in group B (p = 0.046). The mean American Orthopaedic Foot and Ankle Society (AOFAS) Ankle and Hind foot score at the final follow-up was 79 in group A and 86 in group B (p = 0.23). Two patients in group A that went to non-union required re-arthrodesis using contoured plate and cross screw fixation ; both attained eventual union. We conclude that anterior contoured plate plus cross screw fixation is a simple and reproducible technique for ankle arthrodesis that gives stable internal fixation and excellent clinical results.

Keywords : ankle arthrodesis ; screw fixation ; plate ; non union ; contoured plate.

INTRODUCTION

Symptomatic osteoarthritis of the ankle joint is a difficult problem to treat. Treatment options include conservative measures such as walking aids, orthotic devices, and intra-articular steroids, while arthroscopic debridement, arthrodesis and joint replacement are well-established surgical treatment modalities. Albert (*1*) first described arthrodesis of the ankle in 1879, and this procedure is currently performed more frequently than that of the hip or knee (*21*). Different techniques have been described including external compression devices, open and arthroscopic debridement of joint surfaces, fixation by fibular strut grafts, interposition grafting and various forms of internal fixation with or without interposition grafting (*19*). Various methods of internal fixation have been reported to provide stable fixation progressing to union (*15, 18, 19*).

In 1951 Charnley popularised compression arthrodesis using an external compression clamp, emphasising the advantage of compressing the joint surfaces to decrease the rate of non-union. Reported rates of non-union with these devices

■ Gopikrishna Kakarala, MS Ortho, MRCSEd, Junior Clinical Fellow.

■ Daniel T. Rajan, Mch (Ortho), FRCS (Tr & Orth), Consultant Orthopaedic Surgeon.

King's College Hospital, London, United Kingdom.

Correspondence : Mr. G. Kakarala, 24 Heathend Road, Nuneaton CV10 7JQ, United Kingdom.

E-mail : kakaralagk@yahoo.com.

No benefits or funds were received in support of this study

ranged from 10 to 38% (*10*). However the high incidence of pin site infections and poor patient compliance paved the way for the increasing use of internal fixation techniques for ankle arthrodesis.

Bony apposition, compression and rigid immobilisation are necessary for successful arthrodesis of any joint. Biomechanical studies have shown that rigid fixation leads to increased rates of union in ankle arthrodesis (*7*). In general, more secure fixation is associated with increased rates of fusion. The technique of transarticular screw fixation provides excellent bony coaptation dorsally but contact between the sides of the talus and malleoli may not be complete (*15*). The rate of fusion of ankle arthrodesis has varied significantly between different series of internal fixation techniques, some having a non-union rate as high as 35% (*8, 10, 20*).

Morgan *et al* (*18*) reported fusion rates of 95% using transarticular screw fixation and Maurer *et al* (*15*) reported 100% fusion rate using the same technique. Likewise, internal fixation with plates anteriorly has been described in literature with good results. Rowan *et al* (*19*) reported 94% fusion rate in a series of 33 patients treated with an anterior AO T plate. Scranton *et al* (*20*) reported a 100% rate of fusion using either a medial or a lateral T-plate in their series. Mears *et al* (*16*) found a fusion rate of 82% in 17 patients treated with an anterior two-holed tension plate.

None of these previous studies have compared internal fixation using plates versus plates plus cross screw fixation. The purpose of this study was to provide a prospective comparison of two forms of internal fixation techniques of cross-cannulated screw fixation and anterior contoured plate plus cross screw fixation. Our aim was to assess the rate of fusion and functional outcome associated with both forms of fixation.

PATIENTS AND METHODS

Between June 2000 and July 2004 we performed open ankle arthrodesis on 22 consecutive patients using either cross screw fixation (group A) or anterior contoured plate and cross screw fixation (group B) in age and gender matched groups of patients. Patients who did not respond to non operative modalities of treatment and continued to have symptoms affecting activities of daily living and impeding function of the foot were included in the study. Patients with neuropathic findings were excluded from the study. None of these patients were suitable for arthroscopic fusion of the ankle joint. The choice of internal fixation was a clinicoradiological decision. We avoided plate in patients in whom the lower tibial shaft had an overtly sharp edge to its anterior border. We also avoided plate fixation in patients who due to past operations/infection had poor quality skin over the anterior part of the distal tibia. All patients in both groups were operated by the same surgeon (DTR) and were independently reviewed by another surgeon (GK). Mean follow-up was 26.8 months with a range of 12 to 47 months. Functional outcome of the procedure was assessed using the American Orthopaedic Foot and Ankle Society (AOFAS) ankle and hind foot scoring system (*12*) at the final follow-up.

At the time of follow-up, the efficacy of treatment was evaluated by clinical examination, radiographic assessment of union and alignment, assessment of ankle stability, time to union and ability to perform normal activities with the foot**.** Union was confirmed clinically as a pain-free stable joint correlating to evidence of fusion on radiographs. Clinical findings of painful abnormal mobility and joint line tenderness confirmed by radiographs constituted the criteria for non union. Clinical results were graded as excellent, good or poor. Excellent results were characterised by union and absence of pain and return to normal activities. Good results are those with union and mild pain, difficulty in performing normal activities. Results were rated as poor when there was moderate to severe pain, delayed union or non union and functional disability. Our follow-up programme consisted of regular clinico-radiological reviews at 2, 6, 12, 16, 24 and 52 weeks following the operation. Patients were then followed once annually throughout the study period.

Mean values of the following parameters were calculated : patient age, length of follow-up, time to union and AOFAS scores. The Wilcoxon rank sum test was performed to determine whether there was any statistically significant difference between the two patient groups with respect to time to union and AOFAS scores.

Operative technique

An anterior approach was used. Full thickness flaps were raised with utmost respect to the soft tissues without the use of self-retaining retractor. Tissue planes were developed between tibialis anterior and extensor hallucis

Fig. 1. — Radiographs taken 3 months after ankle arthrodesis using the cross screw fixation technique.

Fig. 2. — Radiographs taken 3 months after ankle arthrodesis showing the typical position of the anterior contoured plate and cross screw fixation and sound union.

longus tendons. When large anterior osteophytes were present these were removed to expose the joint line. The joint surfaces were freshened to expose cancellous subchondral bone. Both gutters were accessed through the same approach. When the fibula had to be excised it was approached via posterolateral incision. The freshened articular surfaces were then compressed to each other and held by either form of fixation depending on the group of the patient. Bone graft from the fibula was used to supplement the arthrodesis if any bone defects were noticed ; bone graft augmentation was used in 4 patients in group A and 4 patients in group B.

We used 2 crossed cannulated screws to achieve rigid fixation in patients from group A (fig 1). Patients in group B received a contoured narrow plate augmented with 2 cannulated screws (fig 2). Patients in both groups had a below-knee cast and remained toe touch weight bearing for 6 weeks, followed by partial weight bearing for the next 6 weeks. Thereafter, they went on to progressive weight bearing in a walking cast for 4 weeks.

RESULTS

Each group had 11 patients (12 ankles) with one patient having undergone bilateral procedures. There were 13 males and 9 females with mean age of 54 years (range : 33 to 88). The distribution of the patients in two groups is depicted in table I. The mean age of patients at the time of intervention was 56.7 years in group A and 53.1 years in group B.

Table I. — Demographics and distribution of patients in the two groups

	Group A	Group B
Sample size	11	11
Male	6 (54.5%)	7(63.6%)
Female	5 (45.4%)	4 (36.3%)
Mean age (Range)	56.7 (37-77)	53.1 (39-74)
Post traumatic osteoarthritis	7	7
Primary degenerative arthritis	2	2
AVN Talus	1	1
Failed ligament reconstruction	1	
Rheumatoid arthritis		1

Patients were followed-up for a mean duration of 26.8 months (range : 12 to 47). The mean time to fusion was 18.8 weeks (range : 16 to 22) in group A and 16.8 weeks (range : 16 to 20) in group B. Using the Wilcoxon rank sum test there is a marginal statistically significant difference between the two groups with respect to time to clinical union ($p = 0.046$). Two patients in group A developed a non-union. There were no technical difficulties or obvious errors associated with the primary surgery in either of these patients. Both patients underwent a

revision fusion procedure using a contoured anterior DCP and cross screw fixation resulting in eventual union. All patients in group B achieved union.

One patient in group B developed an undisplaced, unicortical stress fracture just above the proximal end of the plate. The fracture occurred at 18 weeks postoperatively, 2 weeks after she began full weight bearing without a plaster cast. The diagnosis of stress fracture was made with presenting symptoms of new onset of pain away from the arthrodesis site and confirmed by radiographs. This patient had a history of rheumatoid arthritis treated with methotrexate and steroids, and had undergone an uneventful arthrodesis of her contralateral ankle 18 months prior to this second ankle operation.

At the final follow-up, 80% of group A patients rated their outcome as excellent, 15% as good and 5% as poor. One patient in group A developed complex regional pain syndrome that resolved with treatment. Ninety percent of the patients in group B rated the outcome as excellent while the rest rated the outcome as good. As a result of the surgical intervention all patients in both groups had their preoperative ambulatory status enhanced. The mean AOFAS ankle and hind foot score in group A was 79 and in group B was 86. Using the Wilcoxon rank sum test there was no statistically significant difference in the two groups in AOFAS Scores ($p = 0.23$). Two patients in group A and one patient in group B commented on the fact that they regretted not having had the surgery performed earlier.

Clinical findings of painful abnormal mobility and joint line tenderness confirmed by radiological investigations constituted the criteria for non union. Two patients in group A developed non-union. There were no technical difficulties or obvious errors associated with the primary surgery in either of these patients. Both underwent a revision fusion procedure using a contoured anterior DCP and cross screw fixation resulting in eventual union. All the patients in group B achieved union.

DISCUSSION

Arthrodesis is still a standard surgical procedure for treatment of symptomatic osteoarthritis of the ankle joint. The long term follow-up studies of ankle arthrodesis performed for isolated ankle osteoarthritis have shown symptomatic osteoarthritis in other joints of the foot (*5*). Ankle arthroplasty is other alternative to prevent these complications. Conventionally arthroplasty has been reserved for patients with polyarthritis with low physical demand and arthrodesis for osteoarthritis because of early failure of the prosthesis (*13*). Kofoed *et al* (*13*) showed equally good results in both rheumatoid and osteoarthritis groups treated by cemented ankle arthroplasty. However ankle arthroplasty is a technically challenging procedure with five year survival rates of 70%, much lower than in the hip or knee (*2*). Anderson *et al* (*2*) recommended arthrodesis when there is deficient bone stock, severe malalignment of the hind foot that cannot be corrected before or during replacement and whenever wound healing problems can be expected. These operations were done in our patients who opted for ankle fusion and certainly in the physiologically young male, we recommended ankle fusion as against prosthetic replacement.

Arthroscopic ankle arthrodesis has become a viable option in selected patients. The advantages of arthroscopic ankle arthrodesis are high fusion rate, less time to fusion and low cost (*9, 24*) as compared to the open arthrodesis. However the patient selection criteria should be critical with no or mild angular deformity and less than 30% avascular necrosis of the talus (*24*). The senior author (DTR) has his strict criteria for performing arthroscopic fusion of the ankle joint and none of the patients in this cohort was an ideal candidate for arthroscopic fusion.

Our study is a comparative study involving a small number of patients in each group. Though patients were not randomised in the study, we elected to compare the outcome of two forms of internal fixation used for open ankle arthrodesis. The limitations of the study were lack of randomisation, 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 aetiology in both groups was identical (table I), the lack of randomisation and small sample size in both

groups reduces the clinical significance of our statistical conclusions.

Our results of fusion using the transarticular screw fixation were inferior to those reported in previous studies (*15, 18*). This might be a reflection of poor patient selection in our series, as both patients who experienced non-union had bone loss and severe deformity. With respect to combined plate and screw fixation, our results were comparable to previous studies but with a greater percentage of fusion.

The AOFAS developed four rating systems to provide a standard method of reporting clinical results of foot and ankle surgery. This rating scale takes into account subjective and objective factors and represents them on a numerical scale to describe function, alignment and pain (*12*). However, later studies have shown that the AOFAS score does not reflect the true outcome following surgical interventions to the ankle and hind foot (*3, 23*). However, SooHoo *et al* (*22*) reported a strong correlation between the AOFAS and the SF 36 when it concerns the hind foot. As our study was related to the hind foot, we elected to use the AOFAS score.

Stress fractures in the tibia following ankle and hind foot arthrodesis have been reported in the literature (*6, 14, 17, 19*). In a series of 165 patients who underwent ankle and triple arthrodesis, Lidor *et al* (*14*) reported stress fractures in 13 patients at a mean follow-up of 16 months. Rowan *et al* (*19*) reported two stress fractures in their series of 33 patients who had ankle arthrodesis with use of anterior T-plate. One fracture occurred 3.5 months postoperatively and the other 9 months following arthrodesis. Both fractures were in the distal tibia at the proximal end of the plate and were managed non operatively. The factors that contribute to these fractures were increased bending forces transmitted to the distal tibia by the longer lever arm of a rigid foot compounded by concomitant decrease in the mechanical strength of bone following surgery and immobilisation (*11*). In the patient who developed a stress fracture in our series, disuse and rheumatoid-related osteopenia in combination with the increased forces that occur during gait after arthrodesis (*4*) might have contributed to the stress fracture 18 weeks postoperatively.

An ankle arthrodesis is considered successful if it can restore the patient's function in terms of activities of daily living. This is reflected in the outcome assessment scores of our patients using the AOFAS ankle and hind foot rating scale although there is no statistical significant difference in the forms of internal fixation. The supplementation of the anterior contoured plate to cross screw fixation has provided stable fixation leading to probable higher rate of arthrodesis.

REFERENCES

1. **Abdo RV, Wasilewski SA.** Ankle arthrodesis : a long term study. *Foot Ankle* 1992 ; 13 : 307-312.
2. **Anderson T, Montgomery F, Carlsson A.** Uncemented STAR total ankle prosthesis. *J Bone Joint Surg* 2004 ; 86-A Suppl 1 : 103-111.
3. **Brodsky AR, O' Malley MJ, Bohne WH *et al.*** An analysis of outcome measures following the Brostrom-Gould procedure for chronic lateral ankle instability. *Foot Ankle Int* 2005 ; 26 : 816-819.
4. **Carmines DV, Nunley JA, McElhaney JH.** Effects of ankle taping on the motion and loading pattern of the foot for walking subjects. *J Orthop Res* 1988 ; 6 : 223-229.
5. **Coester LM, Saltzman CL, Leupold J, Pontarelli W.** Long term results following ankle arthrodesis for post traumatic arthritis. *J Bone Joint Surg* 2001 ; 83-A : 219-228.
6. **Crosby LA, Yee TC, Formanek TS, Fitzgibbons TC.** Complications following arthroscopic ankle arthrodesis. *Foot Ankle Int* 1996 ; 17 : 340-342.
7. **Dohm MP, Benjamin JB, Harrison J, Szivek JA.** A biomechanical evaluation of three forms of internal fixation used in ankle arthrodesis. *Foot Ankle Int* 1994 ; 15 : 297-300.
8. **Dohm M, Purdy BA, Benjamin J.** Primary union of ankle arthrodesis : review of single institute/ multiple surgeon experience. *Foot Ankle Int* 1994 ; 15 : 293-296.
9. **Ferkel RD, Hewitt M.** Long term results of arthroscopic ankle arthrodesis. *Foot Ankle Int* 2005 ; 26 : 275-280.
10. **Hagen RJ.** Ankle arthrodesis : Problems and pitfalls. *Clin Orthop* 1986 ; 202 : 152-162.
11. **Hvid I, Rasmussen O, Jensen NC, Nielsen S.** Trabecular bone strength profiles at the ankle joint. *Clin Orthop* 1985 ; 199 : 306-312.
12. **Kitaoka HB, Alexander IJ, Adelaar RS *et al.*** Clinical rating systems for the ankle-hind foot, midfoot, hallux and lesser toes. *Foot Ankle Int* 1994 ; 15 : 349-353.
13. **Kofoed H, Sorensen TS.** Ankle arthroplasty for rheumatoid arthritis and osteoarthritis : prospective long term study of cemented replacements. *J Bone Joint Surg* 1998 ; 80-B : 328-332.

14. **Lidor C, Ferris LR, Hall R *et al.*** Stress fracture of the tibia after arthrodesis of the ankle or the hindfoot. *J Bone Joint Surg* 1997 ; 79-A : 558-564.
15. **Maurer RC, Cimino WR, Cox CV, Satow GK.** Transarticular cross screw fixation A technique of ankle arthrodesis. *Clin Orthop* 1991 ; 268 : 56-64.
16. **Mears DC, Gordon RG, Kann SE, Kann JN.** Ankle arthrodesis with an anterior tension plate. *Clin Orthop* 1991 ; 268 : 70-77.
17. **Mitchell JR, Johnson JE, Collier BD, Gould JS.** Stress fracture of the tibia following extensive hindfoot and ankle arthrodesis : a report of three cases. *Foot Ankle Int* 1995 ; 16 : 445-448.
18. **Morgan CD, Henke JA, Bailey RW, Kaufer H.** Long term results of tibiotalar arthrodesis. *J Bone Joint Surg* 1985 ; 67-A : 546-550.
19. **Rowan R, Davey KJ.** Ankle arthrodesis using an anterior AO T plate. *J Bone Joint Surg* 1999 ; 81-B : 113-116.
20. **Scranton PE Jr.** Use of internal compression in arthrodesis of the ankle. *J Bone Joint Surg* 1985 ; 67-A : 550-555.
21. **Scranton PE.** An overview of ankle arthrodesis. *Clin Orthop* 1991 ; 268 : 96-101.
22. **SooHoo NF, Shuler M, Fleming LL.** Evaluation of the validity of the AOFAS Clinical Rating Systems by correlation to the SF-36. *Foot Ankle Int* 2003 ; 24 : 50-55.
23. **Westphal T, Piatek S, Halm JP *et al.*** Outcome of surgically treated intraarticular calcaneus fractures–SF-36 compared with AOFAS and MFS. *Acta Orthop Scand* 2004 ; 75 : 750-755.
24. **Zvijac JE, Lemak L, Schurhoff MR *et al.*** Analysis of arthroscopically assisted ankle arthrodesis. *Arthroscopy* 2002 ; 18 : 70-75.