



Long-term results after triple arthrodesis: Influence of alignment on ankle osteoarthritis and clinical outcome

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ABSTRACT

Background: Pain, deformity and instability are the main reasons for fusion of the tarsal joints, a triple arthrodesis. The short and midterm results show that mobility, function and satisfaction increase postoperatively. However, osteoarthritis (OA) of the adjacent ankle joint is described as a long-term complication. Alignment of the foot could be an influencing factor. The aim of this study was to examine whether malalignment after triple arthrodesis leads to a higher grade of OA at long-term follow-up.

Methods: Between 1991 and 2002, 81 patients underwent a triple arthrodesis. Preoperatively, postoperatively, 3, 7.5 and 15 years after surgery, dorsoplantar (DP) and lateral X-rays were taken and used to evaluate the degree of OA and the geometry of the foot. The degree of OA was estimated using the Kellgren and Lawrence score. The geometry of the foot was assessed using Meary's angle; a Meary's angle exceeding 15° in DP and/or greater than -5 to 5° from the lateral view was defined as malalignment. In addition to the radiological evaluation, clinical scores (FFI and AOFAS) were recorded.

Results: Thirty-five patients (40 feet) were available for analysis 15 years after surgery. In 19 cases there was an increase in ankle OA following the operation. Eight feet showed malalignment on the lateral view and 28 on the DP view. There was no difference in both an increase of ankle OA or clinical outcome between correct aligned feet and feet classified as malaligned. Thirty-three patients with 38 treated feet stated that they would decide to undergo the treatment again. Two patients would not want to undergo the same surgery again. The patients were satisfied with the result of surgery, clinical scores improved after surgery and remained stable in the long-term.

Conclusions: Triple arthrodesis is a salvage procedure in patients with a painful and deformed hindfoot and results in a clinically beneficial outcome, even 15 years after surgery. The present study did not show that malalignment after triple arthrodesis results in a higher grade of OA of the ankle joint in the long-term. The cause of the aggravation of OA is still not fully understood and needs further research. Nevertheless, clinical results are satisfying 15 years postoperatively.

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1. Introduction

Medical conditions such as neuromuscular diseases, posttraumatic conditions, rheumatoid arthritis, congenital and flat foot deformities can be the cause of a painful, deformed and/or unstable hindfoot. Due to deformity and pain, disability evolves and consequently the quality of life reduces. Triple arthrodesis, conjoining the talocalcaneal, talonavicular and calcaneocuboid joints, is known as a salvage procedure to restore the form of the hindfoot and reduce pain [1]. Although patient satisfaction is high after a triple arthrodesis, the procedure has a disadvantage, it can lead to degenerative changes of the ankle joint in the long-term [2,3].

The development of osteoarthritis (OA) of the ankle joint is possibly a result of abnormal stresses placed on the ankle and midfoot joints due to the absence of tarsal movements [3,4]. After the performance of an arthrodesis, the peak pressure in the ankle joint increases; this might cause an overload of pressure on the joint and consequently results in osteoarthritis [5]. Correct shape and alignment of the foot is pursued to obtain the most natural position of the hindfoot and thus provide optimal pressure distribution in the adjacent joints. However, triple arthrodesis is a technically difficult procedure and correction of the alignment of a sometimes severely deformed foot might not always be as successful as intended. Persistent malalignment after operative correction might cause aggravation of OA in the long-term.

Previously, our group presented the short- and midterm results of patients after triple arthrodesis [6,7]. It was noted that a certain degree of OA of the ankle joint was already present due to the

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underlying pathology and/or deformity prior to surgery. Interestingly, it seemed that patients with a valgus position of the ankle more often had aggravation of OA seven years after surgery. Although the results were not statistically significant, it was suggested that aggravation of OA was related to malalignment. Therefore, the aim of the present study was to determine whether the geometry of the foot aggravates OA of the ankle joint 15 years after triple arthrodesis. In addition, the clinical outcome was evaluated and we examined whether this was related to malalignment. We hypothesised that if malalignment persists after operative correction, this will lead to aggravation of OA in the ankle joint in the long-term.

2. Methods

2.1. Patients

This study was a follow-up of a previous prospective study investigating the results of triple arthrodesis performed between 1999 and 2002 at the St. Maartenskliniek Nijmegen, The Netherlands [6,7]. A total of 81 patients who underwent 93 fusions were initially included in the study. In 2003, the short-term results were evaluated in 75 patients, including 87 fusions. Subsequently, in 2008, the midterm results were assessed in 48 patients including 55 feet. Patients who completed the midterm follow-up were invited to participate in the present study.

The protocol of the present study was approved by the hospital's investigation review board. This study was conducted in accordance with the Declaration of Helsinki. The patients participating in the present study gave their written informed consent.

2.2. Outcome

2.2.1. Radiological outcome

The main study outcome was the grade of osteoarthritis (OA) in the ankle joint and malalignment of the foot. The grade of OA in the ankle joint was determined with the Kellgren and Lawrence score [8]. One grade increase on the Kellgren and Lawrence score over time was considered an aggravation in OA. The score ranges from grade 0, implying no radiographic features of OA, to grade 4, indicating large osteophytes, marked joint space narrowing, severe sclerosis and definite bony deformity. The grade of OA was determined pre-operatively and during all post-operative follow-up moments.

The geometry of the foot was determined with Meary's angle (talo-1st metatarsal angle) measured on the dorsoplantar (DP) and lateral view. A talo-1st metatarsal angle less than 15° on the DP view and a talo-1st metatarsal angle between -5 and 5° on the lateral view are considered the preferred alignment in literature [9]. These values were used as cut-off points to define preferred alignment and malalignment. All radiological measurements for the mid-term and long-term results were performed by the same observer (CAMA). Fusion or total ankle replacement for treatment of disabling OA of the ankle was considered as failure.

2.2.2. Clinical outcome

Patient characteristics, additional procedures and complications after initial surgery were extracted from the electronic patient files. Patients completed the Dutch version of the Foot Function Index (FFI) questionnaire during the pre-operative visit and all postoperative visits [10]. The FFI consists of two subscales in which pain and disability are rated on a 5-point Verbal Rating Scale. A minimum score of 0 and a maximum score of 100 can be obtained for both subscales; the higher the score, the more pain or disability the patient experienced. In addition to this patient

reported outcome, the American Orthopaedic Foot and Ankle Score (AOFAS) was completed by the clinician during the postoperative visits [11]. The AOFAS-score includes three subscales, pain, function and alignment of the hindfoot. A total score of 100 points can be obtained; however, subtalar motions (six points) were not possible in the participating patients due to the fusion. Therefore, a maximum of 94 points could be reached. Furthermore, all patients were asked whether they would undergo the surgery again and if they were satisfied with the result of the surgery.

In addition to the radiological examination, digital photographs were taken of the foot to assess malalignment. The protocol of Tuinhout et al. [12] was used to take digital photographs of the foot. The photograph from the rear view of the foot was used to determine the angle between the midpoint of the calcaneus just proximal to the fat pad, the midpoint of the calcaneus at the insertion of the Achilles tendon and at mid-calf level. The photographs obtained from the medial and lateral side of the foot were excluded for analysis due to the limited reliability of those measurements [12].

2.3. Statistical analysis

Descriptive statistics were used to provide an overview of the patient characteristics and the obtained radiological and clinical outcomes. To investigate whether malalignment as measured on the radiographs induces OA, a Chi² test was performed. In addition to the radiographs, the values obtained from the digital photographs were compared between the patients with aggravation of OA and without aggravation of OA using a Mann-Whitney U test.

The clinical outcome scores were evaluated with one-way repeated measures ANOVA to determine whether there were differences in clinical outcome (FFI and AOFAS) over time. Furthermore, the clinical outcome of patients with malalignment and the preferred alignment were compared using a Mann-Whitney U test. A p-value of <0.05 was considered significant.

3. Results

Thirty-eight of the 48 patients, who completed the midterm follow-up, visited the hospital between November 2015 and June 2016 to participate in the present study. Ten patients were lost-to-follow-up because they passed away (n=3), withdrew their consent (n=3), were unattainable (n=3) or were not able to visit the hospital (n=1). There were three failures. One patient with rheumatoid arthritis underwent an ankle arthroplasty due to ankle OA grade 4 and progressive pain. The two other patients underwent an ankle arthrodesis. One suffered from a progressive varus deformity with grade 3 OA and the other patient had grade 4 ankle OA. These three patients were excluded from the clinical follow-up, however their last preoperative X-ray was used for radiological analysis of ankle OA. Finally, 35 patients were included in the long-term follow-up including a total of 40 triple fusions. The mean (SD) age of the patients at the time of the 15 year follow-up visit was 53 (17) years, with 22 male feet and 18 female feet. Table 1 provides an overview of the indications prior to the surgery.

Table 1

Overview of indications for triple arthrodesis (35 patients, 40 triple fusions).

Charcot Marie Tooth disease (CMT)	14	Flat feet	2
Pes cavovarus	6	Rheumatoid arthritis	2
Clubfoot	2	Tarsal coalition	3
Neuropathy	1	Post-compartment syndrome	1
Post-polio syndrome	1	Talus verticalis	1
Osteoarthritis	6	Posttraumatic	1

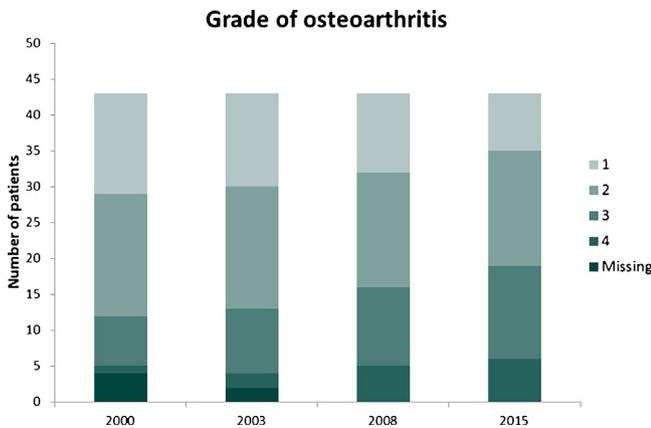


Fig. 1. Distribution in grades of osteoarthritis of the ankle joint over the years according to Kellgren and Lawrence.

Table 2
Aggravation of ankle osteoarthritis after triple arthrodesis surgery until 15 years follow up.

Change of gradation	Number of feet
1–2	6
1–3	6
2–3	3
3–4	1

3.1. Osteoarthritis and malalignment

The degree of OA in the ankle joint increased in nineteen feet during the 15-year study period (Fig. 1, Table 2).

Alignment measured using Meary’s angle resulted in a median of 5.8 (range –13.3 to 28.2) degrees for the lateral view and a median of 8.1 (range –18.4 to 20.2) degrees for the DP view. Considering the cut-off points, eight feet showed malalignment on lateral view and 28 feet on DP view (Fig. 2). Analyses showed no significant differences between the purposed aligned feet and the feet with malalignment with respect to the increase of OA over time; p values were 0.95 for the lateral view and 0.86 for the DPAP view, respectively. In addition to the radiographs, the values obtained from the digital photographs were not significantly

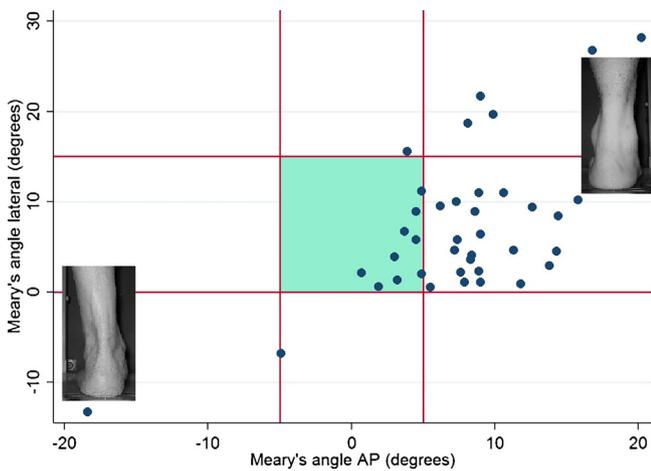


Fig. 2. Distribution of geometry, the square between the red lines represents the preferred zone of alignment (blue centre). Corresponding clinical pictures of extreme varus foot and flat foot as viewed in the FBRS. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

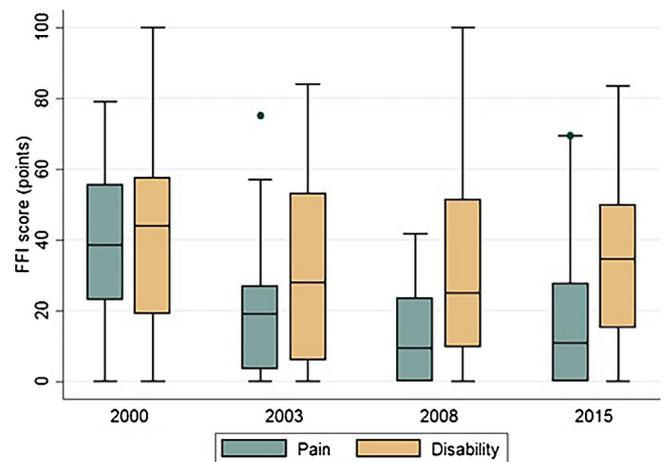


Fig. 3. FFI Pain and Disability scores obtained pre-operatively (2000) and postoperatively (2003, 2008 and 2015).

different for patients with increased OA compared to patients with no increase in OA (p = 0.08).

3.2. Clinical outcomes

The results show that FFI Pain decreased significantly over time, $F(3,117) = 20.90, p < 0.001$, whereas no significant differences were found for FFI Disability (Fig. 3). No significant differences were found between patients in the preferred alignment and malalignment group for the FFI Pain 15 years postoperatively; p values were 0.32 for the lateral view and 0.94 for the DP view. In addition, no significant differences were found for the AOFAS score over time (Fig. 4) or the clinical outcomes between the feet with preferred alignment and the feet with malalignment; p values were 0.20 for the lateral view and 0.36 for the DP view, with respect to the FFI Disability and 0.68 for the lateral view and 0.51 for the DPP view for the AOFAS score.

Thirty-three patients with 38 treated feet stated that they would decide to undergo the treatment again. Only two patients did not want to undergo the same surgery again. In addition, the patients were satisfied with the result of surgery in 30 feet and unsatisfied with the results in 3 feet and 7 patients (7 feet) were neutral about the results of their feet 15 year postoperatively. Shoe wear worn by the patients included: normal confection in 21 cases, inlays in 2 cases, semi-orthopaedic shoes in 4 patients and orthopaedic (custom made) shoes in 13 patients.

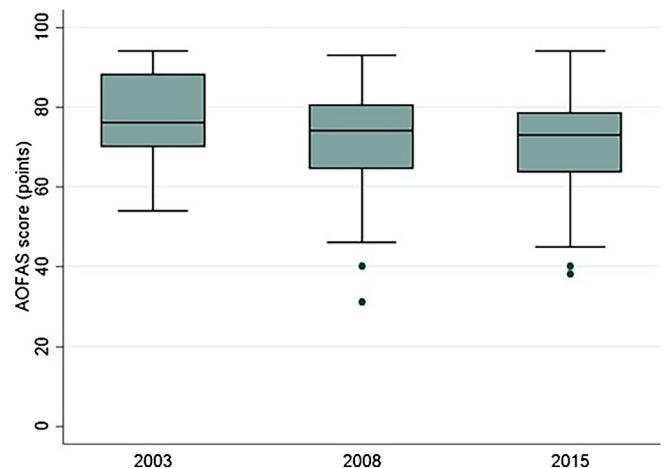


Fig. 4. AOFAS score postoperatively in 2003, 2008 and 2015.

4. Discussion

In the present study good clinical results were found 15 years after surgery in patients who underwent a triple arthrodesis. Patients remain satisfied after the procedure and the pain is significantly reduced. Examining Fig. 3, one might argue that there is a slight tendency towards an increase in disability over time, however this is not significant. This is not surprising as most of the patients included are patients with a progressive neuromuscular disease (CMT). The majority of patients were still wearing normal confection shoes, indicating adequate correction of the foot, and most patients were satisfied with the results of the arthrodesis and would undergo the surgery again given the choice. The clinical outcomes of our study are in line with that which has been previously reported in the literature [1,13,14], confirming that triple arthrodesis is a suitable treatment for patients with feet deformity, pain and instability of the hindfoot.

The main aim of this study was to investigate the effect of (mal) alignment on OA at long-term follow-up after a triple arthrodesis. Hypothesising that if malalignment persists after operative correction, this would lead to a significant increase in osteoarthritis of the ankle joint after surgery and that correct alignment would not result in arthritic changes. However, no differences were found in the progression of osteoarthritis or the clinical outcomes 15 years after surgery between correct aligned feet and feet with malalignment. The absence of any effect of alignment might be explained by the fact that the differences in alignment in the assessed feet are small. Although there were feet indicated as malaligned according to values known in the literature, there was no indication that those feet had an increase in OA or decrease in clinical outcome. The values defining malalignment, especially in the DP direction, seem too strict since a large number of the patients are classified outside the preferred alignment ranges without having any problems (Fig. 2). The age of the patients varied in the present study. After 15 years, a number of patients reached an age at which an increase in OA might be caused due to the natural degenerative process. Considering the progressive character of CMT in addition to age, an increase of ankle OA, disability and/or pain would not be surprising. Furthermore, a previous study investigating ankle OA in patients with CMT found a much higher incidence of OA [3]. Therefore, we controlled our results for age and CMT, but there was no relation found with an increase of OA or a decrease of clinical outcomes 15 years postoperatively.

This study has certain limitations that need to be considered. Firstly, the number of patients who completed the follow-up period of fifteen years is limited, reducing the power of the study. Secondly, the primary indication for patients undergoing triple arthrodesis varies in this cohort. There is a relatively large amount of patients with a neuromuscular disorder which might influence the results of the clinical outcome in this study. The increase in disability in this patient group can be aggravated due to the progressive nature of their disease and is not necessarily dependent on the performed surgery. However, this cohort is still large compared to the number of patients reported previously in literature and can be seen as the general population with a triple arthrodesis. Thirdly, as also described in the previous paper, unfortunately no hindfoot alignment views were used as parameter in the present and previous study [15]. At the time this study was set up it was decided to use digital photographs in order to determine the alignment of the hindfoot [12]. The use of such radiographs would have been preferable because visual judgement is described to be less reliable compared to radiographic assessment of alignment [16]. Although Frigg et al. showed that hindfoot alignment correlated with dynamic load patterns on heelstrike, there was no significant influence on the midfoot and forefoot load patterns [16].

Further studies are necessary to investigate whether there are other explanations besides the performed surgery which might explain the increased ankle OA after triple arthrodesis.

5. Conclusion

Malalignment, as defined in the present study, did not result in a significantly higher grade of ankle OA in the long-term. What might cause the increase in ankle OA of the treated patients in the long-term is still unknown. Nevertheless, clinical results are still satisfying 15 years postoperatively. Taking the long-term results into account, triple arthrodesis is a salvage procedure in patients with a painful and deformed hindfoot, resulting in a clinically beneficial outcome even 15 years after surgery.

Conflict of interest

The authors declare that they have no proprietary, financial, professional, or other personal competing interests of any nature or kind.

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