

# Arthroscopic Versus Open Ankle Arthrodesis: A Multicenter Comparative Case Series

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**Background:** Ankle arthrodesis results in measurable improvements in terms of pain and function in patients with end-stage ankle arthritis. Arthroscopic ankle arthrodesis has gained increasing popularity, with reports of shorter hospital stays, shorter time to solid fusion, and equivalent union rates when compared with open arthrodesis. However, there remains a lack of high-quality prospective data.

**Methods:** We evaluated the results of open and arthroscopic ankle arthrodesis in a comparative case series of patients who were managed at two institutions and followed for two years. The primary outcome was the Ankle Osteoarthritis Scale score, and secondary outcomes included the Short Form-36 physical and mental component scores, the length of hospital stay, and radiographic alignment. There were thirty patients in each group.

**Results:** Both groups showed significant improvement in the Ankle Osteoarthritis Scale score and the Short Form-36 physical component score at one and two years. There was significantly greater improvement in the Ankle Osteoarthritis Scale score at one year and two years and shorter hospital stay in the arthroscopic arthrodesis group. Complications, surgical time, and radiographic alignment were similar between the two groups.

**Conclusions:** Open and arthroscopic ankle arthrodesis were associated with significant improvement in terms of pain and function as measured with the Ankle Osteoarthritis Scale score. Arthroscopic arthrodesis resulted in a shorter hospital stay and showed better outcomes at one and two years.

**Level of Evidence:** Therapeutic Level III. See Instructions for Authors for a complete description of levels of evidence.

The disability associated with end-stage ankle arthritis is substantial, causing pain and severe limitation of function<sup>1,2</sup>. Open ankle arthrodesis traditionally has been the preferred surgical method to treat ankle arthritis, providing patients with less pain and improved function<sup>3</sup>. Since its first description in 1983<sup>4</sup>, arthroscopic ankle arthrodesis has gained increasing popularity. Improved instrumentation and greater experience have produced encouraging results, with most recent studies demonstrating shorter hos-

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pital stays and reduced time to solid fusion while maintaining fusion rates equivalent to those associated with open techniques<sup>5-7</sup>. An arthroscopic approach also extends the scope of ankle arthrodesis to include patients with compromised adjacent soft tissue who may be considered to have a relative contraindication to an open procedure.

The purpose of the present study was to compare patient-reported clinical outcome, morbidity, and length of hospital stay between two cohorts of patients who were managed with either an

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open or an arthroscopic arthrodesis for the treatment of end-stage ankle arthritis.

### Materials and Methods

This was a comparative case series. Institutional review board approval was granted from all participating sites, and informed consent was obtained from all study participants. Patients undergoing ankle fusion at two institutions were invited to participate in the study, which formed part of the ongoing Canadian Orthopaedic Foot and Ankle Society (COFAS) study on the clinical outcomes of arthrodesis or total ankle replacement. Subjects were included if they were over eighteen years of age and presented with isolated end-stage ankle arthritis (COFAS types 1 and 2)<sup>8</sup>. Patients with ongoing infection, previous ankle or hindfoot fusions, or previous ankle arthroplasty were excluded. Patients with arthritis in the triple joint complex (subtalar, talonavicular, or calcaneocuboid joint) or substantial deformity requiring corrective osteotomies or arthrodeses beyond the ankle joint (COFAS types 3 and 4) were also excluded. A computed tomographic (CT) scan was routinely used to assess triple joint arthritis. For the purposes of the study, patients with concomitant ipsilateral hindfoot arthritis were only included if the ankle pathology alone required surgical intervention.

All arthrodeses were performed by orthopaedic surgeons who were engaged in a full-time foot and ankle practice. Open arthrodeses were performed at one site by a single surgeon through an anatomic transfibular approach with use of a fibular sparing Z-osteotomy, as previously described<sup>9</sup>. Arthroscopic arthrodeses were performed by one of three surgeons at a second site. Arthroscopy was performed with use of noninvasive distraction and anteromedial and anterolateral portals. Adequate inflow was achieved with use of a 2.9-mm arthroscope within a 4.0-mm fenestrated cannula or a 4.0-mm arthroscope with a 5.5-mm fenestrated cannula and a pump with 30 mm Hg of inflow pressure at the discretion of the surgeon. One surgeon frequently added a posteromedial portal. After the removal of articular cartilage, the subchondral bone was prepared with use of a 2-mm drill and osteotome or high-speed burr. Osseous contours were preserved and fusion sites were stabilized with use of two or three compression screws at the discretion of the surgeon. Only one of the three surgeons routinely debrided the lateral gutter and placed a screw from the fibula into the talus. Postoperatively, patients were managed with immobilization of the ankle in a cast or cast boot, were kept non-weight-bearing for the first six weeks, and were allowed to proceed to full weight-bearing during the second six weeks.

The primary outcome measure in the present study was the change in the Ankle Osteoarthritis Scale (AOS) score from baseline to twenty-four months postoperatively. The AOS is a reliable, validated, visual analog-based, disease-specific, self-administered outcomes instrument that is designed specifically to measure disability and pain resulting from ankle osteoarthritis<sup>10</sup>. Both the pain and disability components were used to calculate the total score. The score ranges from 0 to 100, with a lower score indicating more normal function. The minimum clinically important difference for the AOS score is not known.

Demographic data were collected preoperatively. Secondary outcome measures also included the Short Form-36 (SF-36) health survey<sup>11</sup>, radiographic alignment, operative time, and length of hospital stay. Data were collected and anteroposterior and lateral radiographs were made at baseline and at the twelve and twenty-four-month visits. Complete radiographs were available for data analysis for twenty-seven subjects in the open arthrodesis group and twenty-seven subjects in the arthroscopic arthrodesis group. Sagittal alignment was measured as the angle between the anatomical axis of the tibia and the long axis of the talus as viewed on a lateral radiograph. Coronal alignment was measured as the angle between the anatomical axis of the tibia and the proximal talar subchondral surface as viewed on an anteroposterior radiograph. The deviation from neutral was measured, but the varus or valgus direction was not recorded. We believed that the magnitude of the coronal plane deformity was important for the purposes of this study but that the varus or valgus direction was not.

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The database was funded by the St. Paul's Hospital Foundation, which did not play any role in the investigation.

### Statistical Analysis

The primary objective of the present study was to compare the open and arthroscopic treatment groups in terms of the magnitude of change in the AOS score from baseline to twenty-four months postoperatively. In the analysis, the change in the AOS score between baseline and the twenty-four-month follow-up visit was calculated for each patient. The treatment effect was assessed by comparing the average change in score between the two treatment groups with use of a linear regression model. In particular, the change in the AOS score was the response variable and the treatment group was considered as the primary interest variable in the model. The analysis was adjusted for sex and

TABLE I Demographic Characteristics

	Open Arthrodesis	Arthroscopic Arthrodesis
Number of patients	30	30
Age at time of surgery* (yr)	54.7 ± 11.5	59.4 ± 10.6
BMI*	29.6 ± 5.9	27.4 ± 3.7
Male:female ratio (no. of patients)	11:19	20:10
Coronal plane alignment†	9° (0° to 36°)	8° (0° to 30°)
Sagittal plane alignment†	20° (5° to 36°)	21° (10° to 30°)
Diagnosis (no. of patients)		
Posttraumatic	4	23
Primary osteoarthritis	19	4
Inflammatory arthritis	4	1
Hemophilia	0	1
Osteonecrosis	2	0
Poliomyelitis	1	0
Flat foot	0	1

\*The values are given as the mean and the standard deviation. †The values are given as the mean, with the range in parentheses.

TABLE II Group Comparison

	Open Arthrodesis*	Arthroscopic Arthrodesis*	P Value
Tourniquet time ( <i>min</i> )	107 ± 19.5	99 ± 16.4	0.13
Length of hospital stay ( <i>d</i> )	3.7 ± 1.8	2.5 ± 1.3	0.05
AOS score ( <i>points</i> )			
One year	33.5 ± 21.0	17.5 ± 15.9	0.01
Two years	29.2 ± 17.2	17.2 ± 17.9	0.05
SF-36 score ( <i>points</i> )			
PCS			
One year	37.9 ± 11.6	46.3 ± 8.1	0.01
Two years	38.2 ± 11.8	45.0 ± 9.3	0.26
MCS			
One year	51.3 ± 11.0	54.3 ± 8.0	0.68
Two years	52.2 ± 12.0	55.1 ± 8.1	0.70

\*The values are given as the mean and the standard deviation.

preoperative coronal plane alignment as possible confounding variables. We also explored the treatment effect on the change in the AOS score from baseline to twelve months and from twelve to twenty-four months with use of the same analysis approach.

We repeated the aforementioned analysis for the two secondary outcomes, physical component score (PCS) and mental component score (MCS) of the SF-36.

All p values were reported as two-sided in this report. The level of significance was set at  $p \leq 0.05$ .

## Results

There were thirty open and thirty arthroscopic arthrodeses. In the open arthrodesis group, the mean age (and standard deviation) was  $54.7 \pm 11.5$  years, the mean body mass index (BMI) was  $29.6 \pm 5.9$ , and the sex distribution was eleven males and nineteen females. In the arthroscopic group, the mean age was  $59.4 \pm 10.6$  years, the mean BMI was  $27.4 \pm 3.7$ , and the sex distribution was twenty males and ten females. In the open arthrodesis group, the mean coronal plane alignment was  $9^\circ$  (range,  $0^\circ$  to  $36^\circ$ ) and the mean sagittal plane alignment was  $20^\circ$  (range,  $5^\circ$  to  $36^\circ$ ). In the arthroscopic arthrodesis group, the mean coronal plane alignment was  $8^\circ$  (range,  $0^\circ$  to  $30^\circ$ ) and the mean sagittal plane alignment was  $21^\circ$  (range,  $10^\circ$  to  $30^\circ$ ). The preoperative coronal and sagittal alignment between the two groups were similar. The demographic data and preoperative diagnoses are listed in Table I.

Fifty-five of the original sixty patients were available for the twenty-four month follow-up. One patient in each group had a revision for the treatment of a symptomatic nonunion before twenty-four months. In the open arthrodesis group, an additional three patients were not available (two had been lost to follow-up and one had died).

Both open and arthroscopic groups demonstrated a significant improvement in AOS scores from baseline to twelve months ( $p < 0.01$ ) and from baseline to twenty-four months ( $p < 0.01$ ). Table II shows a comparison of the results in both groups.

There was a significant difference in the AOS score between the two groups in favor of the arthroscopic group at both one year ( $p = 0.01$ ) and two years ( $p = 0.05$ ) (Fig. 1). The difference between the groups was not statistically influenced by sex or coronal plane alignment at any time point in the regression analysis.

The analysis of the improvement in SF-36 PCS scores demonstrated no difference between the groups at two years (mean improvement,  $8.12 \pm 10.13$  in the open group and  $11.45 \pm 11.66$  in the arthroscopic group;  $p = 0.26$ ) but showed a significant difference between the groups at one year (mean improvement,  $6.32 \pm 10.07$  in the open arthrodesis group and  $12.92 \pm 9.85$  in the arthroscopic arthrodesis group;  $p = 0.01$ ) (Fig. 2).

The SF-36 MCS scores at one year and at two years were similar between the two groups. The hospital stay was significantly shorter for the arthroscopic arthrodesis group than for the open arthrodesis group (2.5 compared with 3.7 days;  $p = 0.05$ ). The mean tourniquet time was 107 minutes for the open arthrodesis group and ninety-nine minutes for the arthroscopic arthrodesis group.

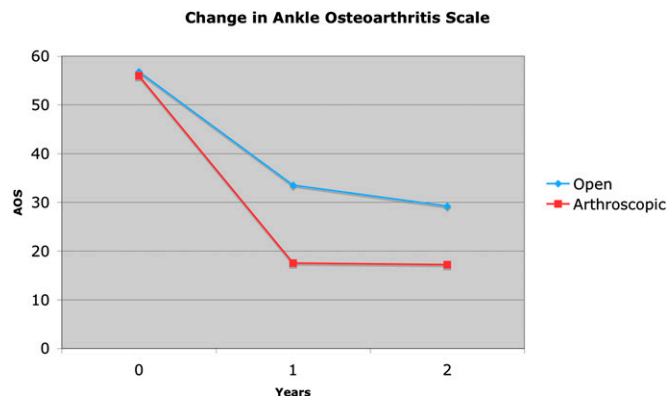


Fig. 1  
Line graph showing the change in the AOS score.

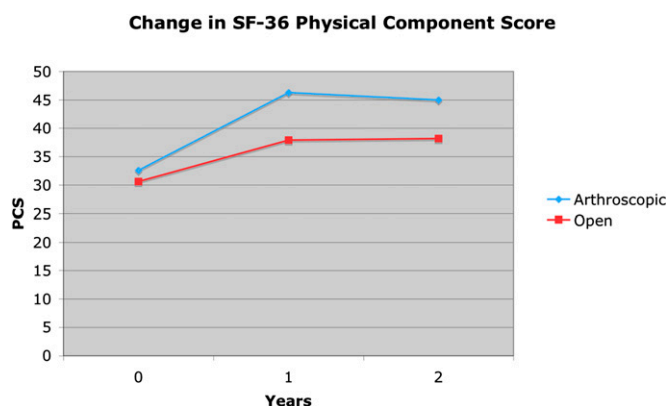


Fig. 2  
Line graph showing the change in the SF-36 Physical Component Score.

There was improvement in ankle alignment in both groups. In the open arthrodesis group, the mean postoperative coronal plane alignment was 4° (range, 1° to 12°) and the mean postoperative sagittal plane alignment was 20° (range, 5° to 32°). In the arthroscopic arthrodesis group, the mean postoperative coronal plane alignment was 2° (range, 0° to 8°) and the mean postoperative sagittal plane alignment was 20° (range, 10° to 35°). In each group, there was one nonunion that successfully united following revision surgery. There was one case of delayed wound-healing in each group, and there were two additional surgical procedures for the removal of symptomatic implants in the arthroscopic arthrodesis group.

## Discussion

There are currently very few published clinical studies comparing arthroscopic and open ankle arthrodesis. A recent review of the literature on arthroscopic arthrodesis identified only three studies with Level-III evidence (case control studies, retrospective comparative studies, or systematic reviews of Level-III evidence) in support of arthroscopic ankle arthrodesis<sup>12</sup>. Myerson and Quill performed the first retrospective comparative study and noted a similar fusion rate in both groups but reported a shorter time to fusion in the arthroscopic arthrodesis group<sup>13</sup>. In a retrospective cohort study, O'Brien et al. also demonstrated similar fusion rates and less morbidity, shorter operative times, and shorter hospital stays in the arthroscopic treatment group<sup>14</sup>. Ogilvie-Harris et al. reported prospectively collected data on nineteen arthroscopic arthrodeses and demonstrated an average length of stay of only one day<sup>15</sup>. Fusion was achieved in eighteen patients, and sixteen patients reported a good or excellent outcome. However, the lack of a control group and the lack of a valid outcome measure prevent useful comparison with the standard open technique. Our review of the English-language literature failed to identify any other clinical studies of arthroscopic ankle fusion that involved the use of a validated outcome measure.

In keeping with the studies noted above, we found a low nonunion rate in both treatment groups and a significantly shorter hospital stay (difference, 1.2 days) in the arthroscopic treatment group. The degree of improvement in the AOS score was both greater and more rapid in the arthroscopic

treatment group than in the open treatment group, with maximum improvement achieved by one year. The minimum degree of soft-tissue envelope disruption associated with arthroscopic arthrodesis may reduce the degree of permanent functional impairment of the joints and soft tissues adjacent to the arthrodesis site. It also appears to allow more rapid activation of the bone-healing cascade, leading to more rapid bone healing and earlier functional improvement. Also, it is currently our standard practice to perform arthroscopic ankle arthrodesis as outpatient procedure.

Previous authors have cautioned against performing arthroscopic ankle arthrodesis in the presence of a large coronal plane deformity<sup>13,15,16</sup>. In the present series, both groups included coronal plane deformities of as large as 30° and 36°. It has not been our experience that such coronal plane deformities are a contraindication to the arthroscopic technique. We have found that, with increasing experience, larger coronal plane deformities can be managed. Careful preoperative assessment with weight-bearing ankle radiographs and CT scans (also necessary to investigate arthritis of adjacent joints, specifically, the subtalar joint) frequently demonstrates that large coronal plane deformities are the result of talar tilting within the ankle mortise, with little deformity in the actual tibia or talus. After arthroscopic debridement, the surgeon can reposition the talus to eliminate the coronal malalignment without the need for major bone resection or osteotomy. The use of arthroscopic arthrodesis for larger coronal plane deformities was supported by Gougoulias et al., who compared the outcomes of arthroscopic ankle arthrodeses in patients with <15° deformity and >15° (up to 45°) of deformity<sup>17</sup>. The outcomes were similar, with good results in 79% and 80% of the patients, respectively, and good correction in both groups. In our study, there was no significant difference between the groups with regard to preoperative alignment or deformity correction.

The present study is limited by a lack of randomization. Patients were not consecutive, and, in the initial period, an open technique was used for some of the more difficult cases at the center at which the arthroscopic procedures were performed. However, we would like to point out that, after the initial period following the introduction of the arthroscopic technique, the authors so strongly preferred the arthroscopic technique that they nearly completely abandoned the open technique. The center where open arthrodesis was performed was recruited to contribute patients to the present study to provide a comparison group.

We acknowledge that there was a difference in sex distribution between the two groups. We are unaware of any published reports in the orthopaedic literature suggesting that this factor influences the outcome of ankle fusion surgery. Our regression analysis does not suggest that the difference in sex distribution affected our primary outcome measure (the AOS score) or the secondary outcome measures. We further note the differences between the groups in terms of diagnosis, with the patients in the arthroscopic treatment group having primarily posttraumatic ankle arthritis and those in the open group having primarily idiopathic ankle arthritis. In the arthroscopic treatment group, many of the patients had a history of multiple sprains or a simple remote ankle fracture and were therefore considered to have

posttraumatic arthritis. We believe that the distinction between this etiology of multiple sprains and/or remote ankle fracture and idiopathic arthritis is subtle and unlikely to bias the study.

In this comparative case series, we have shown that both open and arthroscopic ankle arthrodeses were associated with good clinical outcomes at two years postoperatively on the basis of a validated outcome measure. The arthroscopic treatment group showed significantly improved AOS scores at both one and two years in comparison with the open group, with a more rapid rate of improvement, a shorter hospital stay, equivalent deformity correction, and an equivalent nonunion rate. ■

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