

Ankle arthrodesis: A long term review of the literature

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1. Introduction

The gold standard for treatment of end stage ankle osteoarthritis, rheumatoid deformity and post-traumatic ankle arthritis is arthrodesis of the tibiotalar joint.^{1–8} The operation was first described by Edward Albert in 1879.⁹ Refined by John Charnley, external fixation was used until internal fixation became a viable option. In 1983 Schneider described arthroscopic arthrodesis of the ankle joint and all three techniques are in use today.¹⁰ Circular external fixation with tension wiring, open internal fixation with plates or screws and arthroscopic fusion. The literature quotes over 30 different and distinguishable operations for tibiotalar arthrodesis.^{11,12} These operations have proved successful in the short term with a wealth of studies providing evidence on this front. The operation is objectively very successful with studies quoting 80–100% fusion rates.^{11,12} Subjectively it has also been shown to provide benefit to patients, reduction of pain and resuming physical activity are the benchmarks for success for patients. This literature review aims to evaluate the body of research with regards to the long term outcomes.

The authors noted that the published literature does not seem to adequately extend into a long term. The complications that may arise in the long term include adjacent joint arthritis. This, as with any arthritis, would instinctively increase in incidence over time. The longer the outcome measures, hopefully, the truer the picture of the outcomes for ankle arthrodesis. In the same vein reoperations will have a first wave as early complications occur but may increase as time goes on for late complications and indeed adjacent joint arthritis.

2. Methods

A thorough literature search was performed using PubMed, Embase and Cochrane was performed (Fig. 1).

The main search terms were ‘ankle fusion’ or ‘ankle arthrodesis’ and variants including ‘tibiotalar fusion’ along with ‘long term follow up’ and a number of synonyms. The search strategy is detailed in the figure below. In the first instance Medline produced 679, Embase, 1266 and Cochrane 19 papers. After de-duplication 1471 results were obtained.

Two other searches were performed for the main outcome measures of this paper to review literature for reoperation rates and adjacent joint arthritis in long term follow up of ankle fusion. These provided another 87 and 15 papers respectively.

The titles and abstracts of these 1573 papers were reviewed for suitability. Of these only papers in English were selected. Those comparing ankle fusion to total ankle replacement were excluded. The remaining papers which were deemed to be relevant were again reviewed to narrow the review to those with longer than an average of 8 years follow up. The abstracts were reviewed for inclusion; they were assessed for mean follow up time and outcome measures. Where the information regarding duration of follow up was not provided in the abstract the full paper was requested and reviewed for inclusion.

Of the original papers only 8 were suitable given mean follow up time of more than 8 years for isolated tibiotalar arthrodesis for any indication by any method.

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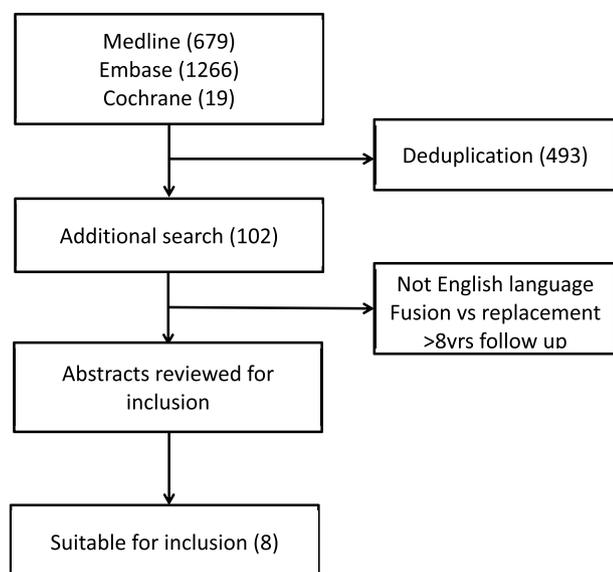


Fig. 1. Literature search inclusion/exclusion criteria.

3. Results

Of the 8 papers Coester et al. had the longest follow up time with an average of 22yrs.¹³ Their outcomes were clinical examination by the authors, the WOMAC (western Ontario and McMaster University Osteoarthritis index), the Short form 36 (SF-36) and radiographic examination of both lower limbs bilaterally. This provided good data on one of this papers outcome methods. It was found that 'the majority of patients had substantial and accelerated arthritis changes in the ipsilateral foot'. There were 23 patients involved in the study, a power analysis determined 20 would be sufficient to determine a significant difference in subtalar arthritis. A significant difference was demonstrated for the subtalar, talonavicular, tarsometatarsal, naviculocuneiform, calcaneocuboid and 1st MTP joints in order of power from most to least likely to be significant. Indeed twenty one of twenty three subtalar joints on the ipsilateral side demonstrated moderate to severe arthritis radiographically. Coester et al. also noted that the ipsilateral subtalar joint demonstrated reduced motion in all patients with no motion whatsoever clinically in 9 patients. Patients, on review of their questionnaires, were found to have increased overall foot pain and disability in the affected foot. Interestingly 67% were still happy with their outcome and 88% would have the operation again. There was no data provided on reoperation rates in this study. This is one possible explanation for the difference between those who were happy and those who would have the operation again.

The second longest follow up time was Troullier et al. who followed 17 patients up for an average of 15 years.¹⁴ Results were clinical, radiological and analysis of gait. They used a grading score found commonly in the literature of JM Mazur¹⁵ to determine pain and function in the ankle post arthrodesis. 100 points are given to an entirely normal ankle and the maximum score achievable post arthrodesis is 90 due to the inherent restriction in movement. An average of 67 points over the entire patient cohort determined a 'satisfactory' result. 94% of the patients themselves were satisfied with the results when asked. There was one reoperation noted for revision although 3 did not undergo complete bony union. Troullier et al. suggested on radiographic examination that arthrosis of the subtalar joint starts posteriorly at the posterior half of the talocalcaneal joint then moves anteriorly to the anterior half of the aforementioned joint and into the talonavicular joint. The gait analysis proved that specially designed orthopaedic shoes provided a more physiological gait pattern, this could possibly help to reduce abnormal strain on other joints and therefore arthritis.

Craig D Morgan et al. provided a large study of 101 tibiotalar arthrodesis over an average 10 year follow up.¹⁶ Ninety six ankles obtained adequate fusion. It was noted that six ankles received a less good clinical rating due to pain in the fore or hindfoot which was 'associated with degenerative changes in the midtarsal joints or in the subtalar joints'. It was also noted that this degeneration was more likely to be seen in the older patients in the series. Tarsal motion was measured at 11° more on the operated side than the non-operated side. This is in contrast with the findings of coester et al. although both papers agree that there was no clinical or radiological evidence of correlation. There were 5 non unions. In terms of reoperations 13% of patients required reoperation. Notably one for infection, on to convert to pan-talar arthrodesis for a symptomatic arthritis due to protrusion of screws into the subtalar joint. One other reoperation was a pantalar arthrodesis for symptomatic subtalar arthritis. They describe a good or excellent clinical functional result in 90% of patients although it was specifically noted that this did not change over the 25 year follow up (the longest follow up in this particular patient series).

Takenouchi et al. followed up 27 patients with RA who underwent a specific arthrodesis with an intermedullary nail with fins over an average of 10 years.¹⁷ This study was included due to the long follow up of this group however it has to be taken into account that their fusion method differed from others in this review. They proposed a novel prosthesis which fused both the tibiotalar and talocalcaneal joint. This was intended to provide stability to the hindfoot and correct deformity whilst fusing the ankle. There was a 100% rate of fusion. There were no reoperations in the cohort, the only complication of delayed wound healing resolved with dressing changes. 100% of patients were satisfied with the operation. The Japanese Orthopaedic Association rating system for foot disease was used (a 100 point system which measures pain, deformity, instability, ROM, Walking ability, muscle strength, sensation, and activities of daily living both in fore and hindfoot). They did note that preoperatively 19 patients had changes indicative of OA in the Chopart joint although didn't note if there was any change of movement in this joint. Interestingly the authors found the average scores over all the domains increased initially postoperatively to a significant degree and throughout the follow up period decreased again. This is the only study to be reviewed that gives multiple points of reference for the follow up period. The final result at 10 years follow up is still statistically significantly better than preoperatively but importantly it was statistically significantly worse than immediately postoperatively. The excellent results of fusion in this case could be due to the small sample size or could be an effect of fusing the hindfoot as well.

Over 9 years of follow up both Buchner et al.¹⁸ and Hendrickx et al.¹⁹ provided studies. Buchner followed 48 patients over an average of 9.3 years and once again had subjective, clinical and radiological results. Subjectively the patients were satisfied, as past studies have found 92% would have the procedure again. Clinically the patients were measured on the orthopaedic foot and ankle society ankle and hindfoot scale. There were only 3 of 48 who had a poor score at followup whereas 41 were poor preoperatively. Tarsal mobility was reduced on the operated side which the authors in this case found was associated with worse clinical outcome. It was also found that the degree of arthrosis in the subtalar joints in this study correlated with a worse foot and ankle score and 'a worsening in the grade of arthrosis in the subtalar joint was observed in more than 2/3rds of patients, by an average of one grade in 10 years'. 9 reoperations were seen for complications (4 for non-union, 4 for infection, one to correct the position). Once again, as with Morgan et al., the clinical results did not seem to be dependent on the length of follow up although no method was provided for this conclusion. Over the same follow up period Hendrickx et al. took 60 patients (66 ankles). 91% achieved fusion and 91% were satisfied clinically based upon SF-36 score, Foot and ankle ability measure (FAAM), and American Orthopaedic foot and ankle society hindfoot and ankle scale. Preoperatively subtalar OA was seen in 91% (60) of ankles, of which only 20 progressed to a higher score. 77% (51) there

Table 1
Comparison of all papers with main outcome measures for this review.

	Coester	Trouiller	Morgan	Buchner	Hendrickx	Boobyer	Mazur	Takenouki	Average
Patients	23 (7%)	17 (5.2%)	101 (31%)	48 (14.7%)	60 (18.4%)	37 (11.3%)	12 (3.6%)	27 (8.3%)	40.625
Fusion	100%	82%	95%	92%	94%	78.4%	100%	93%	91.8% (92.17% weighted)
Complications	12.5	35	13	19	9	0	0	0	11.2%
Satisfaction	67	94	90	79	91	70	75	100	85%
Arthritis	Up	Up	Up	Up	Up	Up	Up	Up	–
Subtalar ROM	Down		Up	Down		Down	Down	–	–

were signs of talonavicular OA preoperatively and 19 progressed. 10% (7) calcaneocuboid joints had preoperative OA although 12 of the original 66 progressed at least one grade. Once again this progression did not marry with clinical results of either pain or function although there was more likely to be a progression if preoperatively there were signs of OA to begin.

G.N Boobyer reviewed 37 patients (26 clinically).²⁰ Of these they documented a fusion rate of 78.4%. Three of these patients underwent a below knee amputation all due to infection, two of these were after subsequent revision operations due to failure of fusion. It was noted there was some subtalar ‘stiffness’ in three patients but the authors did not define what this meant. One patient developed midtarsal hypermobility for which he underwent a further operation. He underwent a talo-navicular arthrodesis.

Mazur et al. reviewed 12 patients over 8 years average.¹⁵ The authors developed a scoring system previously referenced in this article for which 90 is the maximum score in a fused ankle. The average postoperative score was 80. There was evidence of subtalar and mid tarsal degeneration which didn't marry with symptoms or scores. There were two patients with severe OA and these patients had postoperative scores of 81 and 82 and were able to continue with their preinjury sports/hobbies. Mazur found that there was some compensatory hypermobility in the subtalar joints which might contribute to the degeneration but did not define it exactly.

These 8 papers, comprising of 325 patients, provide the body of evidence with the longest follow up for isolated arthrodesis of the tibiotalar joint (Table 1).

4. Discussion

This review set out to find evidence in the available literature on long term follow up for ankle arthrodesis of both reoperation rates post arthrodesis and adjacent joint arthritis. It was the authors intention to assess the ability to draw a comparison between time and degeneration of the surrounding joints if it exists. The first conclusion drawn was that out of a large pool of published literature on the matter the number of good quality long term studies over 10 years of follow up was vanishingly small. As ankle arthrodesis as a procedure is over 100 years old one must demand a longer follow up period than is offered.

However the papers included in this long term follow up review did show continued good clinical outcomes on a number of different validated scores despite radiological evidence of worsening arthritis in surrounding joints. Most were found to conform with the standard 80–100% fusion rate. The average fusion rate was 91.8%, the weighted average of these studies was 92.17%. The patient reported outcomes seemed to be good in all studies with an average of 85% of patients being satisfied with the outcome even in the face of complications and 88.8% willing to recommend the procedure to a friend. There were a number of factors that seemed to impact most upon successful fusion. Horst and Nunley after review of the literature found the ideal position should be ‘neutral dorsiflexion/plantarflexion, 0–5° hindfoot valgus and 5–10° of external rotation’. Interestingly it was noted by Patton et al. that smoking or BMI did not impact upon fusion rates.

It is still not clear, even after review of the longest follow up, if the subtalar and midtarsal joints become restricted or hypermobile after

fusion. There were no studies which documented the change over time to perhaps enlighten us on the natural course of the disease post fusion.

5. Conclusion

This paper has aimed to review the long term outcomes of tibiotalar arthrodesis with regards to complications, reoperation rates and adjacent joint arthritis over a period of time. The main body of literature published on the subject of ankle fusion, as discussed above, is with short term follow up.

The conclusion of this review is that long term outcomes are good and objective and subjective measures of success are maintained over 8 years follow up. However definitive high quality studies are needed regarding adjacent joint arthritis and deterioration of function after 10 years of follow up. There is no value in adding to the wealth of short term follow up papers as this period has been studied adequately. However as alternatives to ankle fusion become more viable the long term outcomes need to be known to provide an accurate comparison and improve patient care.

Conflicts of interest

There is no conflict of interest to declare for any of the authors of this paper.

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