Arthroscopic ankle fusion: Preoperative deformity can be successfully corrected as long as the distal tibia is not deformed

ABSTRACT

Introduction

Coronal deformity is considered a relative contraindication for arthroscopic ankle fusion. *This study assessed whether preoperative coronal ankle joint deformity influenced the outcome of arthroscopic ankle fusion.*

Methods

97 patients had 62 arthroscopic and 35 open ankle fusions between 2005 and 2012. Clinical outcomes were prospectively recorded with use of the *Ankle Osteoarthritis Scale (AOS) and* Ankle Arthritis Scale (AAS) preoperatively, 6, 12, 24 months and final follow-up.

Radiological alignment was measured using the tibiotalar angle, the tibial plafond angle, the lateral talar station and the lateral tibiotalar angle.

Results

Both groups had the same demographics.

Preoperative deformity was the same regarding sagittal alignment and overall coronal alignment but the arthroscopic group had less tibial deformity (tibial plafond angle range 0 to 19 degrees vs. 0 to 43 degrees). At final follow-up the arthroscopic mean AOS was 34.2, (95% CI 23.3 to 45.2) vs. open 33.9, (CI 17.8 to 49.9). The AAS at final follow up for arthroscopic was 26.0, (CI 21.0 to 31.0) vs. open 27.5, (CI 19.7 to 35.2).

Both groups had the same tibiotalar angle, lateral talar station, and lateral tibiotalar angle at follow up.

Regression analyses revealed no influence of type of surgery, preoperative deformity, postoperative radiological alignment, age, gender, BMI, smoking status, etiology of the arthritis, and need for bone grafting on outcome scores (all $p > 0.05$).

Conclusion

Arthroscopic and open ankle fusion yielded equivalent results for both patient reported outcome measure and radiographic alignment in patients with coronal and sagittal joint deformity. Patients with higher tibial plafond angles more often underwent open fusion.

Keywords

Ankle arthritis; ankle fusion; ankle arthrodesis; sagittal alignment; coronal alignment; varus deformity; valgus deformity; arthroscopic arthrodesis; arthroscopic fusion; coronal plane deformity

Introduction

End-stage ankle arthritis often affects young patients and causes substantial pain and limitation of function.[4] Both open and arthroscopic fusions lead to considerable reduction of pain and improved function, with arthroscopic fusion reported to result in faster postoperative recovery and better outcome in the short term.[8]

Substantial preoperative coronal deformity is considered a relative contraindication and most studies advocate using an arthroscopic technique only for ankles with less than 15 degrees of varus or valgus malalignment as measured with the tibiotalar angle.[5,11] Yet, newer studies showed that arthroscopic fusion is still feasible in ankle with coronal malalignment.

.[2,12] However, little information is available about the effect of preoperative malalignment on the outcome after arthroscopic ankle arthrodesis. *The aims of this study were to elucidate the extent of ankle joint deformity that was addressed by arthroscopic fusion in a single center with three surgeons with expertise in arthroscopic ankle fusion and to reveal the influence of the preoperative deformity onto the outcome after arthroscopic fusion.* We assumed that clinical outcome was comparable between these two groups and that patients who underwent arthroscopic fusion had less malalignment than those with open fusion. We also aimed to elucidate the clinical outcome of arthroscopic and open ankle fusions over time to see whether there were differences in the postoperative recovery period between the two groups.

Material and Methods

The ongoing (blinded for reviewing) collects data on patients who had unsuccessful trial of nonoperative treatment, gave informed consent for database enrollment, and were treated with total ankle replacement or ankle arthrodesis. Patients enrolled in this study (blinded for reviewing) and had isolated ankle joint fusion at a single institution, by one of three fellowship trained surgeons between 2005 and 2012. This was a comparative case series.

After exclusion of all patients with either preexisting subtalar fusion (n = 13), subtalar fusion in the same procedure (n = 3), revision surgery of prior ankle fusion (n = 2), Charcot’s neuroarthropathy (n = 4), and patients with unavailable preoperative radiological workup (n = 12), 97 patients with isolated arthroscopic (n = 62) or open (n = 35) ankle fusion were identified. Figure 1 illustrates the selection process.

[Figure 1: Exclusion criteria]

Collection of clinical data

Patient assessments were completed by the treating orthopedic surgeon preoperatively, at six and 12 months following surgery, and annually thereafter. Patient demographics, comorbidities, and diagnoses were recorded preoperatively. Operative details were collected prospectively with use of the (blinded for reviewing). Clinical outcomes were recorded preoperatively and at each follow-up visit with use of the Foot and Ankle Follow-up Questionnaire developed by a coalition of ten orthopedic associations, including the American Academy of Orthopedic Surgeons.

The components administered were the Ankle Osteoarthritis Scale (AOS) and the Ankle Arthritis Score (AAS). The AOS is a validated, reliable, self-reported ankle-specific assessment and consists of 20 questions regarding pain and disability resulting from ankle osteoarthritis.[3] The AAS is a revised version of the AOS. For the AAS, 13 of these 20 questions that either contained duplicate information or lack of variability were eliminated. Additionally the retained questions are now weighted according to their variability. The AAS therefore retains the most discriminative information in the AOS but is shorter and has improved psychometric properties.

Radiographic measurements

Radiographic measurements were performed on weight bearing true-anterior to posterior and lateral x-rays taken preoperatively and 12 months postoperatively.

The talar tilt angle was measured between a line along the tibial plafond and the proximal talar subchondral surface. Positive values corresponded to varus tilting and negative values to valgus tilting. *For the talar tilt measurement, previous studies have shown intra-observer reliabilities of 0.93-0.99 and inter-observer reliabilities of 0.92-0.97.*[1,6] The medial tibiotalar surface angle was the angle between the tibial axis and the proximal talar subchondral surface. *This angular measurement was shown to have an intra-observer reliability of 0.99 and an inter-observer reliability of 0.98.*[7] The distal tibial plafond angle was computed using the aforementioned angles. Varus alignment corresponded to values lower than 90 degrees and valgus alignment to values higher than 90 degrees. *(Figure 2)*

Figure 2: Measurement of the talar tilt angle, the tibiotalar angle, and the tibial plafond angle.

Sagittal alignment was measured as the angle between the anatomical axis of the tibia and the long axis of the talus on the lateral view. Antero-posterior translation of the talus was measured as the lateral talar station with positive values indicating anterior translation and negative values indicating posterior translation.[9]

Operative technique

Arthroscopic fusion was performed with 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, a pump with 4 kPa of inflow pressure, and non-invasive traction of the joint.

In the case of large anterior osteophytes, removing these with a curette as a first step helped facilitate proper insertion of the instruments. Osseous contours were preserved during removal of the articular cartilage. The subchondral bone was scaled with a 2 mm drill and an osteotome or a high-speed burr.

Two surgeons used standard anteromedial and anterolateral portals only and removed the cartilage in the medial but not the lateral gutter. They only debrided osteophytes and scar tissue in the lateral gutter that impeded proper reduction in case of an internally rotated talus, but they did not remove the cartilage of the lateral gutter. These two surgeons stabilized the fusion with two or three partially threaded 6.5 mm cannulated compression screws placed under x-ray guidance.

One surgeon always added a low anteromedial and a low anterolateral portal to remove the cartilage in the medial and the lateral gutter. He also used a posteromedial portal to facilitate posterior debridement. He used four to five 4.5 mm full-threaded cortical screws, with one of these placed from the fibula into the talus to fixate the debrided lateral gutter.

All surgeons used the first screw as a compression screw. This first screw aimed for the medial talar body in case of preoperative valgus alignment and for the lateral talar body in varus alignment. Postoperatively, patients were managed with immobilization of the ankle in high aircast boot for ten weeks and were kept nonweightbearing for the first six weeks.

Open arthrodesis was most commonly performed through a transfibular approach and an additional anteromedial incision to debride the medial gutter.

Alternatively, a direct anterior approach in the interval between the tibialis anterior and extensor hallucis longus or two small incisions anteromedially and anterolaterally were used.

Statistics

Primary outcome measure was the AOS collected at baseline, at 6, 12 and 24 months and at final follow-up. The AAS was also calculated. The scales at different time points were compared using repeated ANOVA tests. The differences of the scales for arthroscopic and open fusions at specific time points were compared using Student *t* tests.

Radiological alignment between the two groups were compared using Student *t* tests for normally distributed data and Mann-Whitney tests for data not normally distributed as verified by the Kolmogonov-Smirnov test.

Univariate regression analyses tested the influence of the preoperative deformity onto the AOS and AAS at final follow-up. For the coronal measurements the deviation from neutral was used, but the varus or valgus direction was ignored. We believed that the magnitude of the coronal plane deformity was important but that the varus or valgus direction was not.

Furthermore, the influence of the following parameters onto the AOS and AAS at final follow up was tested using univariate regression analyses: type of surgery (arthroscopic vs. open), postoperative alignment, age, gender, BMI, smoking status, and etiology of arthritis.

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Results

No difference was found between the arthroscopic group and the open group regarding mean age at surgery (57.4 vs. 57.1 years, p = 0.882), female to male proportion (23/29 vs. 9/26, p = 0.099), body mass index (28.2 vs. 28.2, p = 0.457), incidence of diabetes (8 vs. 3, p = 0.741), smoking status (p = 0.317), incidence of posttraumatic (32 out of 62 vs. 21 out of 35, p = 0.525) or inflammatory arthritis (8 out of 62 vs. 2 out of 35, p = 0.486), and duration of follow-up (4.5 vs. 4.1 years, p = 0.467). The demographic details of the patient cohort are summarized in Table 1.

[Table 1: Demographics]

Preoperative radiological alignment

The coronal plane deformity was lower in the arthroscopic group compared to the open group as measured using the mean tibiotalar angle (8.2 vs.12.3 degrees, p = 0.014) and the tibial plafond angle (3.6 vs. 11.4 degrees, p < 0.0005). However, the range of the measured angles allows revealing to which extent of deformity an arthroscopic fusion was performed. While the range of the tibiotalar angle was similar between the two groups (0 to 25 degrees vs. 0 to 27 degrees), the range of the tibial plafond angle was notably higher in the open group (0 to 19 degrees vs. 0 o 43 degrees). Furthermore, in the arthroscopic group the tibial plafond angle was 5 degrees or less in 79% of the patients, 6 to 10 degrees in 15% of the patients, and higher than

10 degrees in 6% of the patients. In the open group 46% of the patients exhibited a tibial plafond angle of 5 degrees or less, 17% a tibial plafond angle of 6 to 10 degrees, and 37% of more than 10 degrees. (table 2a, figure 4a) *There was no difference in sagittal plane deformity between the groups as measured by the lateral talar station (mean 2.9 mm, range -8 to + 14mm vs. mean 3.8 mm, range -12 to +16mm, resp) (table 2, figure 4).*

[Table 2: Preoperative radiological deformity and postoperative radiological alignment]

[Figure 3: Ranges of preoperative tibiotalar angle and tibial plafond angle]

Clinical outcome

Both arthroscopic and open ankle fusion led to improvement of the mean AOS and AAS at 6, 12, 24 months, and at final follow up when compared to the preoperative AOS and AAS (all p < 0.05).

(table 3 a and 3 b, and figure 4a and 4 b)

[Table 3a: AOS and Table 3 b: AAS]

[Figure 4a: AOS over time and Figure 4 b: AAS over time]

Postoperative alignment

The radiological outcome at 12 months after surgery, presented in Table 2, was identical in both groups, with proper alignment in the coronal plane (medial tibiotalar angle 89.3 vs. 88.3 degrees, p = 0.371), and sagittal plane alignment regarding lateral talar station (1.3 mm vs. 2.3 mm, p = 0.061) and lateral tibiotalar angle (111.2 vs. 110.4 degrees, p = 0.574).

Clinical outcome dependent on preoperative deformity

Univariate regression analyses were performed to evaluate the influence of several parameters *onto the AOS and AAS* at final follow up in the arthroscopic group. As all patients in the arthroscopic group had tibial plafond angles of less than 20 degrees, we also conducted the regression analyses including all patients of both groups with tibial plafond angles below 20 degrees to compare open and arthroscopic fusions of ankles with the same extent of tibial plafond deformity.

The univariate analysis demonstrated that the only variable to *influence the AOS and AAS* at final follow up was the preoperative AOS or AAS.

Preoperative deformity in the coronal or the sagittal plane did not affect *the AOS or AAS* at final follow up. Similarly, postoperative radiological alignment, type of surgery, age, gender, BMI, smoking status, etiology of the arthritis or need for bone grafting also had no effect on *the AOS or AAS at* final follow up (all $p > 0.05$, see Table 4).

[Table 4: Univariate regression analyses]

Complications

7 patients (10%) had 11 reoperations in the arthroscopic group and 5 patients (14%) had 6 reoperations in the open group. The reoperations mainly consisted of hardware removals, whereas 2 patients (3%) in the arthroscopic and 1 patient (3%) in the open group needed symptomatic non-union revision.

Discussion

The presented study confirms arthroscopic ankle fusion as a viable option in patients with preexisting *ankle malalignment*, thus confirming the results of previous studies.[2,12]

We note with interest that our univariate analysis found that the only variable to influence the A0S or AAS at final follow up was the preoperative score, with a higher preoperative score resulting in a higher score at final follow up. This suggests that patients experiencing the highest level of patient reported dysfunction may fail to obtain the best possible function postoperatively. However, Coe et al previously demonstrated that a higher preoperative AOS Score resulted in a larger change score at last follow up (i.e. preoperative score minus postoperative score = change score) suggesting that higher levels of patient reported dysfunction lead to a bigger functional improvement. We believe further study is warranted to better understand the clinical significance if this finding, and in particular whether there is evidence to allow surgeons to better educate patients about the optimum time point to perform surgical reconstruction of their end stage ankle arthritis.

Winson reported the results of 105 arthroscopic ankle fusions.[13] The preoperative coronal deformity was between *20 degrees of varus and 28 degrees of valgus* as measured by the tibiotalar angle. 80% of the patients had a deformity of less than 10 degrees. Four patients required a calcaneal osteotomy to correct persisting hindfoot malalignment after fusion. Clinical review showed excellent results in 48 patients, and 35 good, 10 fair and 11 poor outcomes. Nine of the patients with poor outcome had non-union; the remaining two poor results required a subtalar fusion and still had ongoing pain. No information was given about the correlation between the preoperative deformity and the clinical outcome in that cohort. During the same period, the author performed 10 open fusions, thus about 8% of the isolated ankle fusions were conducted by an open procedure. However, he also stated that he accomplished 60 tibiotalocalcaneal fusions in the same period, mainly in patients with higher degrees of ankle joint malalignment who often exhibit subtalar joint degeneration and malalignment as well.

Dannawi compared the results of arthroscopic ankle fusion in 31 patients with less than 15 degrees deformity and 24 patients with more than 15 degrees deformity, again measured by the tibiotalar angle.[2] Although clinical outcome and non-union rates were similar between the two groups, patients with higher deformities had longer time to union and longer hospital stay.

However, these studies used the tibiotalar angle only to describe the preoperative deformity. Based on a more thorough radiological evaluation, our study contributes additional information regarding the limits of preoperative deformity that can be fused arthroscopically. While the tibiotalar angle measures the talar deviation compared to the axis of the tibia, it does not give conclusive information on where precisely the deviation occurs. The tibial plafond angle represents deformities of the distal tibial surface. Therefore using both angles allows for distinction between malalignment caused by tilting of the ankle joint and malalignment due to bony deformities of the distal tibial surface *(figure 5 a, figure 5 b, figure 5 c, figure 5 d).*

[Figure 5: The malalignment on the left is caused by simple tilting of the talus in an otherwise normal ankle mortise, while the malalignment on the right is caused by a deformity of the distal tibial surface. Whereas the tibiotalar angle is similar for both ankles, the tibial plafond angle allows to differentiate between the two different deformities.]

In our experience simple tilting of the ankle joint can be reduced manually and thus permits arthroscopic fusion whereas major deformities of the distal tibial surface require appropriate bone resection to realign the hindfoot, therefore frequently necessitating an open procedure.

The question then arises as to the maximum extent of deformity which can be corrected in an arthroscopic procedure. In the present study, the surgeons performed an open fusion in all cases with a tibial plafond angle deviation of more than 19 degrees of coronal malalignment, indicating that larger deformities of the tibial joint surface required open fusion. *A closer look to the distribution of the tibial plafond angle deviations showed, that only 21% of the patients in the arthroscopic group had tibial plafond angle deviations of more than 5 degrees and only 6% had more than 10 degrees. In the open group 54% of the patients had more than 5 degrees and 37% of the patients had more than 10 degrees of tibial plafond angle deviation. This emphasizes that bigger deformities of the distal tibial surface were more often addressed by an open procedure.* No differences between the two groups were observed regarding sagittal alignment as measured by the lateral talar station. We regarded sagittal malalignment to be caused in most cases by osteophytes in the anterior joint compartment, leading to anterior translation and rotation of the talus. When present, removal of osteophytes at the beginning of the procedure using a curette usually permits proper reduction of the talus. Therefore, the sagittal malalignment does not seem to impede proper realignment by arthroscopic fusion.

To allow proper arthroscopic reduction of coronal malalignment techniques include the removal of osteophytes using a curette, and placement of partially threaded compression screws to correct the deformity. Therefore, in varus ankles the first screw should be placed into the lateral talar body, either directed from the medial or from anterolateral tibial cortex. In valgus ankles the first screw should be placed into the medial talar body.

Winson et al [13] proposed to add a sliding calcaneal osteotomy to correct residual hind foot malalignment after arthroscopic ankle fusion. This might be an option whenever the subtalar joint and the ankle joint are tilted into the same direction. However, in about 50% of varus arthritic ankles, the subtalar joint reveals valgus alignment to counterbalance the ankle malalignment.[10] Thus, the subtalar joint was loaded asymmetrically mainly on the lateral part during the development of the ankle varus alignment. A lateralizing calcaneal osteotomy to correct residual varus alignment after ankle fusion would therefore increase the asymmetric lateral load in the subtalar joint. In conjunction with the increased stress due to the ankle fusion this might lead to early subtalar joint degeneration. The same considerations apply to valgus arthritic ankles, which are compensated in 39% by the subtalar joint. Therefore, if a patient reveals this subtalar mechanism to counterbalance an ankle malalignment that cannot be reduced completely, we prefer to correct the deformity where it occurs. Consequently, we favor an open procedure to perform appropriate resection of the joint line whenever the malalignment is not completely reducible with an arthroscopic fusion.

Similar to earlier studies, the arthroscopic group showed *a trend to* quicker clinical improvement than the open group during early follow-up at 6 and 12 months ,[8] even though the differences were not statistically significant. However, the results of the open group gradually improved over time, and both groups had similar results at final follow-up. This faster improvement of the clinical results with arthroscopic ankle fusion is usually attributed to less soft tissue dissection, leading to less swelling.[8] By the time the soft tissues have recovered and the swelling in the open group decreases, results are similar for both procedures.

Complications needing reoperation were similar in both groups, with two revision surgeries due to ankle fusion non-union in the arthroscopic groups vs. one in the open group. In both groups, one patient needed subtalar fusion during follow-up. Overall, the follow-up duration of the study was too short to provide conclusive evidence in terms of differences in the rate of subtalar joint degeneration between the two groups. Since radiological alignment was similar in the two both groups, we do not expect a remarkable difference.

The strengths of our study are the prospective data collection, a large cohort, the validated clinical outcome measurement, and the detailed radiological analysis of the preoperative ankle joint deformity.

Limitations include selection bias, as it was the surgeon who selected the type of procedure, i.e. open or arthroscopic fusion. This resulted in patients with a higher degree of deformity being more frequently being treated with the open surgical technique.

Conclusion

Clinical and radiological outcome after arthroscopic ankle fusion was not dependent on the preoperative coronal or sagittal ankle joint deformity. However, the type of surgery i.e. arthroscopic or open was chosen on the surgeon's preference for each patient. It became apparent that ankles with higher deviations of the tibial plafond angle were addressed with an open procedure whereas the tibiotalar tilting was similar in both groups.

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