

COMPARING OUTCOMES OF THE ANKLE ARTHRODESIS BY USING TWO DIFFERENT MATERIALS VIA A TRANSFIBULAR APPROACH

COMPARAÇÃO DOS RESULTADOS DA ARTRODESE DO TORNOZELO USANDO DOIS DIFERENTES MATERIAIS ATRAVÉS DE UMA ABORDAGEM TRANSFIBULAR

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ABSTRACT

Objective: To compare clinical and radiologic results and complications of patients who underwent arthrodesis using a transfibular approach with either a cannulated screw or an anterior fusion plate. **Methods:** Patients who underwent ankle arthrodesis were divided into two groups according to the used materials: 6.5 mm cannulated screw (A) and anterior fusion plate (B). The clinical scores were compared between groups. The radiologic results were then assessed by union time. The results were statistically analyzed using SPSS 20. **Results:** There was no significant difference between both groups in the American Orthopedic Foot & Ankle Society (AOFAS) score ($p = 0.75$), and in the visual analog scale ($p = 0.42$). In group B, two cases included wound infection at the surgical site. In group A, the mean union time was 10.5 ± 2.3 weeks. In group B, it was 7.8 ± 1.3 . There was a statistically significant difference ($p = 0.007$) between union time in both groups. **Conclusion:** Anterior fusion plate is an effective method for shorter union time, but the surgeon should be careful with the surgical wound at the skin incision site in the lesion of the distal tibia. **Level of Evidence III, Retrospective comparative study.**

Keywords: Ankle Joint. Osteoarthritis. Arthrodesis.

RESUMO

Objetivo: Comparar os resultados clínicos e radiológicos assim como as complicações de pacientes sujeitos a artrodeose de abordagem transfibular com o uso de parafuso canulado ou placa óssea anterior. **Métodos:** Pacientes sujeitos a artrodeose do tornozelo foram divididos em dois grupos de acordo com os materiais usados: parafuso canulado de 6,5 mm (A) e placa óssea anterior (B). Os escores clínicos de ambos os grupos foram comparados e os resultados radiológicos foram avaliados de acordo com o tempo de união óssea. Os resultados foram analisados estatisticamente usando SPSS 20. **Resultados:** Não houve diferença significativa entre os grupos quanto ao escore American Orthopedic Foot & Ankle Society (AOFAS) ($p = 0,75$) e a escala visual analógica ($p = 0,42$). No grupo B, ocorreu infecção na área da cirurgia em dois casos. No grupo A, a média de tempo de união foi de $10,5 \pm 2,3$ semanas. No grupo B, este foi de $7,8 \pm 1,3$. Constatou-se diferença estatisticamente significativa ($p = 0,007$) quanto ao tempo de união em ambos os grupos. **Conclusão:** Os autores concluíram que a placa óssea anterior é um método eficiente para tempos de união curtos, porém o cirurgião deve ficar atento à ferida cirúrgica na área de incisão da pele em casos de lesão na tibia distal. **Nível de Evidência III, Estudo retrospectivo comparativo.**

Descritores: Articulação do Tornozelo. Osteoartrite. Artrodeose.

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INTRODUCTION

Ankle arthrodesis in end-stage ankle osteoarthritis is still a treatment of choice for this condition due to its short learning curve, short-term follow-up, and fewer complications compared to other treatments, such as failure of implants.¹⁻⁴

There are many reports about the approach and the fixation method for the arthrodesis,¹ including arthroscopic and open arthrodesis.

The required time for the arthroscopic ankle arthrodesis may be longer than that for the open arthrodesis depending on the surgeon's proficiency.^{5,6} In addition, arthroscopic ankle arthrodesis has a disadvantage, because it cannot be performed when there is more than 5° varus or valgus deformities or in the case of a severe bone defect.⁷ Because of such advantages, open arthrodesis is commonly used.

Open approaches include anterior, transfibular, and posterior methods. Among them, the transfibular approach is widely used because it provides enough operation field of view with the advantage of avoiding anterior neurovascular injuries or injury of the posterior deep flexor tendon.⁴ The fixation materials for arthrodesis are the following: cannulated screw, cancellous screw, or plate. Cannulated screw fixation is the most commonly used one to apply a compression force to the fusion site.⁸ Arthrodesis with anterior fusion plate has been reported recently.⁹⁻¹¹ Although there are many studies reporting results for each fixation material,^{1,4} studies that compare these materials are insufficient. This study aims to compare clinical and radiologic results, complications of patients who underwent an arthrodesis using a 6.5 mm cannulated screw, and those who underwent arthrodesis using the same approach with an anterior fusion plate.

MATERIALS AND METHODS

Patient population

The study plan and the patient's data analysis were approved by the Institutional Review Board (IRB number: DSH-인-19-14) of Sun Medical Center. All participants signed an informed consent form. From August 2011 to August 2017, 24 patients (24 cases) underwent arthrodesis due to end-stage osteoarthritis of ankle joints with more than 5° of varus or valgus ankle joint deformity (Figure 1). All cases were performed with the transfibular approach. In group A, 12 cases underwent arthrodesis with three 6.5 mm cannulated screw (Biomet Trauma, IN, USA) (Figure 2), and 12 cases in group B, with anterior fusion plate (Arthrex Inc, FL, USA) (Figure 3). After choosing the fixation materials from the two groups, screws were used in group A in February 2017, in Korea, before the introduction of the anterior fusion plate in group B, which was then performed. The mean patients' age at the time of surgery for group A was 56.9 years (ranging from 33 to 69 years old) and 64.1 years for group B (ranging from 53 to 81 years old). The mean follow-up period was 15.4 months for group A (ranging from 13 to 27 months) and 14.8 months for group B (ranging from 12 to 18 months). There were no statistically significant differences in sex, body mass index (BMI), mean age, diabetes mellitus (DM), smoking, surgical side, durations of symptom, and mean follow-up period between the two groups (Table 1).

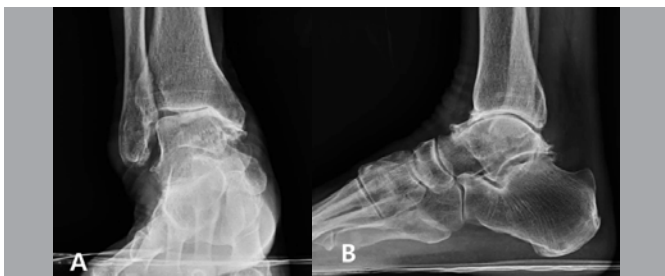


Figure 1. Plain radiographs showing end-stage arthritis in the ankle joint through anteroposterior (AP) view (A) and lateral view (B).



Figure 2. Plain radiographs showing an arthrodesis from group A using the 6.5 mm cannulated screw (Biomet Trauma, Indiana, USA) and complete fused ankle joint on AP view (A) and lateral view (B).

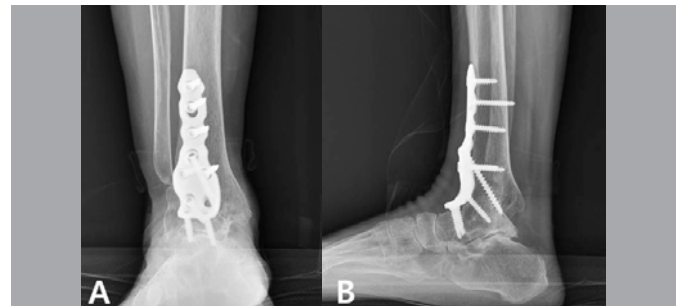


Figure 3. Plain radiographs showing an arthrodesis from group B with anterior fusion plate (Arthrex Inc, Florida, USA) and complete fused ankle joint on AP view (A) and lateral view (B).

Table 1. A statistical description of the case series (N = 24).

	Group A (n = 12)	Group B (n = 12)	P*
Sex (M:F)	8:4	7:5	0.347
Mean age (years)	56 (33 to 69)	64 (53 to 81)	0.235
BMI (kg/m ²)	23.1 3.0	25.2 4.5	0.786
Surgical Side (Left:Right)	5:7	3:9	0.413
DM	2 (16%)	4 (33%)	0.566
Smoking	4 (34%)	3 (25%)	0.651
Follow-up period (months)	15.4 5.1	14.8 2.0	0.786
VAS score at final follow-up	2.3 0.6	2.4 0.5	0.487
AOFAS Ankle-Hindfoot score	64.4 6.1	65.3 5.5	0.525
Union time (weeks)	10.5 2.3	7.8 1.3	0.007
Complications			
Skin necrosis	0 (0%)	2 (16%)	NA

The values are given as mean ± standard deviation. P*: p-value, Mann-Whitney test comparing group A and B; p-value < 0.05 indicates statistical significance; BMI: body mass index (kg/m²); DM: Diabetes Mellitus; Smoking: more than 10 packs/years; VAS: visual analog scale; AOFAS Ankle-Hindfoot score: American Orthopedic Foot and Ankle Society Ankle-Hindfoot score; NA: not applicable.

Surgical technique & postoperative management

The patients on the operating table underwent spinal or general anesthesia using a typical tourniquet in the supine position. For the transfibular approach, an incision was made over the posterior half of the fibula, starting from 8 to 10 cm proximal to the tip of the fibula (Figure 4A). If more skin incision was needed, another incision was made curving anteriorly and distally over the sinus tarsi for another 2 to 4 cm toward the base of the fourth metatarsal. The approach used the internervous plane between the sural nerve posteriorly and the superficial peroneal nerve anteriorly. When performing the dissection at the level of the fibula, full-thickness flaps were created and a subperiosteal dissection was performed to minimize soft tissue

tension. A fibular osteotomy was performed from 3 to 5 cm proximal to the level of the ankle joint. An oblique osteotomy from proximal lateral to distal medial was preferred. The cut edge was beveled to avoid creating bony prominence. Using a micro sagittal saw in the sagittal plane, the medial third of the fibula was removed, morselized, saved as bone graft, and then it was trimmed as a structural and bone chip type.

Fibular bone graft was performed in all cases, because this study speculated that it could reduce the risk of shortening the limb length and that it maintained the stable fusion construct. Although there were many methods of autogenic bone graft, the study used only the fibular structural bone harvest via a transfibular approach, because it could achieve an appropriately structural bone graft and had no additional incisions for the harvest.

A joint distractor or laminar spreader was used to fully expose the tibial plafond and the dome of the talus. Tibial plafond and talar dome preparations were performed with transverse flat cuts. The residual articular cartilage was removed with an osteotome, a curette, and a high-speed burr, exposing the subchondral bone. The medial side of the ankle joint was exposed by the anterior approach between the extensor hallucis longus and the tibialis anterior. The medial cartilage of the talus and tibia was then removed. When a plate was used for arthrodesis, the anterior skin incision was extended over the proximal portion to the distal tibia. The skin incision was carefully made at that time. The anterior skin incision should be sufficiently spaced (more than 5 cm) from the lateral skin incision (Figure 4B). The skin incision interval aimed to prevent skin necrosis at the incision site. The cartilage was removed, and the ankle alignment was adjusted to a neutral extension, 5° of valgus, 5° of external rotation, and hindfoot posteriorly. A 6.5 mm cannulated screw or anterior fusion plate was used for the arthrodesis with an autogenous bone graft from a fibular bone. In screw fixation methods, three cannulated compression screws were applied at 45 degrees on the long axis of the tibia; two of them were into the medial side of the tibia from the lateral side of the talus, and one was into the anterior neck of the talus from posterior surface of the tibia, which is called 'home run screw.'

In the anterior plate method, the ankle was temporarily fixed in a proper position by the Kirschner wire. After the plate was applied, the locking screw was used through the distal talar holes. The compression force in the ankle joint was obtained by placing a nonlocking screw eccentrically in the oblong compression hole on the tibial portion of the plate, and the fixation was continued in the anatomic lag screw hole and in the remained proximal plate holes.

In all cases, the suture was removed postoperatively after two weeks. Short leg cast immobilization and non-weight-bearing were performed for 6 weeks. At 6 weeks, partial-weight-bearing was allowed using walking cast or cam walker boot. Only at 8 weeks the full-weight-bearing was allowed using a cam boot.



Figure 4. Pictures showing the preparation of skin incision for the approach. We prepared the skin incision for transfibular approach (A). And then, the designed skin incision over the posterior half of the fibular, starting from 8 to 10 cm proximal to the tip of the fibula. Interval between the transfibular approach (asterisk) and the anterior approach (arrow) at more than 5 cm (B).

Clinical and radiologic assessment

The clinical assessment used “the American Orthopedic Foot and Ankle Society Ankle-Hindfoot” Score (“AOFAS hindfoot-ankle” score)^{12,13} and the Visual Analog Score (VAS) before and after the surgery. Postoperative complications, such as wound infection and metal failure, were recorded. The radiologic assessment was performed at 2, 3, 6, 9, and 12 months postoperatively. Plain radiographs were taken at standing posture to confirm the fixation and the fusion status.

The fusion of joints was judged to be united when more than 50% of the ankle joint surface was connected on the anteroposterior and on the lateral plain radiographs. The delayed union was defined as a symptom of pain with the absence of union evidence for more than 6 months on radiographs and nonunion lasting for more than 12 months.⁸

Clinical scores, radiographic assessment, and period of the union were recorded for all cases and the statistical comparison was made between the two groups. The statistical tests were performed using the Kolmogorov-Smirnov test, the Leven's test, the Multiple linear regression analysis, the Mann-Whitney test, and the Wilcoxon signed rank test using SPSS 20 (IBM, Inc, New York, NY, USA). This study defined statistical significance level at 5% ($p \leq .05$).

RESULTS

Clinical results

“AOFAS hindfoot-ankle” score in group A was significantly increased ($p = 0.003$) from 43.3 ± 4.3 preoperatively to 64.4 ± 6.1 after the surgery. In group B, it was also significantly increased ($p = 0.002$) from 44.3 ± 4.3 preoperatively to 65.3 ± 5.5 after the surgery. However, there was no significant difference in this score between the two groups ($p = 0.525$) (Table 2).

In group A, the mean preoperative VAS was 7.3 ± 1.0 , significantly improved ($p = 0.003$) to 2.3 ± 0.6 after the surgery. In group B, the mean preoperative VAS was 7.5 ± 0.9 and also significantly improved ($p = 0.002$) to 2.4 ± 0.5 after the surgery. There was no statistically significant difference ($p = 0.487$) in the VAS between the two groups (Table 2).

Nonunion was not observed in both groups. In group B, two cases had wound infection at the surgical site (Figure 5A), and the patients were being treated for diabetes mellitus. One of them underwent skin grafting surgery with full-thickness skin flap of the ipsilateral thigh (Figure 5B), while the other one underwent simple dressing and wound healing (Figure 5C). Neither case progressed to deep infection. The infection did not affect the bone union.

Table 2. Preoperative and Postoperative VAS and AOFAS scores in the Groups, A and B

	Outcomes	Preoperative	Postoperative	p-value
Group A (6.5 mm cannulated screw)	VAS	7.3 1.0	2.3 0.6	0.003
	AOFAS Ankle hindfoot score	43.3 4.3	64.4 6.1	0.003
Group B (Anterior fusion plate)	VAS	7.5 0.9	2.4 0.5	0.002
	AOFAS Ankle hindfoot score	44.3 4.3	65.3 5.5	0.002

Wilcoxon signed rank test comparing preoperative and postoperative in both groups
p-value < 0.05 indicates statistical significance; VAS: visual analog scale; AOFAS Ankle-Hindfoot score: American Orthopedic Foot and Ankle Society Ankle-Hindfoot score.

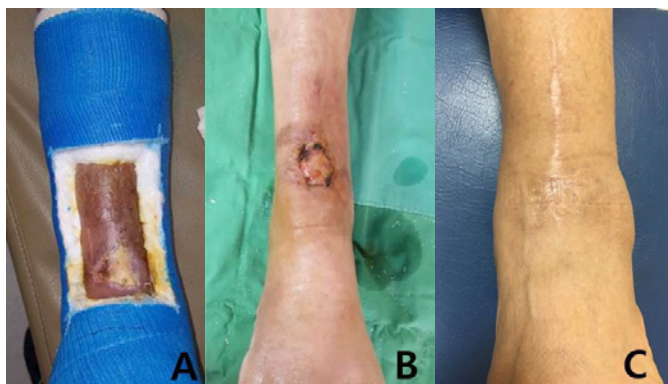


Figure 5. Pictures showing wound problems and the healing process. Surgical site infection occurred in Group B (A). The skin graft was done at infected surgical site (B). The wound was healed at infected surgical site after simple dressing (C).

Radiological results

All cases obtained fusion status in group A. The mean union time was 10.5 ± 2.3 weeks. In group B, fusion was achieved for all 12 cases. The mean union time was 7.8 ± 1.3 . A statistically significant difference ($p = 0.007$) was observed in the mean union time between the two groups.

Statistical analysis

The Kolmogorov-Smirnov test was used to confirm the normal distribution of the data in each group. The Levin's test was used to determine the equilibrium distribution of data between the two groups. The Mann-Whitney test and the Wilcoxon signed rank test were used to compare the results. Multiple linear regression analysis revealed that sex, age, DM, smoking, duration of symptom and BMI were not associated with clinical or radiological results.

DISCUSSION

Ankle arthrodesis is the most commonly used surgical procedure for the treatment of end-stage ankle osteoarthritis. Many approaches (medial, lateral, anterior, and posterior) and fixed materials have been introduced since the first report of the anterior approach by Albert.¹⁴ In general, the anterior and lateral approach are widely used.⁴ The lateral approach is also called the transfibular approach, and useful when it is necessary to do additional fibular osteotomy.¹⁵

The anterior approach can reach all ankle joint surface. However, it has limited access to the medial and lateral malleolus. It is an attentive approach that can injury the anterior vasculature.

However, the transfibular approach is in general easier to expose than the anterior approach. Due to the use of a full-thickness flap, there is less possibility of skin problems and fewer complications.¹⁶

In this study, all cases were performed by a transfibular approach. The most common method of arthrodesis is cannulated screw fixation that can exert a compressive force on the union site. Many studies about union rate, long-term follow-up results, and subsequent complications were performed.¹⁷ Recently, several methods using an anterior fusion plate have been introduced.⁹⁻¹¹ However, there are few comparative studies of plate fixation and cannulated screw fixation.

This study compared 12 cases of cannulated screw fixation and 12 cases of anterior fusion plate fixation via a transfibular lateral approach. As a result, clinical scores in each group were significantly improved after surgery, similar to those reported in previous studies.⁸⁻¹⁰ However, these scores were not significantly different between the two groups. Bone union time was measured at 10.5 weeks for group A and 7.8 weeks for group B. Group B showed significantly faster bone union ($p = 0.007$) than the group A.

Guo et al.⁹ has reported anterior fusion plate fixation performed in 10 cases of end-stage ankle arthritis. In 9 cases with mean 15 weeks follow-up, screw loosening after screw fixation resulted in a union period of 12 weeks in one anterior plate fixation. Although shorter union time was observed in this study, a simple comparison is not possible for those factors that affect the bone union.

According to Park et al.⁸, the union period of cannulated screw fixation was between 6 weeks and 40 weeks, with an average of 9 weeks. The results of their study were similar to those of the screw fixation group in this study. However, their study did not consider all factors affecting the bone union either. With both methods, the results of the union period were not significantly different.

Common complications of ankle arthrodesis are nonunion, malunion, wound infection, deep soft tissue infection, and arthritis of adjacent joints after a long-term follow-up.¹⁷ Mark et al.¹⁰ has reported that nonunion rates are high when arthrodesis of post-traumatic arthritis is performed and that nonunion tends to be due to smoking, history of diabetes, alcohol and illicit drug use, and psychiatric history. According to Zwipp H et al.¹⁶, screw fixation performed in a neutral posture of the ankle has a high fusion rate and low complication rate, with satisfactory functional results at mid-term follow-up.

Many long-term follow-up results have reported an incidence of osteoarthritis in adjacent joints, a typical complication of the nonunion.⁸ However, additional arthrodesis and surgical treatment about these complications remain controversial.

With an anterior approach using an anterior AO-T plate, 31 (94%) of a total of 33 cases achieved fusion. The incidence of complications was relatively low, and the technique was reported to be simple and stable.¹¹ In addition, Mark A et al.¹⁰ has compared nonunion rates of patients who underwent anterior locking fusion plate fixation and screw fixation. One case (2.1%) of patients with an anterior plate (47 cases) reported nonunion in the Mark A et al. study, and the patients using screw fixation reported 4 cases (11.1%). Therefore, the nonunion rate did not differ between the two groups.

In this study, there were no nonunions in both groups ($n = 24$) and two cases of wound infection (16%, 2/12) occurred in the anterior part of the distal tibia in group B. However, nonunions were not observed in these two cases.

In 2 cases, which had wound problem, had no DM, smoking, and other underlying disease.

A possible cause of the wound problem might be the tightness of the sutured wound.

This study has some limitations.

First, there are few cases studied. This study considered that the validity of the statistical analysis could be lower. Second, there were short term results. Long-term follow-up results are needed to observe more complications, such as an incidence of arthritis in the adjacent joint. To confirm the findings of this study, more prospective analysis and comparison with other approaches are

needed, along with more cases and long-term follow-up results for wound infection of the anterior skin of the distal tibia.

CONCLUSION

In conclusion, the anterior fusion plate in the treatment of end-stage ankle osteoarthritis was superior to a cannulated screw in bone

union time. However, complications, such as wound problems, were more common than with the screw method.

The authors concluded the anterior fusion plate is an effective method for the shorter union time, but the surgeon should be careful because of the wound at the skin incision site in the distal tibia lesion.

AUTHORS' CONTRIBUTIONS: Each author individually and significantly contributed to the development of this article. JBK: writing, reviewing, and performing surgeries; BJL: data analysis and writing; DJ: statistical analysis and review; UJ: data analysis and review; CA: writing and statistical analysis.

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