Fusion of the Tarsal Joints:

Outcome, Diagnostics and Management of patient expectations

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Fusion of the Tarsal Joints:
Outcome, Diagnostics and Management of patient expectations

Arthrodese van de Tarsale Gewrichten:
Uitkomst, Diagnostiek en Management van de verwachtingen van de patiënt
(met een samenvatting in het Nederlands)

Ergebnisse, Diagnose und Management
der Patientenerwartungen bei tarsaler Arthrodese
(mit einer Zusammenfassung in deutscher Sprache)

Proefschrift

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Voor mijn ouders

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Chapter 1

General introduction, controversies in tarsal fusion

TARSAL JOINT PATHOLOGY, MANAGEMENT AND PROGNOSTICS

Many diseases may affect the tarsal joints and create a painful, malaligned and unstable foot. Congenital malformations such as clubfoot and tarsal coalition, and neurologic conditions such as poliomyelitis and hereditary motor and sensory neuropathy predispose for malalignment and instability, and cause pain and tarsal joint degeneration. Furthermore, rheumatoid arthritis and trauma can cause early and late degeneration of the tarsal joints and create deformity and pain. Acquired adult flatfoot deformity (associated with posterior tibial tendon disease) and other types of severe planovalgus can cause tarsal pain and instability as well.

Management of these disorders is replete with controversies, both in surgical as well as in conservative care. Patients are often treated with insoles or custom made shoes. With help of conservative treatment measures, patients commonly experience adequate relief of symptoms for many years. However, ultimately, in a selection of these patients operative treatment is indicated for treatment of persistent disabling symptoms and increasing deformity. Double arthrodesis (talonavicular and subtalar fusion) and triple arthrodesis (also including the calcaneocuboid joint) are well known tarsal fusions that are performed for these problems [1,2]. Pseudo-arthrosis and secondary osteoarthritis of ankle and midfoot are described as complications of this operative treatment, but also wound infections, peroneal nerve damage, persistent malalignement and tendon pathology have been mentioned [3-5]. More selective arthrodeses combined with soft tissue procedures or osteotomies of the tarsal bones and single arthrodesis were developed in an effort to reduce these complications, especially in cases with dynamic deformities such as in neuromuscular pathologies [6]. The initial post-operative treatment in the literature varies between immediate weight bearing in a cast to protocols including 6 weeks of non weightbearing. Regardless of weight bearing, the hindfoot is usually immobilized in a cast during a period of 8-12 weeks.

It is not clear after reading the literature concerning tarsal fusion if outcomes differ in the various diagnostic groups. These controversies triggered the wish to investigate the outcome after triple arthrodesis in our own hospital, using the validated Foot Function Index (FFI) pre- and postoperatively. The following research question was posed:
"What is the short-term (1-3 years) outcome after triple arthrodesis in the different diagnostic groups?"

Also, the occurrence and development of osteoarthritis of the ankle as a result of fusion of tarsal joints is debated. Some authors report that fusion of the tarsal joints will eventually give rise to a high incidence of degenerative changes of the ankle joint and should be avoided whenever possible [3,7,8]. Also a cadaver study demonstrated higher peak pressure in the ankle joint after triple arthrodesis, increasing the risk of OA [9]. Other

authors state that pain and reduced mobility of the ankle joint due to osteoarthritis (OA) after triple arthrodesis is minimal and report a persisting high satisfaction rate after surgery [4,10-14]. In this respect it must be taken into account that to a certain degree OA of the ankle may have been present before surgery due to the primary pathology/deformity of the foot [15]. Triple arthrodesis is a technically difficult procedure and correction of the shape/alignment of the foot may be not as adequate as intended [16,17]. Malalignment may persist after operative correction and this factor may be more important in determining OA of the ankle than the fusion as such. The research question formulated from this controversy is:

"Does triple arthrodesis at mid-term (5-8 years) follow-up lead to osteoarthritis in the ankle joint? Does the position/alignment of the hindfoot influence the outcome?"

DIAGNOSTICS IN TARSAL JOINT PATHOLOGY

Whereas all medical decision making starts with a careful history and physical examination, due to the complex architecture of the hindfoot and the multiple pathologies causing hindfoot problems, diagnostic imaging tools are essential to establish a diagnosis and treatment plan. X-ray examination is routinely and scans (CT, MRI, and/or bone scintigraphy) are often applied when surgery is contemplated. Surprisingly, in the literature concerning tarsal fusions, the workup, i.e. the diagnostic tools that were used, are usually not described in great detail. Only a few authors describe the value of certain diagnostic tools, but the available evidence is restricted to a single study only or contains only expert opinion [18-21]. It is also unclear if a surgeon´s experience influences choices regarding the type of diagnostic imaging. There is clearly a need for more evidence and more structure concerning preoperative, intra-operative, and postoperative diagnostic tools in the field of tarsal fusion. A study was set up to answer the following research question:

"What are the preferences of Dutch orthopedic surgeons specialized in foot and ankle surgery for diagnostic modalities in tarsal fusion and how do these relate to the value of diagnostic tools as described in the literature?"

Not only the abovementioned radiological tools, but also diagnostic intra-articular injections are used in the diagnostic work-up towards a possible tarsal fusion especially when multiple tarsal joints are involved in the pathology and uncertainty exists about which joint causes the symptoms [22,23]. However, the use of these injections is under debate in the literature. Various authors report a correlation between a positive result on anaesthetic intra- articular injection and a successful outcome after fusion of that particular joint [24-26]. These studies, however, are lacking a control group. Having used this

diagnostic tool in our institution for many years, a plan was made to investigate its value. It was thought that a positive effect of such an injection could, next to anaesthesia of the involved joint, also be the result of leakage of the fluid to painful soft tissues or other compartments and that a positive effect could also be misinterpreted. Unclear was if a diagnostic injection in the foot could truly predict a good result of surgery, as was proven to be the case for the hip joint [27].

This led to the following research question:

"Is pain reduction after intra-articular anaesthesia indicative for a successful outcome of tarsal fusion?"

OPERATIVE TECHNIQUE OF TARSAL JOINT ARTHRODESIS

The surgical treatment for the above described foot problems has since long been double arthrodesis (arthrodesis of the subtalar and talonavicular joint) first described by Hoke in 1921 [1] and triple arthrodesis (arthrodesis of the subtalar, talonavicular and the calcaneocuboid joint) first described by Ryerson in 1923 [2]. The work of several authors showed that the ankle and hindfoot form a kinematic chain, and disruption of this chain is thought to increase loads on the surrounding joints [28-30]. In recent years, there has been a growing emphasis on selective, single arthrodesis of tarsal joints, including isolated fusion of the talonavicular [16,31], calcaneocuboid [32] and subtalar joint [33] in order to preserve the adjacent unaffected joints. Recent development of arthroscopic techniques bears the promise of reducing the surgical trauma and complication rate of the procedure, enhancing rapid healing and recovery but is in need of thorough evaluation [34]. Due to heterogeneity of pathologies and patient groups, the variety of surgical techniques and the lack of disease and surgery specific scoring systems it is difficult to comprehensively evaluate the results of hindfoot arthrodesis. It is unknown which specific tarsal fusion technique provides the best outcome for which specific diagnosis. In addition, the outcome studies reported in literature make use of a range of different, often unvalidated, outcome scores. Quality selection of the literature is needed and then best evidence synthesis should be used to gather the best possible information. The following research question was addressed in the thesis:

"Which specific tarsal fusion technique is most effective with regard to which specific pathology?"

Open versus arthroscopic technique in tarsal arthrodesis

In the last decade, the arthroscopic technique for tarsal fusion has been adopted by many surgeons. Tuijthof [34] performed a literature review on subtalar arthrodesis, and concluded that early complications are more associated with the open technique than

with the arthroscopic technique. Relatively large incisions in open surgery are associated with infection, neurovascular damage and delayed wound healing while the arthroscopic surgery is reported to prevent these complications. In cases with gross malalignment or bone loss, arthroscopic surgery is contra-indicated. No randomised controlled trials exist comparing open and arthroscopic tarsal fusion, so the benefits and complications after arthroscopic subtalar arthrodesis are still to be proven from a scientific point of view. This led to the next research question:

"Can the results of a randomized prospective study comparing open versus arthroscopic subtalar arthrodesis help to establish the correct indications and limitations of both procedures?"

OUTCOME MEASUREMENTS IN HINDFOOT SURGERY

The objective and subjective outcome of hindfoot surgery has been measured with various scales and evaluation techniques. The subjective satisfaction measurements tend to show marked improvement, whereas less patient-centered or more "objective" medically oriented scores such as the AOFAS score and the Foot Function Index show less improvement [35,36]. Button [37] identified 49 different rating scales in foot and ankle literature. No rating scale was identified that consistently demonstrated reliability, validity, and responsiveness in patients with a variety of foot and ankle conditions. Hunt [38] concludes in a meta-analysis of patient reported outcome measures (PROM´s) as applied in the assessment of foot and ankle problems, that out of 139 different scores only a small portion is used consistently. The five most used scores are the AOFAS, VAS, FFI, SF 36 and AAOS, again with the same limitations as described by Button [37]. Of these scores the AOFAS is not validated, the VAS has low specificity and the other scores are used sparsely. Also in recent years, new outcome measures in foot and ankle surgery were developed and validated. In 2013, the Dutch version of the Foot and Ankle Outcome Score (FAOS) and the Rheumatoid and Arthritis Outcome Score (RAOS) for the lower extremity were validated [39,40]. Also recently in 2014 a new promising score, the Self-reported Foot and Ankle Score (SEFAS) was introduced as an appropriate validated PROM to be used in national registries. Correlation analysis of SEFAS with other questionnaires (FAOS, SF-36 and EQ5D) showed strong correlations and no floor or ceiling effect [41].

Patient views on the quality of health care differ from the views of health care professionals [42]. As Harris [43] put it: "if surgeons overestimate the likelihood of post-operative patient satisfaction, they may be more likely to recommend surgery". To prevent this supposed phenomenon and in order to improve the quality of health care, a new class of additional instruments that incorporate the patients views on the outcome of care are needed. Van Campen and Sixma developed the QUOTE questionnaire (QUality Of care

Through the patient's Eyes) [44,45]. This instrument contains items formulated in collaboration with patients without the influence of health care workers. The items contain questions regarding the general aspects of care, such as waiting time for surgery and also specific aspects of care, such as being able to walk barefoot after surgery. Wensing [46] states that increased participation of patients and the public in healthcare is desirable, that considering patient views can improve processes and outcomes as well as satisfaction. In the literature there are no reports that the Quote method was used to evaluate surgical intervention. We think that better outcome scores are needed incorporating patient views to assess care and improve it.

Our next question thus was:

"Can a questionnaire measuring patient expectations and experience be constructed and validated, in order to improve the quality of care in tarsal arthrodesis?"

AIM OF THIS THESIS

As discussed in the previous section, controversies exist in the field of diagnostics and operative treatment of foot problems that are treated through fusion of tarsal joints. It is not clear which diagnostic tests are most appropriate in the selection of patients and which outcome tool is appropriate for preoperative and postoperative evaluation. This thesis aims, through methodically studying a number of research questions, to clarify certain controversies by evaluating outcome and diagnostic strategies in fusion of the tarsal joints. Due to the different pathologies affecting the tarsal joints and due to different surgical techniques that are applied, it is difficult to determine what is the most suitable operative technique for the treatment of these different problems. The present thesis describes observational outcome studies, a questionnaire based study, a systematic review of the literature, a randomized controlled trial and, finally, the 'quality of care through the patient´s eyes' (QUOTE) method of developing queries. The present studies provide more insight into the context of the diagnostic workup, the most appropriate surgical technique and the optimal outcome measurement. The ultimate goal is to achieve the best outcome for future patients undergoing fusion of the tarsal joints.

OUTLINE OF THE THESIS, QUESTIONS TO BE ANSWERED

The aims and background of the thesis are described in **Chapter 1** "General Introduction".

In order to evaluate the outcome after triple arthrodesis in our hospital, **Chapter 2** presents short term results on pain and impairment using the validated Foot Function Index (FFI) in a cohort of patients after triple arthrodesis of the hindfoot. The question posed is:

1. *"What is the short-term (1-3 years) outcome after triple arthrodesis in the different diagnostic groups?"*
   The relationship between pre-operative OA, proper alignment after triple arthrodesis, and the development of OA of the ankle joint is investigated in **Chapter 3**. A cohort of patients after triple arthrodesis of the hindfoot is followed in time. In this study the question posed is:
2. *"Does triple arthrodesis at midterm (5-8 years) follow-up lead to osteoarthritis in the ankle joint? Does the position/alignment of the hindfoot influence the outcome?"*
   In order to evaluate the current practice regarding diagnostic strategies for tarsal joint pathology among Dutch foot and ankle surgeons, a questionnaire was sent out. The findings from this questionnaire concerning the daily practice are compared with the best evidence concerning diagnostics in this field as found from a review of the

literature. The results of this comparison are described in **Chapter 4** . The research question asked was:

3. *"What are the preferences of Dutch orthopedic surgeons specialized in foot and ankle surgery for diagnostic modalities in tarsal fusion and how do these relate to the value of diagnostic tools as described in the literature?"*

Chapter 5 investigates the predictive value of diagnostic injections in the tarsal joints. The question posed is:

4. *"Is pain reduction after intra-articular anaesthesia indicative for a successful outcome of tarsal fusion?"*

Chapter 6 presents a systematic review of outcome studies after fusion of the tarsal joints according to the Newcastle Ottawa Score evaluating the quality of the literature. The question to be answered is:

5. *"Which specific tarsal fusion technique is most effective with regard to which specific pathology?"*

Chapter 7 describes the results of open and the arthroscopic fusion of the subtalar joint. The two operative methods are compared assessing the prevalence of early complications and the outcome using objective functional scores and patient satisfaction. This led to the following question:

6. *"Can the results of a randomized prospective study comparing open versus arthroscopic subtalar arthrodesis help to establish the correct indications and limitations of both procedures?" is the following question to be addressed.*

In order to incorporate patient's views in the assessment of the quality of care a PROM was developed using the quality of care through the patient's eyes (Quote) methodology to evaluate the quality of care in tarsal joint surgery. This study is described in **Chapter 8** and the question posed is:

7. *"Can a questionnaire measuring patient expectations and experience be constructed and validated, in order to improve the quality of care in tarsal arthrodesis?"*

The general discussion and implications for future research are presented in **Chapter 9**.

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Chapter 2

Triple arthrodesis of the hindfoot, a short term prospective outcome study

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Foot and Ankle Surgery 2006; (12): 71-77

ABSTRACT

This present study was performed to prospectively evaluate the short term results after triple arthrodesis using the validated Foot Function Index (FFI) to measure pain and impairment. Between 1999 and 2002 triple arthrodesis was performed on 81 patients. 4 Patients had died and 2 patients were not available for follow up leaving 87 fusions in 75 patients with a mean age of 40.5 years (range 14-79) for evaluation. Additional to the objective FFI and AOFAS-hindfoot outcome scores, the subjective outcome comprising patient satisfaction, subjective sense of improvement and shoewear were evaluated with a questionnaire and complications were noted. At a mean follow-up of 21 months, range 12-45 months, clinical assessment was performed by an independent researcher.

The FFI 5-point score for pain improved from a mean 39% to a mean 23% (range 100% - 0% and best score 0%). The score for disability improved from 42% to 30%. The FFI 5-point score could not measure statistically significant differences between the various diagnostic groups.

The mean postoperative AOFAS score was 74 points (range 30-94 and best score 94 points). 91% Of the patients would have the surgery performed again if in the same pre-operative situation. Patient satisfaction was good in 74%, fair in 17% and bad in 8%. The use of custom made shoes could be discontinued in 11 patients while a total of 29 patients (39%) had need for special footwear. The foot function was considered better than pre-operative by 89%. The complication rate in this series was 26%, consisting mostly of minor complications. Triple arthrodesis remains a salvage procedure, but the fusion rate was high with generally only minor complications and after this procedure patients suffer less pain and have a better function.

INTRODUCTION

Triple arthrodesis (TA) remains the standard procedure for the operative treatment of severe disabling arthritic pain, deformity and/or instability of the tarsal joints. The aim of this surgical procedure is to establish a painless, stable and plantigrade foot. Various studies describing the indications, techniques and results of TA in children and adults have been reported [1-32]. However, in all these retrospective studies non-validated scoring systems were used.

The primary aim of the present study was to prospectively assess the short term improvement following triple arthrodesis using the Foot Function Index as developed by Budiman-Mak [33]. This scoring system has been validated for the use in the Dutch language as a 5 point verbal rating scale [34]. In order to compare our results with those reported in literature the AOFAS hindfoot score [35] and a questionnaire were also used for evaluation at follow-up.

A thorough description of the operative technique is included and the results and complications regarding various diagnostic groups are reported.

PATIENTS & METHODS

Between June 1999 and December 2002, 93 Triple Arthrodeses (TA) of the tarsal joints (81 patients) were performed. Patients with symptoms of pain and/or clear degenerative changes of the ankle joint were not included in this study because these were likely to have influence on the results of the TA. This does not imply that patients with decreased mobility of the ankle joint were excluded. Six patients (4 deceased) were lost for follow-up. Thus 87 fusions in 75 patients, mean age 40.5 years (SD +/− 19.7) formed the study group.

The triple arthrodeses were performed for the sequela of different pathologies, including congenital disorders (n=7), neurologic disorders (n=15), neuromuscular disease (n=25), rheumatoid arthritis (n=11), posttraumatic disorders (n=11) and grade 3 [36] degenerative flatfoot disorder (n=18).

Of 87 procedures 46 TA were performed on men, and 41 on females. 50 Procedures were done on left feet and 37 on right feet.

See table 1 for an overview of patient data.

Table 1. Patient data

Summary of patient data	
Time frame of the study	June 1999-december 2002
Number of patients included	81 patients (93 triple arthrodeses)
Lost to follow up	6 patients (6 triple arthrodeses)
Studygroup	75 patients (87 triple arthrodeses)
Mean age of patients	40.5 years (SD +/– 19.7)
Male female ratio	1.12 : 1.00
Left right ratio	1.35 : 1.00
Outcome scores	Foot Function Index, AOFAS hindfoot score, union rate and complications
Statistical analysis	ANOVA $p<0.05$, non parametric Wilcoxon and Sign test $p<0.05$

Parameters

Preoperatively (within three months prior to surgery) and at follow-up all patients completed the Foot Function Index (FFI Table 2). The score consists of two scales in which pain (7 items) and disability (8 items) are rated on a 5-point Verbal Rating Scale (5-point VRS) that has a high correlation with the Visual Analog Scale (VAS score)[33]. To calculate the definitive scale scores, the item scores are summed and divided by the sum of the maximum possible score for each completed item, and then multiplied by 100 [34]. The scores range from 0 to 100 ; the higher the score, the more pain and disability is present. The FFI was validated from VAS scores to VRS scores and from the English into Dutch language by Kuyvenhoven [34].

Follow-up time was at least one year postoperatively (1-4 yrs.). Patients were evaluated by an independent orthopaedic surgeon. In order to compare results with those reported in the literature the AOFAS hindfoot score [35] was also taken. For the AOFAS hindfoot score the 6 points allotted to subtalar motion were excluded, thus the maximum possible score reached 94 points. An additional questionnaire asked the patient to report on shoewear, satisfaction regarding the results (good, fair or unsatisfactory), willingness to undergo the procedure again given the same preoperative conditions, and on the subjective improvement.

At follow-up a physical examination consisting of the objective items of the AOFAS hindfoot score including the alignment of the hindfoot, signs of neuropathy of the sural nerve, and other complications was performed.

For statistical analysis a one-way Analysis of Variance (ANOVA) was used to test for the factor diagnosis, with significance defined as $p<0.05$. The preoperative scores of the FFI were compared to the postoperative scores using the non-parametric Wilcoxon and the Sign test with significance defined as <0.05.

Table 2. Foot Function Index (FFI) (Kuyvenhoven et al.)
How much pain did you suffer last week due to the following situations?

B	Pain	No pain 0 points	Little pain 1 point	Moderate pain 2 points	severe pain 3 points	Intense pain 4 points	Not applicable
B.1	Foot pain at worst						
B.2	Foot pain in the morning						
B.3	Pain walking barefoot						
B.4	Pain standing barefoot						
B.5	Pain walking with shoes						
B.6	Pain standing with shoes						
B.7	Pain at the end of the day						

Score B: (ΣB/28)x100; minimum score is 0 ; maximum score is 100

How much difficulty did you have last week due to your foot problems to perform the following tasks?

C	Tasks difficulties	No difficulty 0 points	Little difficulty 1 point	Moderate difficulty 2 points	Severe difficulty 3 points	impos-sible 4 points	Not applicable
C.1	Difficulty walking indoors						
C.2	Difficulty walking outdoors						
C.3	Difficulty walking 4 blocks						
C.4	Difficulty climbing stairs						
C.5	Difficulty descending stairs						
C.6	Difficulty standing on tip toe						
C.7	Difficulty getting up from chair						
C.8	Difficulty climbing curbs						

Score C: (ΣC/32)x100; minimum score is 0 ; maximum score is 100
Total FFI score: (B+C)/2 ; minimum score is 0 ; maximum score is 100.
If an item is scored 'not applicable', the item is omitted in the calculations as described by Kuyvenhoven et al.(2002).

The postoperative radiographs were examined to determine the union rate. A pilot study was undertaken to assess the change of the geometry of the foot using the talometatarsal angle, talonavicular coverage angle and talocalcaneal angles as parameters. Unfortunately, this proved to be unreliable because there was no standard protocol for foot placement during the radiography so that the range of the values measured was too great. This problem has also been reported by other authors [6,12,16].

Operative technique and after treatment

All patients were operated on by the same surgeon using the following standardized technique. Frequently additional forefoot surgery was needed to achieve a plantigrade foot and/or to operatively treat a symptomatic forefoot. (see Table 3)

Table 3. Additional surgery with triple arthrodesis

Additional Surgery combined with Triple Arthrodesis	Patients
Achilles tendon lengthening	34
First metatarsal osteotomy	25
Claw toe correction	19
Hallux Valgus correction	8
PTT lengthening	3
Calcaneal osteotomy	1
Lateral column lengthening	1
IP arthodesis	1
TMT 1 arthrodesis	1
Navicular-cuneiform arthrodesis	1

Both a lateral and a medial incision are used. A lateral incision is made beginning at the tip of the fibula and extending across the dorsal aspect of the calcaneocuboid joint to the base of the fourth metatarsal. When deepening the incision along the dorsal aspect of the peroneal tendon sheath and along the superior border of the extensor digitorum brevis muscle (EDB), the surgeon must take care not to damage an anterior branch of the sural nerve. The EDB is detached, the muscle belly is carefully reflected distally, to expose the underlying sinus tarsi. Then the subtalar, calcaneocuboid and the lateral aspect of the talonavicular joint are exposed sharply with a knife and/or rongeur, removing the contents of the sinus and canalis tarsi with the capsuloligamentous structures. A lamina spreader is inserted into the sinus tarsi to visualize the subtalar joint and to open the middle facet joint also. After denuding the above mentioned joints the subchondral surfaces are scaled with a 4-6 mm osteotome or with an awl to create a bleeding cancellous surfaces to enhance fusion. The medial incision starts at the medial gutter of the ankle joint, just distal to the medial malleolus and is continued longitudinally in the distal direction to the dorsal aspect of the first cuneiform bone. The incision starts in the interval between the anterior and the posterior tibial tendons and is extended so that it obliquely crossed the anterior tibial tendon (ATT). When deepening the incision stay dorsally from the saphenous vein. The extensor retinaculum is carefully incised along the direction of the incision, so as not to damage the ATT. Holding the ATT slightly lateral, the talonavicular joint is opened longitudinally in line with the original direction of this

tendon. A dorsal osteophyte, if present, is now removed. After identification of the joint, the cartilage is denuded.

After the above mentioned preparation the joints are rotated until a neutral hindfoot position is achieved. In case of severe valgus or cavus deformity often an additional Achilles tendon lengthening is performed. For a valgus hindfoot, the angle between talus and calcaneus is corrected by outward rotation of the talus in relation to the calcaneus. The talar head moves slightly upward and the medial column is shortened by adducting and plantarflexing the forefoot in relation to the hindfoot, so the talonavicular joint is compressed and the arch is restored. At this stage a supinated forefoot can be corrected through pronating the forefoot in relation to the hindfoot in the Chopart joints. A lamina spreader can be used to lengthen the calcaneocuboid joint. The axis of the talus and the axis of the of the first metatarsal should be in line.

In case of cavovarus deformity the talar head is positioned laterally, “on top” of the calcaneum. The soft tissues are excised together with release of the medial capsulo-ligamentous structures, including the attachment of the posterior tibial tendon when necessary. For reduction the talar head is pushed medially and the navicular bone is pulled laterally and dorsally. This manoeuvre coincides with increase of pronation of the forefoot. When the foot is flexible enough the tarsus will take a neutral or valgus position. The more fixed the deformity, however, the more bony excision from the talar head and lateral column is needed in order to reposition the tarsus. The talonavicular joint is transfixed with a compression screw/cortical screw in a lag fashion. Because the reduction of this joint completely determines the geometry of the hindfoot this is called the “homerun screw”. The screw (usually 60 mm in length) runs from the medial border of the naviculocuneiform joint at the inferior aspect of the ATT into the body of the talus. Hereafter, the the talocalcaneal joint is compressed with a 6.5 mm screw directed downwards from the dorsomedial aspect of the talus, down into the tuberosity of the calcaneus (length between 80mm-100mm.) The calcaneocuboid joint is fixed last, with a cortical screw directed from the anterior process of the calcaneus to the cuboid (usually 40 mm length). A gap due to lengthening of the lateral column can be closed with bone taken from the dorsal aspect of the anterior process of the calcaneus or bonegraft otherwise. The EDB is closed over the lateral side , after which the subcutaneous tissue and skin are closed. On the medial side the capsular tissue , if possible , and retinaculum are closed, after which the subcutaneous tissue and skin are closed. Pre- and postoperatively the foot is placed in a below knee cast for a period of four weeks. The patients are mobilized non-weightbearing. After four weeks a below knee cast is applied in which the patients are allowed to increase weightbearing. After eight weeks the patients are mobilized full weight bearing in a commercial walking brace, unless there is a sign of

delayed healing. The Walker is used another month. Hereafter the patients start using shoewear on the operative side as soon as comfortable, gradually weaning the use of the Walker. Multiple factors will determine variability to the time of complete recovery, but usually this takes a year.

RESULTS

Objective results

The overall FFI improvement regarding pain was from 39% (SD+/- 21%) to 23% (SD+/- 21%) and the disability score improved from 42% (SD+/- 21%) to 30% (SD+/- 25%). The results per diagnostic group are summarized in table 4 showing improvement for all groups except the congenital disorder group. This group was excluded from statistical analysis with regard to the comparison between groups because of its small numbers. Although the absolute values between groups are different, for example in the RA group versus the neuromuscular group, no statistically significant differences were found between the various diagnostic groups when using the Analysis of Variance test (ANOVA).

The median AOFAS score was found to be 74 points (range 62-94 points). Physical examination showed malalignment in 5 patients (6%). The median plantarflexion in the ankle was 27 degrees (0-50) and the median dorsiflexion was 6 degrees (–10-40).

Table 4. Results FFI pain/difficulty, pre/postop per diagnostic group

	diagnosis	PrePain	PostPain	Prediff.	Postdiff.
1	Congenital	51	40	37	43
2	Degenerative	47	27	52	20
3	Neuromuscular	27	17	35	20
4	Neurologic	31	12	29	18
5	R.A.	58	34	66	47
6	Posttrauma	39	21	35	24

Subjective results

91% Of the patients would repeat the operation given the same preoperative conditions. 88% Of the patients reported improvement compared to the preoperative situation.

According to the questionnaire 11 patients no longer needed custom made footwear whereas 29 patients continued to wear custom footwear. On the question regarding the satisfaction rate, 74% answered good, 17% fair and 8 % answered unsatisfactory.

Complications

The complications and reoperations are summarized in Table 5. Malalignment of the hindfoot was found in 5 patients. One patient underwent a calcaneal osteotomy to correct persistent flatfoot deformity and another underwent a forefoot reconstruction. Six patients demonstrated neuropathy of the sural nerve. One of these underwent an excision of a neuroma with satisfactory results.

In four patients one of the screws proved to be malpositioned (protruding in the lateral gutter of the ankle joint) or causing mechanical pressure in the shoe. These screws were removed. Other complications consisted of 5 superficial wound infections and 1 deep infection. Of these patients one surgical debridement was performed and in another patient a correction of the scar was performed after healing and the fifth toe was amputated following necrosis.

The patient with deep infection and necrosis around the wounds proved to have vascular stenosis which was not recognized preoperatively. This patient underwent femoro-popliteal bypass reconstruction after which the wounds and the arthrodesis fortunately healed.

Radiographic assessment showed a non-symptomatic non-union in one patient and a stress fracture in another patient.

Table 5. Complications after triple arthrodesis.

Complications	Patients	Reoperation	Patients
Major			
Insufficient correction	**5**	Calc. osteotomy	**1**
Non-union	**1**		
Minor			
Deep infection	**1**	Fem-pop bypass	**1**
Superficial infection and necrosis	**5**	Scar tissue correction, amputation 5th toe	**1**
Neuropathy	**6**	Excision neuroma	**1**
Stress fracture	**1**	None	
Malposition of screws	**4**	Screws removed	**4**

DISCUSSION

The present study is the first to compare the results of triple arthrodesis of the hindfoot to the preoperative state using a validated score (the FFI). The scores for pain and for function show a statistical significant improvement, 16 and 12% respectively. Comparing our results with those reported in the literature no important difference is found with regard to the AOFAS hindfoot score and patient satisfaction. Round 90% of the patients

reported improvement compared to the preoperative situation and would repeat the operation given the same preoperative conditions.

It was surprising that the pre-operative FFI score reflected the existence of only a moderate amount of problems regarding pain and function and that it seems that only little (however, statistically significant) change of the FFI scores results from the intervention. An explanation for the discrepancy we found between patient satisfaction and the change of the scores could be the influence of the disease(s) the patient is suffering from and other general factors which are not solved as a result of the surgery. For example, one cannot expect a striking increase of function after a fusion of a deformed hindfoot in patients with a neuromuscular disorder. They are still, probably, importantly incapacitated by paralysis. But being able to stand or walk in reasonably normal shoes with slight increase of balance control could make an important change in life for the involved patient. Correcting a painfull and deformed tarsus can make a lot of difference for those suffering severe rheumatoid arthritis, however the FFI scores may change little as a result of persisting knee, ankle and/or forefoot problems. Such more subtle changes are not reflected through the FFI or AOFAS hindfoot scoring systems. The relatively higher improvement of the scores in the degenerative group (although the differences are not statistically significant) seem to substantiate this explanation.

It is concluded that the items scored with the FFI do not fully reflect all problems that specific patient groups experience, neither do the items reflect the patients expectations. In a quest for new measuring instruments several authors have commented on the Quality of care measurements. So called Quote instruments for reumatoid arthritis patients, cataract patients and the elderly have been developed [37-40]. Presently a questionnaire with specific items for a disease specific target group (Charcot-Marie-Tooth patients) undergoing surgery of the foot is being composed at our department.

Results of TA as reported in the literature are summarized in Table 6a-c. When using a technique as described in the present study the non-union rate can be as low as 0-4.5%, with exception of one study reporting a 17.6% non-union rate (Table 6a). In studies where resection of bone (often bone wedges) was used with internal fixation the non-union rate reached 23% (Table 6b). If resection of wedges without internal fixation is performed a non-union rate of 8-23% is reported (Table 6c). Advantages of no resection or minimal resection techniques is the preservation of bone, thus preventing shortening. The maintenance of the congruity of the bony surfaces, thus more bony contact, may increase the union rate. Resection of excessive wedges of the tarsal bones, particularly the talus may be the cause of talar necrosis as reported in the past [14]. We report a low

non-union rate (1.3%) and only minor complications and conclude that the applied technique positively influences this good result.

Table 6a. Nonresection with internal fixation

Author	Year	F.U.	Npt/Nft	Group	Study	O.T.	O.R.	S.R.	Nonunion
Talarico[20]	2004	4-9 yrs	87(87)	2	retro	3	No data	No data	3%
Graves[9]	1993	4 yrs	17(18)	2, 3, 4, 5	retro	3	No data	1: 82%	17.6%
Bednarz[6]	1999	1-5yrs	57(63)	1, 2, 5	retro	3B	2: 81%	1: 99%	3%
Kissel1[14]	1997	½-3 yrs	14(14)	2	retro	3	No data	1: 86%	2%
Horton[30]	1995	3yrs	14(22)	2	retro	3	No data	'All good'	0%
Tisdel[31]	1995	4yrs	7(8)	3	retro	3	No data	No data	0%
Stegeman	2005	1-4yrs	75(87)	1, 2, 3, 4, 5	retro, FFI prosp	3	2: 74%, 4: P39-23%, F41-30%	1: 74%, 2: 88%, 3: 91%	1%
Sangeorzan[16]	1993	5 yrs	40(44)	2, 3	retro	3	1: 34-6-4 Aims: 3	1: 75%	4.5%
Fortin[10]	1999	4 yrs	25(32)	2	retro	2, 3	2: 39 to 82%	1: 96%	0%

F.U.:Followup **Npt**:patients **Nft**:feet
Group:1=congenital, 2=degenerative, 3=neuromuscular/neurologic, 4=R.A., 5=posttrauma O.T: Operative Technique: 1=resection no fixation, 2=resection and fixation, 3= nonresection with fixation, A=with allograft, B= with autograft OR= Objective results 1= Angus &Cowell, (good-fair-bad) 2=AOFAS, 3=Hallgrimson, 4=MacKenzie, 5=FFI SR= Subjective results: 1=satisfaction, 2=function, 3=willingness to recommend, 4=custom made shoes

Table 6b. Resection with internal fixation technique

Authors	Year	F.U.	Npt/Nft	Group	Study	OT	OR	SR	Nonunion
Jarde[21]	2002	2-17 yrs	14(20)	2	retro	2	2. 90%	2: 60%, 4: 50%	10%
Bennet[12]	1991	3-5yrs	22(22)	1, 2, 4, 5	retro	2	1: 36-13-5	1: 95%	9%
Odgaard[13]	2001	2-9 yrs	29(31)	2, 3, 4	retro	2	1:69-30-15	3: 85%	6%
Saltzman[26]	1999	25-44 yrs	57(67)	3	retro	2	1:75-x-x	No data	23%
Figgie[8]	1992	5 yrs	40(49)	5	retro	2B	No data	1: 90%	2.5%
Herbsthofer[28]	1997	15-25yrs	46(64)	3	retro	2	Mc Guire 91%	No data	9%
Hariditis[29]	1994	25yrs	42(42)	3	retro	1, 2	1: 31-59-10	No data	0%

F.U.:Followup **Npt**:patients **Nft**:feet
Group:1=congenital, 2=degenerative, 3=neuromuscular/neurologic, 4=R.A., 5=posttrauma O.T=Operative Technique: 1=resection no fixation, 2=resection and fixation, 3= nonresection with fixation, A=with allograft, B= with autograft OR= Objective results 1= Angus &Cowell, (good-fair-bad) 2=AOFAS, 3=Hallgrimson, 4=MacKenzie, 5=FFI SR= Subjective results: 1=satisfaction, 2=function, 3=willingness to recommend, 4=custom made shoes. x=no data

Table 6c. Nonresection mostly without internal fixation

Authors	Year	F.U.	Npt/Nft	Group	Study	O.T.	O.R.	S.R.	Nonunion
Wetmore[23]	1989	15 yrs	16 (30)	3	retro	1	1: 34-30-x	No data	13%
Wukich[32]	1989	12 yrs	22 (34)	3	retro	1	1: 32-56-12	1: 86%	25%
Olney[24]	1988	10 yrs	13 (18)	3	retro	1	No data	1: 83%	8%
Mulier[25]	1990	4 yrs	20 (25)	3	retro	1	3: 9-9-3-1	72% good	8%
Mann[22]	1992	7 yrs	10(12)	3	retro	1, 2	No data	1:75%	30%
MacKenzie[18]	1959	1-27	100(100)	1, 2, 3, 4	retro	1, 2	3: 37-44-19	No data	17%
Wilson[19]	1965	1-39	208(301)	1, 2, 3, 5	retro	1, 2	complications	33%	10%
Duncan[17]	1978	1-28	89(109)	1, 2, 3	retro	1, 2	Patterson 75%	1: 95%	9%
Angus[5]	1986	13 yrs	62(80)	1, 3	retro	1	1: 20-34-25	1: 92%	22.5%
Beisschner[11]	1999	5 yrs	13(13)	2	retro	No data	2: 77-15-8	1: 92%	0%
De Heus[27]	1997	6-15 yrs	28(37)	3	retro	No data	No data	4: 78%	0%

F.U.:Followup **Npt**:patients **Nft**:feet
Group:1=congenital, 2=degenerative, 3=neuromuscular/neurologic, 4=R.A., 5=posttrauma O.T: Operative Technique: 1=resection no fixation, 2=resection and fixation, 3= nonresection with fixation, A=with allograft, B= with autograft OR= Objective results 1= Angus &Cowell (good, fair, bad), 2=AOFAS, 3=Hallgrimson, 4=MacKenzie, 5=FFI SR Subjective results: 1=satisfaction, 2=function, 3=willingness to recommend, 4=custom made shoe. X=no data

The key to restoring the geometry of the foot with correct alignment of the hindfoot is reduction of the foot around the talar head as described. Little to no resection of bone is needed even in a case of quite severe deformities. It should be emphasized that correction of an important hindfoot deformity will not succeed as a stand-alone procedure. In case of valgus deformity, fixed supination of the foot might imply the need of a plantar flexing procedure of the medial column. After correcting a varus deformity of the tarsal bones most often a dorsiflexing osteotomy of the first ray is obligatory to correct increased pronation of the forefoot. Not restoring the normal alignment of the foot, as was the case in 5 of our patients, results in a less favourable outcome.

It is now generally accepted practise to internally fixate a triple arthrodesis. Although the use of screw fixation is advocated, other forms of osteosynthesis might also suffice [5,6,14,20,30,31,41].

The use of bone grafting, and whether to use allograft or autograft is still under discussion. In cases where sufficient apposition cannot be achieved resection of wedges and or bone graft may be used, for which an autograft might do better than allograft [6,15,42,43]. In the present study a near 100% union rate was achieved without the use of iliac crest autograft or allograft.

CONCLUSIONS

Triple arthrodesis of the hindfoot is a salvage procedure for the final stage of disease. Following the use of the surgical techniques advocated in this study the percentage of satisfied patients is high and the complication rate is low. Although the FFI score is validated for all patients with foot problems this scoring system does not reflect the true benefit of this procedure for patients requiring a triple arthrodesis. New and more specific scoring systems are needed.

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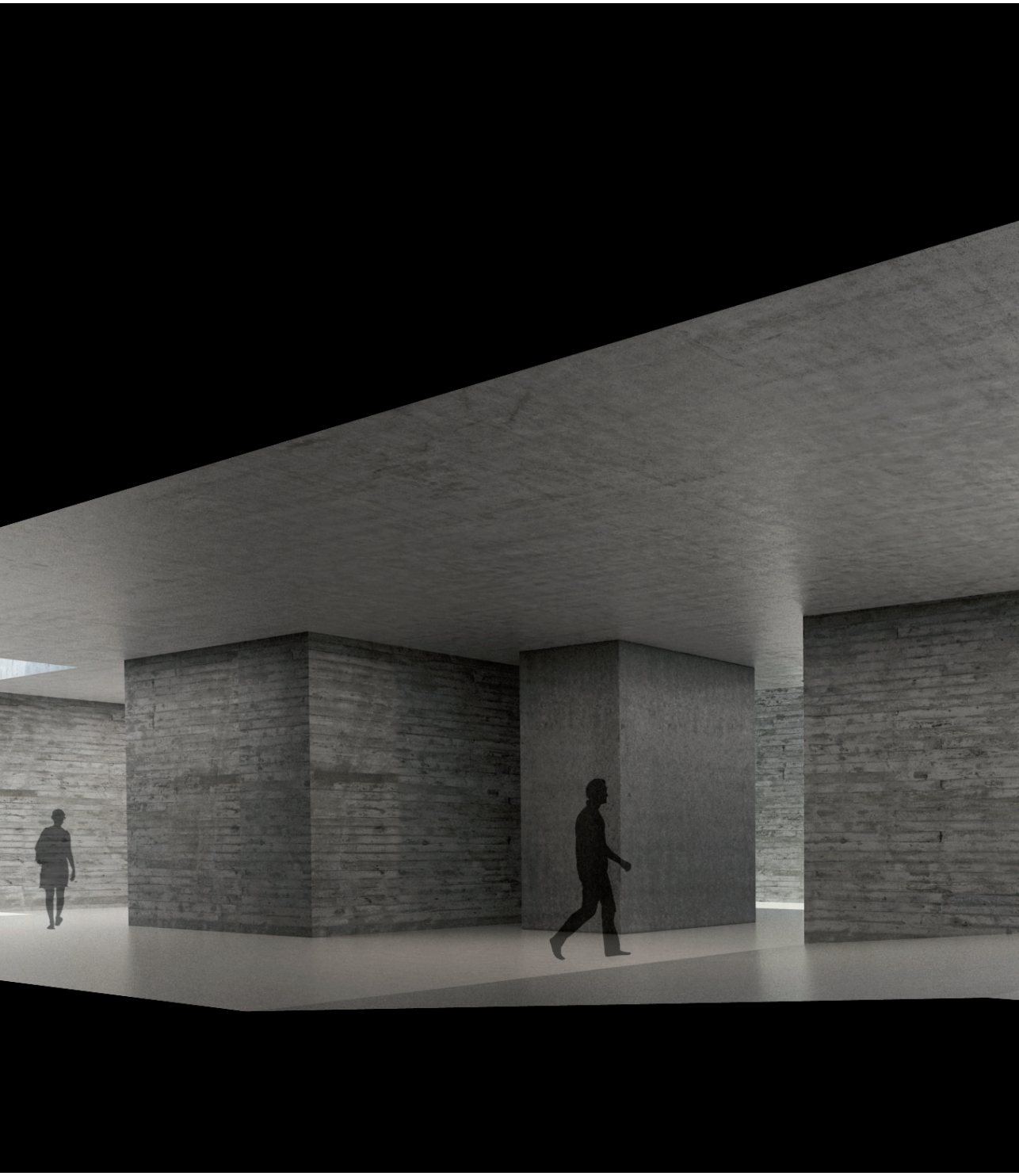

Chapter 3

Does osteoarthritis of the ankle joint progress after triple arthrodesis? A midterm prospective outcome study

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Submitted for publication

ABSTRACT

Background: Debate exists regarding the effect of triple fusion on the development of osteoarthritis (OA) of the ankle joint. The midterm outcome after triple arthrodesis and the prevalence of OA in this cohort are reported in this study. The role of alignment in the development of OA was investigated.
Methods: Seventy-five patients (87 feet) were evaluated at a short-term follow-up in 2003, of which 48 patients (55 feet) were available for a second evaluation in 2008 (this study). X-ray images were acquired of the ankles and feet prior to surgery, again in 2003 and in 2008, and the level of OA was graded using the Kellgren and Lawrence score. On all postoperative radiographs, the anteroposterior and lateral talo first metatarsal angles were compared. Also, standardized digital images were acquired to assess the geometry/alignment. The Foot Function Index (FFI) and the American Orthopaedic Foot and Ankle Society (AOFAS) hindfoot score instruments were completed. To investigate the role of the underlying alignment on the aggravation of ankle OA, patients were divided into 'varus' and 'valgus' groups based on the indication for surgery.
Results: The outcome scores (AOFAS and FFI) after triple arthrodesis remained stable in the present 7.5-year follow-up study (data collected in 2008). An important increase of OA of the ankle was not found; 58% of the patients showed no aggravation, 31% a one-grade increase, and 2% a two-grade increase of OA. A trend was found (P=.063) toward aggravation of OA of the ankle in patients of the varus group with the highest medial arches (persistent cavovarus deformity).
Conclusion: This study reports minor, non-significant, changes of the ankle joint following triple arthrodesis after 7.5 years. Clinical outcome remained stable over time.
Clinical relevance: It seems triple arthrodesis per se does not lead to major OA of the ankle, given that adequate alignment of the hindfoot is achieved.

Level of evidence: Level II.

Keywords: Ankle osteoarthritis; Hindfoot; HMSN; Triple arthrodesis

INTRODUCTION

Triple arthrodesis is a surgical procedure for the treatment of painful, deformed and unstable tarsal joints. Some authors report that fusion of the tarsal joints leads to a high incidence of degenerative changes of the ankle joint and should be avoided whenever possible [1-3]. Also, a cadaver study demonstrated higher peak pressure in the ankle joint after triple arthrodesis, thus increasing the risk of osteoarthritis (OA) [4]. Other authors state that the pain and reduced mobility of the ankle joint due to OA after triple arthrodesis are minimal, and that there is an enduring high rate of satisfaction after surgery [5-10]. However, it must also be considered that, to a certain extent, OA of the ankle may have been present before surgery as a consequence of the primary foot pathology/deformity [7-11]. Triple arthrodesis is a technically difficult procedure and correction of the shape/alignment of the foot may not be to the degree intended [12,13]. Malalignment may persist after operative correction, and this factor may be more important in determining OA of the ankle than the fusion per se.

The present study is the mid-term follow-up of a cohort of triple fusion surgeries by a single surgeon. The short-term results were described by our group in 2006 [14]. To assess the mid-term results of triple arthrodesis on the ankle joint in this cohort, development of secondary OA of the ankle was investigated. At the same time, the geometry of the feet was assessed in order to investigate the role of alignment in the development of OA of the ankle.

The hypothesis was: after a mean follow-up time of 7.5 (range 6-8) years, any observed increase in OA of the ankle joint would be associated with pre-existing OA and persistent malalignment of the foot after triple arthrodesis.

PATIENTS AND METHODS

Patients

From 1999 to 2002, 81 patients underwent 93 triple arthrodesis procedures in our institute. When this single-surgeon cohort was first evaluated in 2003, four patients were by then deceased and two patients were not available for follow-up; therefore, the short-term study included results for 75 patients with 87 fusions [14].

For the present study, 48 patients (55 feet) returned for a new examination in 2008. Unfortunately, of the original 75 patients studied, 27 (32 feet) could not be evaluated for this second postoperative examination in 2008 for several reasons: four patients were deceased, four only completed a questionnaire, and 19 thought the distance to the hospital was too far and/or did not acknowledge the purpose of this extra examination.

Table 1. Patient characteristics

Study group at 7.5-yr follow-up	48 patients (55 triple fusions)
Mean age of patients at 7.5-yr follow-up	47.24 years (S.D. ± 19.05)
Male: female ratio	1:1
Left: right ratio	1.39:1

Of the 48 patients reexamined, 24 (28 feet) were male and 24 patients (27 feet) were female, with ages ranging between 22-82 years. Thirty-two left and twenty-three right feet were operated on (Table 1). Deformity of the foot due to neurological problems such as Charcot–Marie–Tooth disease (also known as hereditary motor and sensory neuropathy, HMSN) was the most frequent indication for surgery in this population, followed by acquired degenerative flat foot, rheumatoid arthritis, OA, posttraumatic deformity, the sequelae of a tarsal coalition, and talus verticalis (Table 2).

Table 2. Indications for triple arthrodesis, divided into two groups

Group 1		Group 2	
HMSN	15	Osteoarthritis	8
Pes cavovarus	6	Flat feet	8
Clubfoot	2	Rheumatoid arthritis	6
Neuropathy	1	Tarsal coalition	3
Postpolio syndrome	1	Post compartment syndrome	1
Foot drop	1	Talus verticalis	1
Pyramidal syndrome	1	Posttraumatic	1

Operative technique and after-treatment

The indications and techniques of the procedures used in the present study have been described previously [14,15]. All patients underwent surgery by the same surgeon (JWKL) applying the same standardized technique for triple fusion, using a bilateral approach and screw fixation. In addition to the standard triple arthrodesis, further procedures were often necessary to achieve a plantigrade foot. All of these procedures were performed to optimize alignment of the foot, to improve muscle balance, or to correct the forefoot (see Table 3). The specific types of procedures and the complications following surgery have also been reported previously [14].

Outcome parameters

For all 48 participating patients (55 feet), standardized weight-bearing radiographs and digital photographs of the foot and ankle were acquired [16]. Patients completed a questionnaire (Foot Function Index, FFI), validated for use in The Netherlands [17]. The FFI

Table 3. Eighty-one additional procedures

First MT osteotomy	23
TMT1 arthrodesis	12
PIP resection	9
Calcaneal osteotomy	2
Achilles lengthening	26
Tendon transfer	6
Flexor tenotomy	1
Ankle arthrotomy	1
Split skin graft	1

consists of two different scales in which pain and disability are rated on a 5-point Verbal Rating Scale (5-point VRS). The scores range from 0 to 100; the higher the score the more pain and disability. Furthermore, the American Orthopaedic Foot and Ankle Society (AOFAS) scale was completed [18]. For the AOFAS hindfoot-score, the six points allotted to subtalar motion were excluded; thus, the maximum possible score was 94 points.

The weight-bearing X-rays were obtained in two directions: anteroposterior and lateral. OA of the ankle joint was graded using the Kellgren and Lawrence score (Table 4) [19,20].

To evaluate the geometry of the foot, an anteroposterior and lateral talo-1st metatarsal angle was measured on the lateral view. A talo-1st metatarsal angle less than 15 degrees on the anteroposterior view and a talo-1st metatarsal angle between -5 and 5 degrees on the lateral view (also Meary´s angle) is considered to be normal [10-21]. Unfortunately, the pre-operative X-rays were found not to be accurate enough for measurement of radiological angles due to lack of standardization. However, the grading of OA on these pre-operative X-rays was possible.

Standardized digital photos were made postoperatively to evaluate the alignment of the hindfoot. These images were acquired using a Foot Build Registration System (FBRS). The reproducibility of the measurements made with this device has been reported previously and is most accurate with regard to the posterior view [16]. Digital images of the feet were made at the follow-ups in 2003 and 2008. The patients were photographed in a single-leg

Table 4. Kellgren and Lawrence score

Grade 1	Doubtful narrowing of joint space and possible osteophytic lipping
Grade 2	Definite osteophytes, definite narrowing of joint space
Grade 3	Moderate multiple osteophytes, definite narrowing of joint space, some sclerosis and possible deformity of bone contour
Grade 4	Large osteophytes, marked narrowing of joint space, severe sclerosis and definite deformity of bone contour

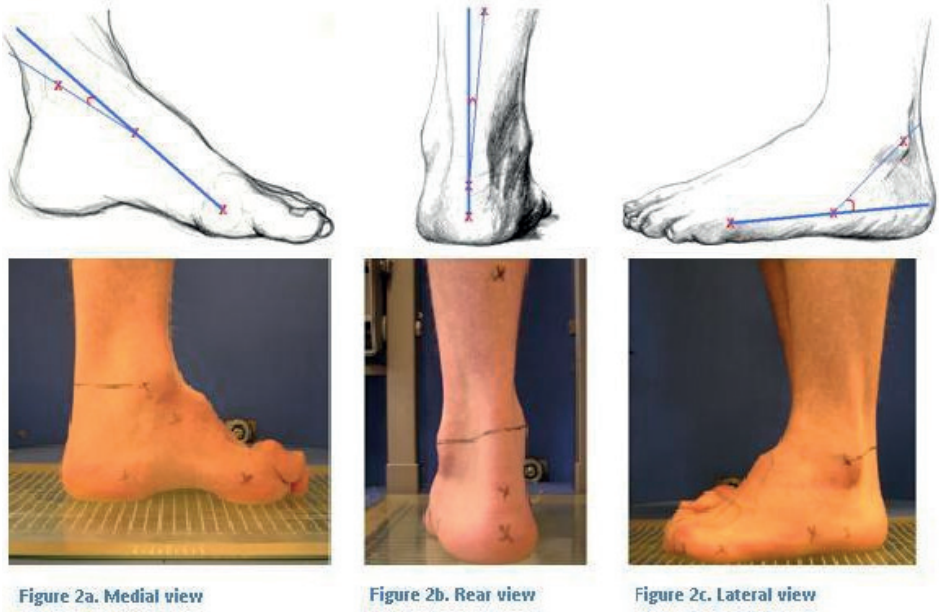

Figure 1. Different angles and markers on the foot.

weight-bearing position with the foot in the mid-stance position. On the photographs, using custom made software, the following three angles were determined (Figure 1): a) to evaluate the medial longitudinal arch, the angle is measured between two lines — one line from the medial malleolus (most distal border) to the center of the navicular tuberosity, and the second line from the center of the navicular tuberosity to the center of the head of MT1; b) to evaluate the posterior alignment of the calcaneus and tibia, the angle is measured between the posterior midline of the calcaneus (just proximal to the fat pad to the insertion of the Achilles tendon) and the line bisecting the calf (from the Achilles insertion up to 15 cm above ground level); and c) the lateral view, the angle between a line from the center of the head of MT5 to the tuberosity of MT5 (proximal plantar border) and a line from the tuberosity of MT5 to the lateral malleolus (most distal border).

Analysis

For all 48 patients (55 feet) included in the present study, the FFI scores and AOFAS scores measured preoperatively and in 2003 were compared with the scores from the present follow-up (2008).

Secondly, considering overall alignment, it was decided to divide the patients into two groups based on their original diagnostic type of malalignment: (cavo)varus and (plano) valgus. Group 1 (27 feet): HMSN, cavus, postpolio, neuromuscular, varus and club foot. Group 2 (28 feet): OA, rheumatoid arthritis, posttraumatic deformity and pes planus (Table 2).

A Kolmogorov-Smirnov test was used to test for equal variances between the groups. The three angles measured on the digital photos (evaluating the geometry of the foot) were compared between the two groups with a two-sample Student's T-test or a non-parametric median test, as appropriate. The two-sample T-test was used to compare the FFI and AOFAS-score between both groups as well. The angles measured on the X-ray images were compared between the two groups by using a non-parametric median test. Correlation coefficients were calculated between the FFI and the foot geometry, and between the AOFAS score and the foot geometry, and between the angles on the X-ray images and the FFI and AOFAS scores. To investigate whether pre-existing malalignment was related to OA, each diagnosis group was subdivided into three groups: the five feet with the highest medial angles of foot geometry, the five feet with the lowest medial angles, and the "in between" angles. Subsequently, aggravation of the OA (pre-op to 2008) was compared between the three subgroups, for each diagnosis group, by using a median test.

Finally, for all 48 patients the different grades of OA at the three examination times (preoperatively, 2003 and 2008) were compared. The grade was compared within each patient individually to evaluate if there was aggravation of the OA from the preoperative period to the second follow-up evaluation.

Statistical analyses were performed with Stata software package version 10.1. P-values of ≤0.05 were considered statistically significant.

RESULTS

Preoperatively, 21 feet had the lowest grade of OA, as determined by X-ray examination (Figure 2). In 2003, twenty feet and in 2008, fifteen feet showed grade 1 OA. Grade 2 OA was found in 21 feet at all three evaluation points. The number of grade 3 OA increased from 8 feet preoperatively to 10 feet in 2003 and 13 feet in 2008. Preoperatively, one ankle was already found to have grade 4 OA, in 2003 two ankle joints were graded 4, and in 2008 five were graded 4. Four X-ray results were missing preoperatively. From the first evaluation point in 2003, two X-ray results were missing. The radiographic imaging for one patient in 2008 was unsuitable for grading due to the severity of the deformity. The majority of the patients showed no (58%) or one grade (31%) of aggravation of OA 7.5 years after surgery (Table 5).

The clinical outcomes were comparable to those described earlier by Stegeman et al. [14]. The mean AOFAS hindfoot score 5 years prior was 74 (SD 11.82) [14]; in the present study a mean score of 73 (SD 15.68) was found. The FFI prior to the fusion was 39.3 (SD 20.70) and was 24.1 (SD 19.80) at the first evaluation point. At the second evaluation point the FFI remained unchanged: the mean FFI was 23.9 (SD 17.81), with 13.5 (SD 16.25) for pain and 34.4 (SD 28.27) for disability.

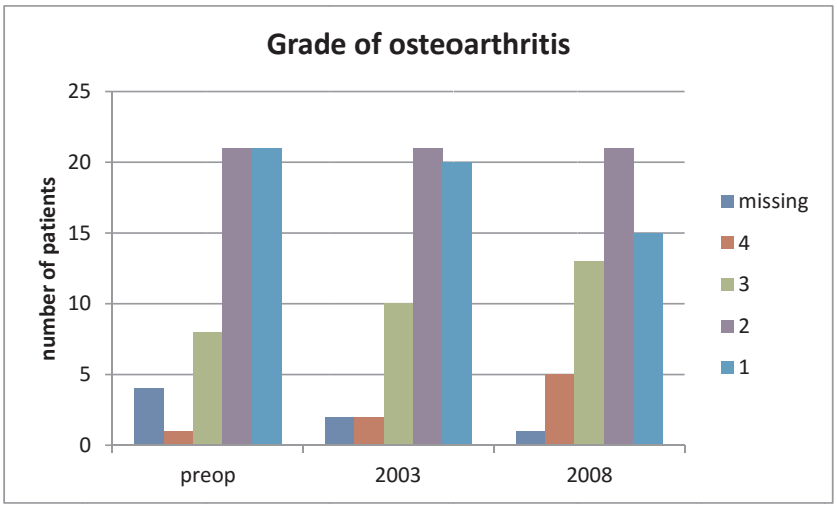

Figure 2. Distribution of grades of osteoarthritis

The FFI was not significantly different between group 1 and group 2, with a mean index of 26.3 (95% CI [18.8-33.7]) in group 1 and 21.7 (95% CI [15.1-28.3]) in group 2, (*P*=.35). The mean AOFAS score of group 1 was 68.9 (95% CI [62.0-75.9]) and in group 2 it was 76.4 (95% CI [71.3-81.5]), also not significantly different (*P*=.08).

Of the 55 feet, five were not photographed with a digital camera due to technical problems with the data storage. There was no significant difference between groups 1 and 2 postoperatively regarding the angles measured on the digital posterior view photos (*P*=.87) (Table 5). Similarly, none of the angles of the lateral view were

Table 5. Aggravation of osteoarthritis in 2008 compared to preoperatively

Osteoarthritis grade		Number of feet and aggravation
Grade 1	15	• 14 no aggravation • 1 no preoperative X-ray
Grade 2	21	• 13 no aggravation • 7 aggravation of one grade • 1 no preoperative X-ray
Grade 3	13	• 4 no aggravation • 7 aggravation of one grade • 2 no X-ray preoperative and at the first evaluation
Grade 4	5	• 1 no aggravation • 3 aggravation of one grade • 1 aggravation of two grades
Missing	1	• Not assessable due to wrong angle of X-ray
Total	55	

Table 6. Results of analyses of the digital photos and X-ray images

Mean angle or median angle:	Group 1 (95% CI) or [range]	Group 2 (95% CI) or [range]
Posterior view digital photo	-0.29 (-4.0 - 3.4)	0.07 (-3.1 - 3.3)
Lateral view digital photo	44.7 (41.7-47.7)	43.1 (40.3-45.9)
Medial view digital photo	25.8 [1-57.2]	50.1 [4.9-64.2]*
Talo 1st MT lateral X-ray	6.4 [-7.3 - 27.5]	0.8 [-9.5-18]
Talo 1st MT AP X-ray	8.4 [-8.7-49]	4.9 [-16-16]

*p<0.05 between Group 1 and Group 2

significantly different between group 1 and group 2 (*P*=.43). The medial view, however, showed a significant difference between the two groups; in group 1, lower angles were found than in group 2 (*P*<0.001), implying higher arches of the foot (Table 6).

The angles measured in group 1 were higher than those measured in group 2 both on the medial view (*P*=.005) and the anteroposterior view (*P*=.022) (Table 5), consistent with a more cavovarus tendency in group 1.

No correlation was found between the FFI and the angles on the posterior view, medial view and lateral view photographs (*R* = 0.24, 0.02, and 0.16, respectively). Neither was there a correlation between the AOFAS score and these angles (*R* = 0.07, 0.27, and 0.21, respectively).

For group 1 there was a trend toward more OA aggravation for those feet with the highest medial angles postoperatively (i.e. cavovarus feet) (*P*=.063). For the feet in group 2, there was no relationship between OA aggravation and foot geometry (*P*=.33).

DISCUSSION

Stegeman et al. [14] reported the short-term (2-year) results of triple arthrodesis performed on patients included in the present study and described a statistically significant improvement of the FFI for pain and disability. The present study shows that the AOFAS score and FFI remain unchanged between the 2-year and 7.5-year follow-ups. Moreover, the scores are comparable to those reported in the literature [22,23].

As could be expected, a slight difference was found when comparing the alignment of the feet after surgical correction between group 1 (including the cavovarus feet) and group 2 (including the degenerative flatfeet). Table 6 shows postoperative measurements with higher medial arches in group 1, as was to be expected because most group-1 feet had a cavovarus deformity. However, the postoperative differences between the groups are not statistically significant.

One of the most important drawbacks of triple fusion, as mentioned in the literature, is that fusion of the tarsal joints can provoke OA of the ankle joint, and several studies

suggest there is increased OA of the ankle joint after triple fusion. It is postulated that the apparent higher incidence of ankle OA may be because the hind foot becomes stiffer, thus increasing the shock/impact on the ankle at heel strike and foot flat during gait [1-3]. However, other authors have found no increase of OA at long-term follow-up after subtalar or triple fusion [7]. Kim et al. (2010), in a study comparing ankle replacement with and without a fused hindfoot, found no adverse effect of a fused hindfoot on the outcome of the ankle replacement [24]. Surprisingly, the occurrence of OA in the subtalar joint after ankle arthrodesis is widely known and reported [25-27]. A possible explanation could be that the ankle joint has more compensatory mechanisms to dissipate forces (e.g. to the knee joint) than does the subtalar joint.

In evaluating any increase of OA following triple fusion, it is important to consider that the ankle joints of these patients, depending on the underlying pathology, may already have experienced a certain degree of degenerative change prior to the triple fusion [5-11]. Indeed, a significant number of patients that underwent ankle fusion showed a preexisting degree of OA of the tarsal joints on radiographic examination [11]. Malalignment of the hindfoot may even be more important in the development of ankle OA. The relationship between pathology of the foot and pathology of the ankle remains commonly acknowledged but poorly understood.

In our series, degenerative changes of the ankle joint prior to triple fusion were found to exist radiologically in 59% of the cases (Figure 2). At the 7.5-year follow-up, no or only mild progression of OA was evident. For the majority of cases with neutral alignment of the foot, no important increase of OA in these 7.5 years was noted. In some cases the OA grade of the ankle joint after triple arthrodesis was found to be higher (Figure 2); however, also in these cases the postoperative alignment of the foot was inadequate. These findings support the hypothesis that increased OA of the ankle joint would be mild and associated with pre-existing OA of the ankle joint and/or with persistent malalignment of the foot after triple fusion. All X-ray results were interpreted by one independent observer. When in doubt, a second observer was involved. The kappa value of the intraobserver variability lies between 0.51-0.81 [20, 28]. For this reason there was no second observer in the majority of the cases.

An important limitation of this study is that a relatively large proportion of patients was lost to follow-up. Despite repeated invitations and phone calls, we were not able to motivate some patients to visit the outpatient clinic to participate. Unforeseen technical problems with the digital camera resulted in a failure to collect data from some participants. However, the patient characteristics in the lost-to-follow up group had the same patient characteristics as the study population.

Another limitation of the study, already mentioned in the previous publication [14], was that the pre-operative radiographic images were not considered accurate, so they could not be compared to the standardized postoperative radiographs. However, the FBRS,

which was developed after the study was initiated, allowed us to compare the alignment postoperatively and determine whether OA is associated with a malaligned triple arthrodesis. We believe the influence of hindfoot alignment on the worsening of ankle OA is dependent on the alignment postoperatively and not so much on the alignment preoperatively.

We acknowledge that no Salzman views or hindfoot alignment views were made preoperatively or postoperatively. However, we have the posterior view of the FBRS that accurately assesses the alignment postoperatively at first and second evaluation [16]. With this technique, we can measure the postoperative success in achieving normal alignment and also evaluate any deterioration of alignment.

The present 7.5-year follow-up study does not support an important increase of OA as a result of triple fusion. Given adequate correction to achieve good alignment and sufficient stability, the quality of the ankle joint seems to remain stable over time, as do the outcome scores (AOFAS and FFI). A further prospective follow-up of these patients is being performed, and long-term results will be reported in the future.

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Chapter 4

Diagnostics in tarsal fusion: the theory and practise in The Netherlands

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Submitted for publication

ABSTRACT

Background: This study compares the preferences of Dutch orthopaedic surgeons for different diagnostic modalities in performing tarsal fusions versus consensus and expert opinion reported in the literature.
Methods: A literature search of Medline was performed to obtain evidence-based information on various diagnostic tools. In addition, 89 registered Dutch foot and ankle surgeons were sent a questionnaire concerning the diagnostic modalities they use in tarsal fusion.
Results: Fifty-eight (65%) questionnaires were returned. The experienced surgeons measured outcomes significantly more often than other surgeons. Diagnostic injections were often used, although scant evidence exists in the literature. Postoperative diagnostics mainly consist of X-ray examination, although there is consensus in the literature that computed tomography is more accurate.
Conclusions: The study revealed some surprising discrepancies concerning the use of diagnostic imaging in tarsal fusion. More clinical research is needed to identify the most effective diagnostic imaging modalities so as to encourage their wider adoption.

Keywords: Diagnostics, Imaging, Tarsal Fusion, Hindfoot.

Abbreviations: AOFAS, American Orthopaedic Foot and Ankle Score; AP, antero-posterior; CAOS, computer-assisted orthopaedic surgery; CT, computed tomography; FAOS, Foot and Ankle Outcome Score: FFI, Foot Function Index; Lat, lateral; MRI, magnetic resonance imaging; PET, positron emission tomography; PROMS, Patient Reported Outcome Measures; PTTD, posterior tibial tendon dysfunction; PVNS, pigmented villonodular synovitis; SPECT, single-photon emission tomography; VAS, Visual Analogue Scale

INTRODUCTION

Owing to the complex architecture of the hindfoot and the variety of pathological conditions causing hindfoot problems, diagnostic imaging tools are necessary to establish the diagnosis and a treatment plan. Although a thorough history and physical examination may point to a problem in a specific joint in the tarsus, diagnostic injections, X-ray examinations and scans (computed tomography (CT), magnetic resonance imaging (MRI), or bone scintigraphy) are necessary when surgery is contemplated. A recent study showed diagnostic injections to be of no true predictive value for successful surgery [1]. Moreover, the value of postoperative X-ray examination to determine the union of an arthrodesis has been debated in the past decade by multiple authors [2-5].

This study was performed to ascertain the need for evidence concerning pre-, intra- and postoperative choices of diagnostics in tarsal fusion, with the aim of contributing to the success of these diagnostic tools in the treatment of hindfoot problems. Because experience and years of practice are expected to influence the choice of diagnostic modalities, we also investigated whether more experienced or high-volume specialists have a different work-up towards surgery than less experienced or low-volume specialists.

MATERIALS AND METHODS

Literature search

A PubMed literature search was performed to find articles reporting the value of different diagnostic tools. Search terms were [Hindfoot arthrodesis] AND [MRI Hindfoot arthrodesis] AND [CT Hindfoot arthrodesis] AND [X-ray Hindfoot arthrodesis] AND [Ultrasound Hindfoot arthrodesis] AND [Diagnostic Modality in Foot and Ankle]. The search was conducted for the years 1946 to 2014.

Questionnaire

A questionnaire was sent to 89 registered orthopaedic surgeons who specialise in foot and ankle surgery. Three recalls by E-mail were made to encourage the surgeons to participate. The number of years of experience in the orthopaedic profession was queried by providing tick boxes: “less than 5 years”, “between 5 and 10 years” and “more than 10 years”. Also, the degree of experience was evaluated by the percentage of hindfoot surgery in the total practise and the number of hindfoot surgeries (>10 or <10) per specialist per year. Participants were asked if they routinely check the outcome of surgery and, if so, which instrument they use. For six different diagnoses (degenerative flatfoot, osteoarthritis, posttrauma, clinically active arthritis, neuromuscular disease,

clubfoot, previous surgery tarsus) and four different types of tarsal fusion (triple arthrodesis, talonavicular arthrodesis, calcaneocuboid arthrodesis, double arthrodesis) the following questions were asked: "How often do you use X-ray examination, CT, MRI, bone scintigraphy, ultrasound, diagnostic injections or gait analysis pre-operatively in your practise?" Answers were subdivided into never, seldom, regularly, often, and always. Also, the frequency of intraoperative use of X-ray examination (fluoroscopy) or computer-assisted orthopaedic surgery (CAOS) and the use of postoperative X-ray examination or CT scanning was queried (see Table 1 for examples). The local hospital review board granted permission for this study. Ethical approval was not required for this study.

Table 1. Survey sample questions

How often do you use the described intraoperative diagnostic tools in the following patient groups?						
Intraoperative diagnostic tools in Triple Arthrodesis						
	Never	Seldom	Often	Usually	Always	NA
X-ray	O	O	O	O	O	O
Computer Assisted Surgery	O	O	O	O	O	O
Intraoperative diagnostic tools in Subtalar Arthrodesis						
	Never	Seldom	Often	Usually	Always	NA
X-ray	O	O	O	O	O	O
Computer Assisted Surgery	O	O	O	O	O	O
Intraoperative diagnostic tools in Talonavicular Arthrodesis						
	Never	Seldom	Often	Usually	Always	NA
X-ray	O	O	O	O	O	O
Computer Assisted Surgery	O	O	O	O	O	O
Intraoperative diagnostic tools in Calcaneocuboid Arthrodesis						
	Never	Seldom	Often	Usually	Always	NA
X-ray	O	O	O	O	O	O
Computer Assisted Surgery	O	O	O	O	O	O

Statistics

The data were analysed using descriptive statistics. Frequency statistics were used to describe the degree of experience in hindfoot surgery amongst the respondents and to describe the pre-, intra- and postoperative use of diagnostic modalities for different diagnoses and tarsal fusions. Crosstabs were used to analyse the differences in use of pre-, intra-, and postoperative diagnostic modalities between the low- and high-experienced surgeons. For this purpose, the degree of experience, defined by the number of hindfoot surgeries performed per year, was dichotomised into more than 10 or less than 10 per year.

STATA 13.1 (StataCorp LP, Texas, USA) was used to analyse the data.

RESULTS

Descriptive analyses

Fifty-eight questionnaires were returned by the 89 solicited foot and ankle surgeons, a response rate of 65%. Forty-seven (81%) of the returned questionnaires were filled out completely. The distribution of the respondents' years of experience in hindfoot surgery was balanced (Table 2). Forty-three (74%) of the respondents reported devoting 25% to 75% of their practise to foot and ankle surgery. Most surgeons evidently have two or more other specialities. Thirteen percent of the respondents reported they perform more than 30 hindfoot surgeries per year.

Table 2. Years of experience in 58 Dutch foot & ankle specialists

	Frequency	Percentage
1-5 years	17	29.31
5-10 years	23	39.66
>10 years	18	31.03
Total	58	100.00

Concerning the evaluation of surgical outcome, foot and ankle surgeons who perform more than 10 tarsal arthrodeses annually (n= 37; 64%) evaluate the outcome more frequently than surgeons who perform fewer than 10 annually (51% vs 24%, p=0.041). Visual Analogue Scale (VAS) is used most often (30%) as a first-choice outcome instrument, followed by the Foot Function Index (FFI) (25%), American Orthopaedic Foot and Ankle Score (AOFAS) (17%), the Foot and Ankle Outcome Score (FAOS) (8%), and Patient Reported Outcome Measures (PROMS) (4%). The majority of surgeons (59%) did not measure outcome routinely (see Table 3).

Table 3. Usage of outcome measures in 58 Dutch foot & ankle specialists

	Yes	No	n.a.
Measure Outcome	**24**	**34**	**0**
AOFAS	4	20	34
FFI	6	18	34
VAS	7	17	34
X-ray	21	3	34
History	1		
FAOS	2		
PROMS	1		

Abbreviations: AOFAS, American Orthopaedic Foot and Ankle Score; FFI, Foot Function Index; VAS, Visual Analogue Scale; FAOS, Foot and Ankle Outcome Score; PROMS, Patient Reported Outcome Measures

X-ray examination

Reports from the literature

Regarding the diagnostic workup towards surgery of the hindfoot, there are strong indications of an empirical consensus in the literature that antero-posterior (AP) and lateral (Lat) weight-bearing X-ray examination and posture of the foot are important [6-10], and there is scientific proof that a long axial view is more reliable than a Saltzmann view for adequate planning of correction in the case of malalignment [11]. In the assessment of osseous union after arthrodesis, there is consensus in the literature that X-ray examination is not accurate [2,4].

Results of the questionnaire

Weight-bearing X-ray AP and Lat examination of the foot were considered to be always indicated by most of the respondents (80% and 98%, respectively), and in the ankle (AP and Lat) by many respondents (61% and 72%, respectively). Except in the case of neuromuscular disease, clubfoot or other cases where patients are incapable of standing, no weight-bearing X-ray examinations were ordered. A minority (36%) of the respondents reported they often use axial hindfoot X-ray examination, mostly in cases of pseudarthrosis or posttraumatic arthritis. Long leg X-ray imaging was always used in clubfoot cases by 35% of the respondents, and seldom to regularly in posttraumatic deformity by 77% of the respondents. These respondents were mainly not high-volume surgeons. Broden subtalar views were reported to be used regularly in osteoarthritis cases (24%) and less often in the other diagnosis groups. Intraoperative fluoroscopy is always used by 76% of the surgeons. In postoperative evaluation of the position of the foot after fusion of a tarsal joint, X-ray examination was the modality of choice.

CT scanning

Reports from the literature

CT scanning was found to be a useful tool in assessment of pre- and postoperative evaluation of patients with posttraumatic arthritis and rheumatic arthritis [12,13]. The value of CT assessment for the incongruency of joints and the specific assessment of bony structure and the subchondral bone was described by Hintermann et al. [8]. Various authors have prospectively investigated the use of X-ray examination versus CT scanning for the determination of fusion after arthrodesis and revision cases [2,4,5]. All authors reached the same conclusion that X-ray examination as such is not accurate in determining fusion, and that CT scanning is significantly more reliable. Thus, consensus exists in the literature that CT scanning is a useful tool in pre- and postoperative evaluation of the hindfoot in all diagnostic groups.

Results of the questionnaire
Foot and ankle specialists responded that they regularly use CT scanning as a preoperative tool in the diagnostic groups degenerative flatfoot (73%), osteoarthritis (77%), posttrauma (81%) and pseudarthrosis (89%). CT was seldom to regularly used in the active arthritis and neuromuscular diagnosis groups, but never or seldom in the clubfoot diagnosis group. CT scanning as a postoperative tool was seldom to never used in all diagnostic groups. Many remarks in the questionnaire indicate that CT is appreciated predominantly in cases where there is doubt concerning the position of material or the progress of fusion. Experienced or high-volume surgeons did not use CT scanning more often than less experienced or low-volume surgeons.

MRI

Reports from the literature
MRI is reported to be accurate in pre- and postoperative evaluation of tendon pathology and tendon surgery [14, 15], and valuable in rheumatoid arthritis, acquired degenerative flatfoot, and posterior tibial tendon dysfunction (PTTD). For optimal assessment of rheumatic foot problems, high-field MRI is the standard tool, and better than ultrasound, according to Wakefield et al. [16]. MRI was also found to be accurate for the diagnosis of pigmented villonodular synovitis (PVNS) [17] and of cartilage or fibrous tarsal coalition [18]. Wang et al. [19] commented on the value of MRI in the early stages of osteonecrosis of the tarsal bone in adults (Muller-Weiss syndrome). With regard to the value of MRI in PVNS, tarsal coalition and osteonecrosis, the conclusions are based predominantly on expert opinion or small clinical studies.

Results of the questionnaire
The respondents reported that MRI is seldom to regularly used in the degenerative flatfoot group, the posttrauma group, and the pseudarthrosis group of patients. It is seldom or never used in the osteoarthritis, neuromuscular and clubfoot groups, but is often to regularly used in the active arthritis diagnostic group.

Ultrasound

Reports from the literature
Kotnis et al. [20] studied medial sided ankle pain and reported various non-osseous causes such as tarsal tunnel syndrome and tendon pathology. Ultrasound was found to accurately demonstrate tendon and ligament pathology in the hindfoot. No consensus was found in the literature concerning the use of ultrasound in the workup of tarsal fusions.

Results of the questionnaire
The respondents reported that ultrasound is seldom to regularly used only in active arthritis cases and seldom to never in any of the other diagnosis groups.

Diagnostic injections

Reports from the literature
Several authors have described good results of surgery after positive diagnostic intra-articular injection, concluding that a positive effect of the injection correlates with a good result of the operative treatment [21-23]. However, a recent study did not confirm this predictive value [1]. No consensus is found in the literature regarding diagnostic injections in foot and ankle evaluation.

Results of the questionnaire
Respondents reported regular use of diagnostic injections in evaluating the involvement of osteoarthritic joints, posttraumatic arthritis cases and pseudo arthritis cases. Their application in assessing degenerative and posttrauma cases ranged from seldom to regular, and they are reportedly never used in active arthritis, neuromuscular and clubfoot cases.

Computer-assisted orthopaedic surgery

Reports from the literature
Richter and colleagues [24,25] concluded that C-arm-based computer-guided correction of posttraumatic deformities is a fast and highly accurate method compared to CT-based computer-assisted surgery. In 10 patients with correction arthrodesis of the ankle and subtalar joint, the authors reported achieving a level of planned correction of 95% (range 75-100). A 2-year follow-up study described 26 cases of correction arthrodesis of the subtalar joint with a level of accuracy within 2 degrees or 2 mm of the planned correction [25].

As these are the only studies that can be found evaluating this interesting technique, consensus in the literature is not applicable.

Results of the questionnaire
Intraoperative use of fluoroscopy is common (between 68% and 76% of the surgeons reported they always use fluoroscopy), but no intraoperative use of CAOS was reported by any of the respondents.

Gait analysis

Reports from the literature
Gait analysis was described in the literature as being able to provide detailed information that cannot be determined by conventional physical examination alone, and also as an approach that leads to a lower incidence of additional surgery [26-28].

Results from the questionnaire
Amongst the foot and ankle specialists responding, 15% noted regular use in neuromuscular cases, 24% noted that they seldom use it, and 39% reported they never use gait analysis in patients with neuromuscular pathology.

Bone scintigraphy

Reports from the literature
In evaluation and management of lesions causing foot and ankle pain, Dual-Phase Bone Scintigraphy and 18F-fluoride positron emission tomography (PET)/CT was compared by Kim et al. [29]. Those authors stated that bone scintigraphy is well known to be sensitive but lacks specificity. In their study of 61 lesions in 31 patients, they concluded that using 18F-fluoride PET/CT changed the clinical management in 51% of cases. Mohan et al. [30] stated that the combination of highly sensitive bone scintigraphy with highly specific CT scanning will add to the diagnostic options.

Results from the questionnaire
Bone scintigraphy is used regularly to often in cases of pseudarthrosis and active arthritis, seldom to regularly in degenerative flatfoot and osteoarthritis, and never in neuromuscular and clubfoot cases. PET/single-photon emission tomography (SPECT) CT is mentioned by the respondents as being an additional diagnostic modality. In the diagnosis group *persisting pain after a triple arthrodesis*, the respondents indicated a high preference for the use of bone scintigraphy, with 67% of the specialists using this modality regularly or often.

DISCUSSION

Although there is consensus amongst the responding surgeons that weight-bearing X-ray examination is important, the literature provides only scarce evidence for this assertion [7,10]. No consensus is found amongst the respondents for X-raying imaging of the long axial view, although the literature indicates this view to be important for the

planning of corrections. The items in the questionnaire were not focussed on correction osteotomies, so this may have influenced the results; however, it is interesting that intraoperative correction of hindfoot malalignment in the Netherlands is mainly done by eye, often with the help of fluoroscopy. No match for pre-operative alignment views was found.

Coughlin et al. [2] concluded that assessing osseous union by X-ray examination is inaccurate. Previous studies have reported that the time to union of a hindfoot fusion varies greatly, between 3.4 and 32 weeks. This indicates that the progress of fusion cannot be determined accurately with X-ray examination. In the literature, CT scanning is considered to be a valuable postoperative tool with excellent capability to accurately assess consolidation after arthrodesis. However, the respondents in our study stated CT is used mainly when there is doubt about the position of hardware and in confirming pseudarthrosis when clinically suspected. The Dutch foot and ankle surgeons surveyed in our study apparently rely on their clinical judgement when deciding about union after an arthrodesis. The observation that there is no match for standardised postoperative use of CT scanning after tarsal arthrodesis, we consider to be the first important finding of this study.

For MRI, ultrasound and bone scanning, no match was found between the preferences of the respondents and the consensus in the literature. This can be explained by the fact that the focus of the questionnaire was on tarsal fusion in a limited number of pathologies, and thus many of the diagnostic groups described in the literature (e.g. isolated tendon pathology, PVNS, osteonecrosis, cartilaginous or fibrous coalition) were not actually addressed. Only in planning tarsal fusion in rheumatoid arthritis was there agreement between the surgeons and the literature for the use of MRI.

Diagnostic injections are often used to localise and confirm the involvement of an individual joint or a combination of joints, although the literature is not conclusive in this matter [1, 12,21,22]. No match concerning diagnostic injections was found. More research with a better experimental setup is needed.

The second important finding of this study is that more experienced, high-volume surgeons measure the outcome of their surgery more often. Quality of care is defined as the degree to which perceived performances of health care services (experience) meet the needs of patients with respect to important aspects (expectations) [31,32]. Measurement of outcome was not reported frequently (24/58) in our questionnaire. Apparently, outcome evaluation is more important to dedicated foot and ankle centres which strive to continuously improve their care, and specialised hospitals are probably more likely to facilitate the measurement of outcome. Routine measurement of outcome parameters will additionally facilitate research projects because of the data it provides.

Our presumption that more experience would lead to different (and better) choices in diagnostic modality was not confirmed. This may be because our questionnaire focused on more standard tarsal fusion and not on complex cases.

Limitations of the study

The study has several limitations. First, the response rate (65%) was low despite our efforts to encourage participation, and only 81% of the returned questionnaires were fully completed. These deficiencies may limit the generalisability of the results. Also, as mentioned above, the questionnaire was narrowly focused on tarsal fusion in a limited number of pathologies. With regards to the responses given, it was challenging to critically evaluate the preferences of the surgeons when the literature offers no scientific consensus on most of the diagnostic tools. Many of the conclusions and recommendations in the collected articles are based on expert opinion rather than scientific evidence.

Recommendations for pre-, intra- and postoperative diagnostics in tarsal fusion

The consensus of Dutch foot and ankle surgeons and the literature consensus match in the use of weight-bearing X-ray examination and CT scanning pre-operatively. However, no literature match is found for the postoperative use of X-ray examination and CT scanning reported by the Dutch surgeons, although standard postoperative CT scanning could improve tarsal arthrodesis care. Instead of using CT scanning only to confirm the clinical diagnosis of a non-union, we recommend that CT scanning also be used as a standard to assess union after tarsal arthrodesis. Dorsey et al. [33] performed a retrospective study of 42 hindfoot arthrodesis patients and found a correlation between CT-based fusion ratios of >33% and a clinically stable hindfoot. This finding implies that by determining the percentage of fusion, the after-treatment can be individualised and shortened for many patients. CT scanning is expected to replace X-ray evaluation for quantifying fusion. The drawbacks of CT scanning such as a higher radiation load, higher costs and problematic patient logistics will probably be overcome. Indeed, the costs of CT continue to decline, and the Pedcat system (CurveBeam, Warrington, PA, USA) is an example of a technology that facilitates logistics in CT scanning combined with low-dose radiation. Also, many radiology departments in The Netherlands now offer appointment-free CT scanning to facilitate patient flow. A relatively new modality was described by Haleem et al. [34]: weight-bearing multiplanar X-ray examination produces CT-like images with full weight bearing, providing more accuracy than conventional radiography and a lower radiation burden. This technique may one day become an alternative to CT scanning.

According to the results of our study, Dutch foot and ankle surgeons generally do not measure hindfoot malalignment pre-operatively as a standard; however, there is evidence in the literature that long axial views are valuable for patients with hindfoot

malalignment [11]. A quality enhancing effect is expected from this diagnostic tool, and we recommend that it be used.

In rheumatoid arthritis and in clubfoot cases, MRI scanning can help to assess the quality of the ligamentous structures and the position of scar tissue from previous surgery. Ultrasound and MRI may also be helpful in the diagnosis of degenerative flatfoot cases caused by PTTD.

Intraoperative use of C-arm X-ray examination in tarsal fusion meets consensus amongst the Dutch surgeons, but intraoperative CAOS as described by Richter and colleagues [24,25] has not yet been adopted. Possibly, improved intraoperative correction could be achieved by using this new technology. Recent and older studies quite convincingly demonstrate the value of hybrid PET/CT or SPECT/CT imaging to improve on the separate quality of both anatomical and functional techniques [29,30,35].

The cost effectiveness of the different diagnostic modalities was not studied but is of great importance. After establishing the clinical value of the different diagnostic modalities, it is important to consider the cost effectiveness, taking into account a possibly shorter after-treatment regimen, as in the case of CT scanning, and also the lower incidence of reoperation as a result of malalignment, as in the case of intraoperative alignment control such as provided with CAOS.

CONCLUSIONS

The best and most economic policy when caring for patients with previous tarsal fusion and persistent complaints, an unclear pathology, or an abnormal post-operative recovery (e.g. prolonged pain, inflammation) is to consult with a radiologist and then choose the best radiologic tool for this specific patient. Confronted with up-to-date evidenced-based clinical research, we expect orthopaedic surgeons will more likely alter their choices regarding the use of diagnostic imaging modalities.

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Chapter 5

Can diagnostic injections predict the outcome in foot and ankle arthrodesis?

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ABSTRACT

Background

Intra-articular anesthetic drug injections are claimed to confirm the localization of the pain in order to treat the pain. The aim of the present study was to evaluate whether a positive effect of injection could be indicative for a successful outcome of future arthrodesis.

Methods

74 Patients underwent fluoroscopically guided and contrast confirmed anesthetic joint injections for diagnostic reasons. Before and after injection, pain was measured by use of the Visual Analogue Scale (VAS) in rest and after exercise. Pain reduction was expressed as delta VAS (dVAS). Also, the Foot Function Index (FFI) was obtained. Based on the effect of the diagnostic injection and various clinical factors, patients were advised a conservative treatment (conservative group, n = 34) or an arthrodesis of the affected joint (operative group, n = 40). After a median follow-up period of 3.6 years (range 2.1 to 4.3 years) patients were again invited to complete the FFI and VAS in rest and after exercise. For data-analysis purposes the patients were assigned to four different groups, based on the result of injection and the occurrence of surgery. Wilcoxon signed rank tests and Mann Whitney U tests were used for statistical analysis.

Results

Based on the analysis of the four groups we found that surgery, irrespective of the presence of pain reduction after injection, was related to improvement of VAS and FFI. Patients with conservative treatment always showed worse VAS and FFI scores, even when previous injections showed an improvement of VAS.

Conclusions

Fluoroscopically-guided anesthetic injections of the supposed painful foot-ankle joint seem not to be indicative for a successful outcome of an arthrodesis of the affected joint. However, the sole occurrence of surgery shows a significant difference in VAS and FFI scores, where conservative treatment does not. The local hospital review board granted permission for this study. Ethical approval was not required for this study.

Keywords

Foot pain, Foot function, Arthrodesis, Diagnostics, Fluoroscopically guided anesthetic injection

BACKGROUND

The precise treatment of foot and ankle pain depends on accurate assessment with regard to the cause and the site of origin of the pain. However, this assessment, accurately identifying the source of pain, can be difficult in the complex hindfoot with its numerous joints and ligaments [1-4]. Most often a diagnosis is based on the medical history, a careful physical examination and one or more imaging modalities. However, the changes or absence of changes seen on these imaging modalities may not correlate with the extent or alleged localization of the clinical symptoms. This can be due to various causes like the presence of multilevel pathology [3,5]. In case of multilevel pathology it can be unclear whether pain is coming from one joint or more joints, or whether it is caused by problems involving the soft tissues.

Intra-articular fluoroscopically-guided anesthetic drug injections may help to confirm the alleged localization of the source of pain by differentiating between two separate joints and between intra-and extra-articular origin of pain, and thus may help in predicting therapeutic outcome. This technique has been described as an aid to the diagnosis of shoulder pain, chronic wrist pain, referred pain in the upper limb and in the diagnosis of nerve entrapment syndromes [6-9]. This procedure is also known for differentiation of hip from spinal problems [1].

We evaluated whether pain reduction after intra-articular anesthetic drug injection could be indicative for a successful outcome (i.e. pain and function) of arthrodesis or conservative treatment in foot and ankle pathology. Our hypothesis states that pain reduction after intra-articular anesthesia could be indicative for a successful outcome of future arthrodesis.

METHODS

Between September 2002 and December 2004, 99 patients (> 18 years of age) underwent a diagnostic fluoroscopically-guided joint injection. Out of these 99 patients 25 patients were excluded from this study for the following reasons. Six patients who after surgery developed a non-union, thus compromising the outcome by other means than a correct or not correct indication for surgery were excluded. Five patients with contrast leakage, two with CRPS, and four patients with additional surgery were also excluded. Finally, eight patients were lost to follow-up. In patients with bilateral injections only the first injection was included [10]. Thus, 74 patients participated in the study. All patients had experienced foot complaints for more than 12 months and the majority of patients at the time of referral to our department had already been treated conservatively. Conservative treatment consisted mostly of modification of shoe wear or inlays. Pre-

operative diagnoses included 39 patients with posttraumatic arthritis, 31 patients with osteoarthritis and 4 patients with rheumatoid arthritis.

All affected joints were injected by a skeletal oriented radiologist under fluoroscopic control (Philips BV300, The Netherlands) using an antiseptic technique and a standardized protocol [4,11]. Confirmation of the intra-articular position of the needle was performed by use of 0.5-1 ml of contrast material (Omnipac 300, GE Healthcare, UK or Xenetix 300, Guerbet Group The Netherlands). The used anesthetic drug consisted of bupivacaine (Actavis Group, The Netherlands) 0.25% and citanest 1% (AstraZeneca BV, The Netherlands). Depending on the size and capacity of the joint the volume anesthetic drug ranged from 1.5 to 6 ml. Special attention was given to leakage of the fluid to connecting joint.

A Visual Analogue Score measuring pain (VAS) was obtained closely before and 30 minutes after the injection in rest and after exercise [12]. Foot Function Index (FFI) was obtained before the injection [13,14,15]. Two foot and ankle surgeons (JWL and BS) decided whether conservative or operative treatment was advised to a patient. This advice was based on history, physical examination and additional information acquired through X-ray examination, CT scans and furthermore a substantial difference in VAS scores before and after the injections. Based on the literature [2,12] and clinical experience a dVAS of 3 or more was determined as the minimum effect of the diagnostic injection in order to regard this as a positive parameter to advise surgery. Subjective criteria such as the involvement in law suits, workers compensation issues, and pain behavior were taken into account also.

Four groups were distinguished and analyzed in this study:

Group 1: Preoperative successful anesthetic injection resulting in successful surgery (34 patients). In this group there was a positive result on injection resulting in a VAS decrease of at least 3 points. Based on the effect of the diagnostic injection and various clinical factors the doctor would advise surgery and the patient agreed to have surgery. The VAS postoperative was at least three points lower than preoperatively. This group seems to show an association between positive result on injection and success after surgery.

Group 2: Preoperative successful anesthetic injection and refusal to surgery (19 patients). This group consists of patients who had a successful preoperative anesthetic injection with a VAS decrease of at least 3 points and choose not to have surgery although they were advised to. No significant improvement was seen from conservative treatment in this group.

Group 3: Preoperative unsuccessful anesthetic injection but surgery anyway (six patients).In this group the unsuccessful injection did not deter the doctor or the patient from surgical intervention. These patients did actually gain from the

surgery as their VAS decreased more than three points, a significant decrease. This would argue against our hypothesis that preoperative anesthetic injection would predict the result of surgery.

Group 4: Preoperative unsuccessful anesthetic injection and no surgery (15 patients). This is the group in which the negative result to anesthetic injection resulted in the decision not to operate. No significant improvement was seen from conservative treatment in this group.

After a mean follow-up of 3.6 years (range 2.1 to 4.3 years), all patients were requested to complete a VAS for pain in rest and after exercise and the FFI. The conservative group was asked if they had undergone surgery elsewhere during the follow-up period and if they were using any kind of foot/ankle orthotics or shoe adaptations. When complications such as non-union occur after surgery the VAS for pain and FFI measurements are gravely influenced and it was decided not to include these patients in the study to prevent a bias. Thus these patients were excluded from the study as mentioned earlier.

Wilcoxon signed rank tests and Mann Whitney U tests were used for statistical analysis. We evaluated whether pain reduction after intra-articular anesthetic drug injection could be indicative for a successful outcome (i.e. pain and function) of arthrodesis or conservative treatment in foot and ankle pathology. The local hospital review board granted permission for this study. Ethical approval was not required for this study.

RESULTS

Table 1 depicts the injected joint locations and number of different hind-and midfoot joints. Most joints included are hindfoot joints, comparable in size and surface. Table 2 shows the patient characteristics of the four groups. The male to female ratio in all groups was equal, with the exception of group 3. The age for all groups is similar. Tables 3, 4, 5, 6 show the differences in VAS and FFI before and after the treatment for the four different groups. There was a significant improvement in VAS at rest in patients with a significant improvement after the injection and after surgery (Table 3). Patients without improvement on injection, but who still underwent surgery showed a trend towards improvement after surgery. Patients without surgery (with and without improvement on injection) showed no statistical difference in VAS scores. Table 4, depicting the differences in VAS scores during exercise before and after treatment showed similar results. The decrease in VAS after surgery is more clear during exercise for the patient groups who underwent surgery. Table 5 and Table 6 show FFI disability scores and activity limitation scores respectively for the different groups. Both surgery groups showed clear improvement where the no surgery groups showed no improvement.

Table 1. Injected joint locations

Injected joint	Number of patients
Talocrural	9
Subtalar	37
Talonavicular	12
Calcaneocuboid	3
Naviculocuneiform	4
First tarsometatarsal	5
Second tarsometatarsal	2
Third tarsometatarsal	2

Table 2. Patient Characteristics

	Gender ♂/♀	Age mean +/− SD
Total group	36♂/38♀	45.6 +/− 14.4
Group I		
Pos-injection + surgery	15♂/19♀	43.3 +/− 14.9
Group II		
Pos-injection–surgery	9♂/10♀	48.9 +/− 15.8
Group III		
Neg-injection + surgery	5♂/1♀	50.8 +/− 7.3
Group IV		
Neg-injection–surgery	7♂/8♀	44.7 +/− 13.4

Table 3. VAS pain scores in rest before and after treatment

	Baseline VAS rest +/− SD	VAS rest at follow-up +/− SD	P-value
Group I			
Pos-injection + surgery	3.5 +/− 2.4	1.3 +/− 1.4	<.001*
Group II			
Pos-injection–surgery	3.1 +/− 2.1	3.5 +/− 1.8	.345
Group III			
Neg-injection + surgery	1.8 +/− 1.7	0.4 +/− 0.7	.068†
Group IV			
Neg-injection–surgery	3.8 +/− 2.8	3.0 +/− 1.4	.289

* Indicating a significant improvement ($p < 0.05$) from baseline to follow-up.

† Indicating a trend to improvement ($p < .10$) from baseline to follow-up.

Table 4. VAS pain scores during exercise before and after treatment

	Baseline VAS rest +/− SD	VAS rest at follow-up +/− SD	P-value
Group I			
Pos-injection + surgery	7.2 +/− 1.5	2.5 +/− 1,51,5	<.001*
Group II			
Pos-injection–surgery	6.3 +/− 1.8	5.4 +/− 2.5	.247
Group III			
Neg-injection + surgery	6.0 +/− 2.3	2.8 +/− 1.3	.046*
Group IV			
Neg-injection–surgery	6.0 +/− 2.3	5.8 +/− 2.5	.694

* Indicating a significant improvement ($p < 0.05$) from baseline to follow-up.

Table 5. FFIb foot function disability scores before and after treatment

	Baseline FFIb +/− SD	FFIb at follow-up +/− SD	P-value
Group I			
Pos-injection + surgery	51.5 +/− 22.9	17.6 +/− 13.6	<.001*
Group II			
Pos-injection–surgery	44.7 +/− 13.9	43.4 +/− 14.8	.845
Group III			
Neg-injection + surgery	53.3 +/− 20.0	17.8 +/− 18.9	.028*
Group IV			
Neg-injection–surgery	42.2 +/− 14.8	39.7 +/− 17.9	.826

* Indicating a significant improvement ($p < 0.05$) from baseline to follow-up.

Table 6. FFIc foot function activity limitation scores before and after treatment

	FFIc +/− SD	FFIc at follow-up +/− SD	P-value
Group I			
Pos-injection + surgery	49.2 +/− 22.5	20.2 +/− 16.1	<.001*
Group II			
Pos-injection–surgery	44.4 +/− 19.9	38.6 +/− 18.3	.230
Group III			
Neg-injection + surgery	56.5+/− 22.5	16.0 +/− 19.9	.028*
Group IV			
Neg-injection–surgery	33.7 +/− 24.3	30.1 +/− 22.1	.925

* Indicating a significant improvement ($p < 0.05$) from baseline to follow-up.

DISCUSSION

The aim of the present study was to evaluate whether a positive effect of injection could be indicative for a successful outcome of future arthrodesis. The results indicate that arthrodesis has a positive effect on pain and function, irrespective of pain reduction after injection. We found that only the intervention of surgery has a predictive value for the relief of pain and improvement of function, and the effect on injection is not related to the outcome of either surgery or conservative treatment. The only way to make this observation possible, is that by coincidence the patients who postponed or chose not to have surgery even with a positive effect on injection formed a very interesting control group, unforeseen by the investigators. Also the group of patients without effect on injection but with surgery formed a small but interesting control group and proved the hypothesis to be false. In our goal to investigate the predictive value of anesthetic injection on the outcome after arthrodesis of the hindfoot or midfoot the injection was defined as an important, but not the only, criteria to either perform surgery or not. A plausible explanation is that the clinical view of the orthopedic surgeon ultimately determines best whether a positive result after surgery is to be expected.

The results of our study are in contrast to the conclusion of various authors mentioning a correlation between a positive result on anesthetic injection and successful outcome after surgery [4,7,16]. Previous studies have described the use of anesthetic drug injections in the foot and subtalar joints [1-5,17-19]. A retrospective study conducted by Khoury et al. described in a group of 20 patients a positive correlation between the effect of foot joint injections and subsequent effect of an arthrodesis [2]. The studies of Crawford, Ruhoy and Bell all conclude that a correlation is present between a positive reaction on injection and a positive result after arthrodesis, but there was no mention of a control group [4,7,16]. We suspect that in these studies the same assumption is made as our initial idea that a positive reaction to injection correlates with a good result of surgery, but when control groups would be included the assumption that injections are predictive of good effect on arthrodesis could be rejected. In these articles there were no patients mentioned who did not have a good result on injection and did not have surgery so the correlation between successful injection and good outcome was believed to be unbiased while it is possible that only the surgical intervention itself was the important variable. Our techniques for injection and exclusion of patients with contrast leakage is consistent with other studies [1,3].

Our study does have limitations. The design of the study was primarily focused on the predictive value of injections, but the surgeons also focused on X rays, CT scans, physical examination and questionnaires in advising the patient surgery or conservative treatment. Also the role of the surgeon is a confounding factor because the decision for operative or conservative treatment was made with full knowledge of the result of

the injection. The cutoff point of VAS 3 was chosen based on publications by DeLoach [12] stating that every VAS measurement is 20 mm imprecise and the publication by Khoury [2] stating that 65% and 50% pain relief after intra articular injection served as a measure to perform arthrodesis. A relatively large number of patients was excluded or lost to follow up (25 of 99 patients). Finally, the use of VAS scores was originally meant for chronic pain measurement, whereas for acute postoperative pain or post injection pain measurement is of less value [12].

For future research we suggest the regular workup for hindfoot arthrodesis followed by a decision to operate or not. The intra articular anesthetic injection should be performed in all cases blinded to the surgeon and the patient. When a true correlation between injection and outcome after surgery or after conservative treatment is found, we can decide whether anesthetic injections are a diagnostic tool of value or not. An example of a good study design is presented in the study of Lucas as the focus in this study has been on the level of confidence of the surgeon before and after a blinded intra articular injection [18]. The injection altered the surgical plan in 82% of 50 patients. Unfortunately the result of the surgical or conservative treatment remains unclear in this study, so the conclusion that the injections aid in the outcome for the patient cannot be drawn. Finally, to investigate the value of an anesthetic injection in the clinical decision making, one should not only study the relationship between a positive test and a significant improvement of the surgery but also take into account the clinically meaningful improvement in a patient's quality of life by determining the Minimum Clinical Important Difference.

In the range of additional diagnostic techniques either MRI, CT or diagnostic injections are favored [4,18,20]. Because recently contrast enhanced ultrasound guided injections have been found to significantly increase the accuracy of injections in the foot, this would be an interesting sequel to this study [21,22].

CONCLUSIONS

Pain reduction after intra articular injections seems not to be indicative for successful outcome after arthrodesis in the foot. This finding contradicts with many published articles on this subject. We found that a careful history, thorough physical examination and radiology imaging will provide the necessary information to recommend surgery and combined with informed consent from the patient predict a good outcome.

Abbreviations

VAS, Visual analogue scale; FFI, Foot function index

Competing interests

The authors declare that they have no competing interest.

Authors' contributions

MS participated in the design and coordination of the study and drafted the manuscript, BvG performed the statistical analysis and helped to draft the manuscript, BB participated in the design, collected data and helped revising the manuscript, MT participated in the design, collected data and helped revising the manuscript, JL participated in the design and helped revising the manuscript, BS participated in the design and coordination of the study and helped revising the manuscript. All authors read and approved the final manuscript.

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Chapter 6

Outcome After Operative Fusion of the Tarsal Joints: A Systematic Review.

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ABSTRACT

Arthrodesis of one or more joints of the hindfoot is performed in order to treat severe functional impairment due to pain, deformity, and/or instability. Evaluation of the results of hindfoot arthrodesis from the literature is difficult due to a great variety of pathologies and surgical techniques reported in the studies. A comprehensive search for relevant articles, as well as reference lists and citation tracking of included studies, was conducted using the PubMed®, Embase®, and CINAHL® databases. Studies had to be prospective, include patients with hindfoot problems, evaluate arthrodesis of one or more tarsal joints, and have at least one of the following primary clinical outcome parameters: pain, function, or complications. Two review authors independently selected relevant studies with the aid of predefined criteria and graded the quality of evidence using a 0 to 9 star scale according to the Newcastle-Ottawa Scale (NOS). Sixteen prospective case series were included. Five studies scored 6 stars, eight scored 5 stars, two scored 4 stars, and one scored 3 stars. A best evidence synthesis was performed and improvement on function and pain was found for three combinations: talonavicular arthrodesis for rheumatoid arthritis, triple arthrodesis for rheumatoid arthritis, and subtalar arthrodesis for post-traumatic arthritis showed good results for pain and function, the last especially when performed arthroscopically. Best evidence syntheses revealed good results for pain and function for the above-mentioned disease-operative technique combinations.

Level of Clinical Evidence: 2

Financial Disclosure: None reported.
Conflict of interest: None reported.

Key words
arthrodesis, best-evidence synthesis, hindfoot, Newcastle–Ottawa Score, outcome scores

INTRODUCTION

Functional impairment of the hindfoot due to pain, deformity, and/or instability is common in adults. When conservative treatments such as the use of orthotics and custom made shoe wear, adaptation of one's activities of daily living (ADL), and medications fail to resolve the pain and improve function, surgery can be considered. Surgical fusion has long been regarded as a salvage operation for relief of the symptomatic hindfoot because of limitations of movement and relatively high complication rates. Triple arthrodesis (fusion of the talocalcaneal, talonavicular, and calcaneocuboid joints) has long been the preferred technique and has been extensively documented by various authors [1-3]. A number of retrospective studies, and a few prospective studies, have documented good functional results and high patient satisfaction rates following hindfoot arthrodesis. In recent years, there has been a growing emphasis on single arthrodesis of tarsal joints, including isolated fusion of the talonavicular [4,5], calcaneocuboid [6], and subtalar joint [7-15] in order to preserve the adjacent unaffected joints. Also, the technique of arthroscopic arthrodesis of hindfoot joints has been described with promising results [16-18].

An important question to answer is which specific tarsal fusion technique is most effective with regard to which pathology. Due to heterogeneity of pathologies and patient groups, the variety of surgical techniques and the lack of disease-specific and surgery-specific scoring systems, it is difficult to evaluate the results of hindfoot arthrodesis. The first step in answering this question is to examine the literature regarding outcome studies that are prospective in design, and focus only on tarsal (talocalcaneal, calcaneocuboid, and/or talonavicular joint) fusion. The aim of this systematic review of the literature was to evaluate which specific tarsal fusion (isolated or combined fusion) was most effective for the treatment of specific hindfoot pathology.

MATERIALS AND METHODS

Search Methods

In January, 2013, a comprehensive literature search for relevant articles was conducted using PubMed® (Medline® PubMed®, United States National Institutes of Health, National Library of Medicine, http://www.nlm.nih.gov/bsd/pmresources.html; 1966 through January 2013), Embase® (Elsevier B.V., Amsterdam, the Netherlands; 1947 through January 2013), and CINAHL® (Comprehensive Index of Nursing and Allied Health Literature, Ebsco Information Services, Ipswich, MA; 1937 through January 2013) databases. The search strings that we used are presented in Table 1. The references of the selected articles were also checked and citation tracking of the selected articles was performed to ensure that no relevant articles were missed. No restrictions were used

on publication date, although we restricted our searches to articles published in English, German, or French.

Table 1. Search strings

Anatomy	(“hindfoot”hind foot OR “ankle”[MeSH Terms] OR “ankle joint”[MeSH Terms] OR “ankle”[All Fields] OR “foot”[MeSH Terms] OR “foot”[All Fields] OR “talo-calcaneal” OR “calcaneal-cuboid” OR “talo-navicular”) AND
Diagnosis	(“neuromuscular diseases”[MeSH Terms] OR “neuromuscular”[All Fields] OR “nervous system diseases”[MeSH Terms] OR (“neurologic”[All Fields] AND “disorders”[All Fields]) OR “posttraumatic”[All Fields] OR “flatfoot”[MeSH Terms] OR “osteoarthritis”[MeSH Terms] OR “osteoarthritis”[All Fields] OR “arthritis”[MeSH Terms] OR “arthritis”[All Fields] OR “Charcot-Marie-Tooth disease”[Mesh] OR “foot deformities”[Mesh] OR “hereditary motor and sensory neuropathies”[MeSH Terms] OR “hmsn”[All Fields]) AND
Treatment	(“arthrodesis”[MeSH Terms] OR “arthrodesis”[All Fields] OR “fusion”[All fields] OR “double arthrodesis”[All Fields] OR “triple arthrodesis”[All Fields])

Search strings for Medline search through PubMed, strings are adapted for the other databases Embase and Cinahl.

Inclusion Criteria

Selection criteria for inclusion of studies in this review are summarized in Table 2. From the electronic search, two *Methodological Study Criteria*

We evaluated the included studies for methodological quality using the Newcastle-Ottawa Scale list for non-randomized studies [19], the score criteria for which are given in Table 3. The methodological quality of each article was assessed independently by two review authors (MS, JTW). and thereafter discussed to meet consensus. In case the reviewers could not reach consensus, a third reviewer (BvG) was consulted.

Table 2. In- and exclusion criteria for literature search

Type of studies	- Prospective study design - The study design has to include a consecutive inclusion of patients
Type of participants	- Region of interest is limited to the hindfoot - The diagnosis of patients evaluated is limited to: congenital disorders, neuromuscular disease, neurologic disorders, rheumatoid arthritis, posttraumatic disorders, degenerative flatfoot, and osteoarthritis.
Type of surgeries	- The treatment for the disorders evaluated is limited to arthrodesis of the hindfoot performed in order to treat severe functional impairment due to pain, instability and/or deformity of the hindfoot when conservative treatment proved to be inadequate or unacceptable.
Outcome measures	- Primary outcome parameters: pain (VAS), function, complications and subjective and objective score list e.g. satisfaction or shoewear. - The outcome assessment and presentation has to include a pre-operative assessment.
Language of article	- English, German or French.

Table 3. Newcastle – Ottawa Quality Assessment Scale – Cohort studies

Selection	
1 Representativeness of the exposed cohort	a) truly representative of the average patient with *hindfoot pathology* * b) somewhat representative of the average *patient with hindfoot pathology** c) selected group of patients d) no description of the derivation of the cohort or too heterogeneous
2 Selection of the non exposed cohort	a) drawn from the same community as the exposed cohort * b) drawn from a different source c) no description of the derivation of the non exposed cohort or no control (all exposed, only diseased selected)
3 Ascertainment of diagnosis	a) valid technique * b) structured interview * c) written self report d) no description
4 Demonstration that outcome of interest was not present at start of study	a) yes * b) no
Comparability	
1 Comparability of (sub-)cohorts on the basis of the design or analysis	a) study controls for *prognostic factors* * b) study controls for *patient expectations* *
Outcome	
1 Assessment of outcome	a) independent blind assessment * b) record linkage * c) self report d) no description or not independent
2 Was follow-up long enough for outcomes to occur	a) yes, *at least 1 year* * b) no
3 Adequacy of follow up of cohorts	a) complete follow up - all subjects accounted for * b) subjects lost to follow up unlikely to introduce bias - small number lost - > 80% follow up, or description provided of those lost * c) follow up rate < 80% and no description of those lost d) no statement

*Note: A study can be awarded a maximum of one star for each numbered item within the Selection and Outcome categories. A maximum of two stars can be given for Comparability. Words in italics are added to the standard format.

Table 4. Data Extraction Form

General Information	Instructions	Data extracted
First author		Fill out
Sponsorship trial	Copy any sponsorship mentioned in the article (usually bottom left first page)	Fill out
Methods		
Study design		RCT → complete van Tulder list quasi-RCT → complete NOS controlled non-randomized CCT → complete NOS controlled Case series → complete NOS cohort Other _____
Population		
Place	Hospital/City/Country	Fill out
Enrollment dates	Helps in finding out double reported populations	Fill out
Inclusion criteria	If not explicitly stated, note this and report the diagnosis included	Fill out
Exclusion criteria		Fill out
Age	Describe the age of the included population	Fill out
Sex	Describe the sex distribution of the included population	Fill out
Duration of symptoms		Fill out
Previous treatments		Fill out
Number of patients who met inclusion criteria		Fill out
Total number of patients operated		Fill out
Total number of patients followed		Fill out
Interventions		
Group 1	Copy the description of the intervention here	Fill out
Group 2	Idem	Fill out

Table 4. Data Extraction Form (continued)

General Information	Instructions		Data extracted		
Outcomes					
Who carried out the measurements?	Preop	Postop___Months	___Months	___Months	___Months
What was measured at each follow-up and with which tool? FFI Quote AOFAS VAS pain Other:	Fill out	Fill out	Fill out	Fill out	Fill out
Analysis					
Statistical technique used:	Which test? Alpha? Power? Sample size calculation? Software used		Fill out		
Does technique adjust for confounding?	Fill out		Fill out		
Was there any assessment of patient expectations preoperatively?	Fill out		Fill out		
Was there an analysis of the effect of patient expectations after surgery?	Fill out		Fill out		
Was there a specific analysis of prognostic variables and what were the results?	Fill out		Fill out		
Results					
Qualitative results	Report the overall conclusion of the study		Fill out		
Adverse effects or complications	Fill out		Fill out		

Extraction and Data Analysis

Two reviewers performed the analyses. One reviewer extracted the data from the articles with the aid of the data extraction form (see table 4), and these were checked by the second reviewer. When outcome parameters for an article varied or the included population proved to be clinically heterogeneous, a best-evidence synthesis was performed. In the best-evidence synthesis, the results were categorized according to methodological quality with a cut-off point at a positive scoring of 50% of the items [20]. Studies were analyzed using meta-analysis of reported estimates of mean averages and ranges about the means, for adequately reported and comparable outcome parameters. Useful results reported in the included reports included clinical scale scores, Clinical Rating Index (CRI) hindfoot score [21], American Orthopaedic Foot and Ankle Society (AOFAS) hindfoot score [21,22], Foot Function Index (FFI) [23], Johnson Score [24], Visual Analog Scale (VAS) pain and function scores [25], radiological parameters, plantar pressure measurements, complications, satisfaction, and recommendation. We pooled the data from the included studies that described patients with the same diagnosis and the same treatment. Then we analyzed the study group size, age, preoperative outcome scores, male to female ratio, and follow up duration (Table 5). For best evidence synthesis, after we decided the study groups were indeed comparable, we added the means and divided by the number of studies, and we reported the range from the lowest value to the highest value for the outcome scores of interest.

Table 5. Patient Characteristics

Study	Patients	Mean age	AOFAS Pre/post	Male/Female	FU (months)
Boack	20	42	38/81	13/7	24-59
Lee	16	44	35/84	16/0	20-46
Glanzman	37	42	53/84	33/8	24-89
Eid	16	30	36/78	12/4	36-48
Garras	20	45	21/71	12/8	13-73
			Pain/walking*		
Feiwell	25	43	3/7-3/4	2/23	24-72
Cracchiolo III	26	53	4, 6/8, 6-2, 5/3, 1	6/20	24-80

* 10=no pain. 5=unlimited walking

Table 6. Included Cohort studies

Study	Year	N	Ft	FU	Diagnoses (feet)	Symptoms	Operation	Treatments	Graft	Fixation	Outcomes
Abu-Faraj et al.	2001	12	17	12	Planovalgus foot deformity with cerebral palsy	Not mentioned	Lateral incision	TC	100% graft	100% screw.	Plantar pressure/ Gait analysis
Boack et al.	2005	20	22	39	Posttraumatic (13) Primary arthritis (7) Postinfection (2)	Hindfoot pain	Arthroscopic	TC (20) TC + TT (2)	41%	100% 2 screws	Maryland score AOFAS VAS pain Radiology Complications
Chen et al.	1998	32	36	64	Calcaneal fracture non-union (36)	Painful subtalar joint	Lateral incision	TC	100%	100% screws	Clinical assessment rating system Radiology
Coughlin et al.	2008	15	15	12	PTTD (10) Primary Arthritis (3) Tarsal coalition (1)	Painful subtalar joint Hindfoot deformity Chronic swelling	Lateral incision	TC (15)	100%	100% 2 screws	Radiology/CT AOFAS VAS SF12
Cracchiolo et al.	1990	26	30	44	RA (16) Juvenile arthritis (3) Posttraumatic (2) Reiter (1) Poliomyelitis (1) Dev flatfoot (1) Posterior tibial tendon rupture (2)	Hindfoot pain	Lateral and medial incision	TA (27) TC (3)	100%	77% staples 23% screws	Pain Walking Radiology Complications
Eid et al.	2010	16	16	41	Posttraumatic (16)	Hindfoot pain	Lateral vertical incision	TC	100%	None	Radiology AOFAS

Table 6. Included Cohort studies (continued)

Study	Year	N	Ft	FU	Diagnoses (feet)	Symptoms	Operation	Treatments	Graft	Fixation	Outcomes
Elsner et al.	2010	19	19	24	Posttraumatic nerve injury (7) Iatrogenic nerve injury due to surgery (5) Spinal pathology (3) Poliomyelitis (2) Charcot-Marie-Tooth (2)	Dropfoot	Lateral incision	TA	100%	100% screws	AOFAS VAS Radiology
Feiwell et al.	1994	25	29	48	RA (18) Friedrich ataxia (3) MS (2) Juvenile RA (1) Peroneal nerve palsy (1) Talo-calcaneal coalition (1) Posterior tendon rupture (1) Systemic lupus er (1) Posttraumatic arthritis (1)	Hindfoot pain Instability Deformity	Not mentioned	TA (24) TA + MC (5)	3%	48% screws, 52% staples	Pain Walking Radiology Complications
Fellmann et al.	1997	36	36	32	Chronic tibial tendon rupture (12) Posttraumatic (fractures) OA (21) Posttraumatic (talar necrosis) OA (2) Postraumatic RA (1)	Pain Deformity	Lateral incision	TC	100%	Pins	VAS Pain Work Satisfaction
Garras et al.	2008	20	21	36	Posttraumatic OA (19) Equinovarus deformity (2)	Pain Loss of hindfoot height	Lateral incision	TC	100%	100% screws	AOFAS Radiology
Glanzmann et al.	2007	37	41	55	Primary arthritis (6) Posttraumatic arthritis (35)	Persistent pain Decreased ROM and walking ability	Arthroscopic	TC	100%	100% screws	AOFAS Clinical rating scale Improvement Radiology Complications

Table 6. Included Cohort studies (continued)

Study	Year	N	Ft	FU	Diagnoses (feet)	Symptoms	Operation	Treatments	Graft	Fixation	Outcomes
Lechler et al.	2012	30	30	16	Primary arthritis (16) Posttraumatic destruction (4) RA (4) Psoriatic arthritis (2) Peripheral neurological impairment (3) Osteonecrosis talus (1)	Pain	Medial incision	TN	20%	100% screws/ plate	AOFAS VAS
Lee et al.	2010	16	16	30	Posttrauma calc. fracture	Not mentioned	Post arthrosc.	TC	Not men-tioned	100% two screws	Angus and Cowell, AOFAS, Complications Unio
Popelka et al.	2010	26	26	54	RA (26)	Pain	Medial incision	TN	Not men-tioned	31% screws 46% staples 23% screw/ staple	AOFAS
Van der Krans et al.	2006	20	20	25	Sympt acquired flatfoot (20)	Peritalar dorsolateral subluxation	Lateral incision	CC	100%	100%plate	CRI FFI Satisfaction Radiology Donor site pain
Zollinger et al.	2004	30	36	34	Tibialis ant insuff (8) Posttraumatic calcaneal OA (16) Talar OA (3) Osteonecrotic OA (2) Secondary OA (1)	Pain Instability talo-calcaneal joint	Lateral incision	TC	100%	100% screws	VAS pain Johnson score Function Radiology Complications

FU = Follow-up in Months; N = number of patients; Ft = number of feet

TC = Talo-Calcaneal (SubTalar); TA = Triple Arthrodesis; TT = Tibia-Talar; TN = Talo-Navicular; MC = Metatarsal-Cuneiniforme; CC = Calcaneo-Cuboid

RESULTS

Search and selection results

The electronic search resulted in 4196 hits, including 2149 (51.22%) in Medline®, 1607 (38.3%) in Embase®, and 440 (10.49%) in CINAHL®. A total of 3936 references were excluded based on title and abstract, and 11 articles were excluded due to language (we included articles published in English, German and French). A total of 249 articles were retrieved, of which 28 (11.24%) articles were duplicates, and therefore 205 (82.33%) articles were excluded because they did not meet the inclusion criteria (Table 2). This left 16 (6.43%) articles to be included in our systematic review.

Overall Results

For this review 16 articles were included, and these described outcomes related to a total of 380 patients. All of the studies were prospective in design, and there were no randomized or non-randomized controlled trials available for selection. An overview of the cohort studies is given in Table 6. Regarding the quality of the studies according to the 9-star maximum Newcastle Ottawa Scale, 5 (31.25%) studies scored 6 stars, 8 (50%) scored 5 stars, 2 (12.5%) scored 4 stars, and 1 (6.25%) scored 3 stars (Table 7). Only 5 (31.25%) studies (4,6-8,26) had a homogenous study group, including diagnoses of rheumatoid arthritis (RA) (n=26), post-traumatic arthritis (n=52), acquired symptomatic flatfoot (n=20), and cerebral palsy (n=12). The other 11 (68.75%) studies concerned multiple diagnosis groups. Isolated talocalcaneal fusion was the most common operation, accounting for 10 (62.5%) of the reports, and calcaneocuboid fusion accounted for only 1 (6.25%) of the 16 reports. Twelve (75%) of the reports described hindfoot arthrodesis using rigid internal fixation with screws or staples, and bone grafting was described in 10 (62.5%) of the 16 reports.

The clinical results from the outcome scores are displayed in Table 8. The AOFAS and/or VAS scores were reported in all of the studies, with 9 (56.25%) reporting the AOFAS score, and 6 (37.5%) reporting the VAS pain score. The calculated mean preoperative AOFAS score was 39.1 (range 12 to 76), whereas the calculated postoperative mean was 80.2 (range 22 to 97). Complications reported in the 16 reports are also summarized in Table 7. Wound healing complications were reported in 17 (4.47%) of the 380 patients, nonunion in 14 (3.68%), misalignment in 20 (5.26%), and painful prominent fixation in 28 (7.69% of 364) of the patients. Results of the quantitative radiological outcome parameters are reported in Table 9. Nine (56.25%) of the 16 studies mentioned radiological angles, and the lateral talar-metatarsal angle was described in 3 (33.33%) of 9 reports, and the mean decrease in this parameter was 10.3º (range -16º to 28º) following arthrodesis surgery.

Table 7. Methodological Scoring of the included cohort studies on the Newcastle – Ottawa Quality Assessment Scale

Item	Aspect	Study															
		Abu Faraj et al	Boack et al.	Chen et al	Coughlin et al	Cracchiolo	Eid et al	Elsner et al	Feiwell	Fellmann et al	Garras et al	Glanzmann	Lee et al	Lechler et al	Popelka et al	Van der Krans	Zollinger
Selection																	
1	Representativeness of the exposed cohort	C	B*	C*	A*	A*	C	C	A*	A*	B*	B*	C	A*	C	B*	A*
2	Selection of the non exposed cohort	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
3	Ascertainment of exposure	D	A*	A*	A*	A*	A*	A*	A*	A*	A*	A*	A*	A*	A*	A*	A*
4	Demonstration that outcome of interest was not present at start of study	No	yes*	yes*	yes*	yes*	yes*	yes*	yes*	yes*	yes*	yes*	yes*	yes*	yes*	yes*	yes*
Comparability																	
1	Comparability of cohorts on the basis of the design or analysis	n.a.	n.a	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a	n.a.	n.a.	n.a.	n.a.	n.a.
Outcome																	
1	Assessment of outcome	B*	B*	C	B*	B*	B*	B*	B*	D	B*	B*	C	B*	B*	B*	B*
2	Was follow-up long enough for outcomes to occur	A*	A*	A*	A*	B	A*	A*	A*	A*	A*	A*	A*	B	A*	A*	B*
3	Adequacy of follow up of cohorts	B*	A*	B*	A*	A*	A*	A*	B*	A*	B*	A*	A*	A*	A*	A*	B*
Total Score		3	6	5	6	4	5	5	5	5	6	5	4	5	5	6	6

*Note: A study could be awarded a maximum of one star for each numbered item within the Selection and Outcome categories. A maximum of two stars could be given for Comparability but this did not apply for these studies. For explanation of the letters A, B, C, D see table 3

Table 8: Clinical results presented in the cohort studies

Study	Parameter	Preoperative				Postoperative			
		N	Value	SD/Range	FU	N	Value	SD/Range	Complications
Boack et al.	Maryland foot score	20	42	23-68	39	20	84	75-93	None
	AOFAS	20	38	14-76			81	75-94	
	VAS pain	20	8/0	4.4-9.6			2.6	0-5.5	
Chen et al.	CARS F	32	47.4F	np	64	32	83.1F	np	1 nonunion
	heel height (cm)		6				7.2		2 screw penetration
									2 superficial wound infections
									9 talonavicular dorsal subluation
									4 additional medial cortex resections
Coughlin et al.	AOFAS,	15	50	np	12	15	84		None
	fusion time (wks)						12		
	VAS		7.3				1.8		
	SF12 (MCS/PCS)		56/35				55/42		
Cracchiolo et al.	Pain score/walking score*	26	1.6/2.5	1-3/0-4	44	26	8.6/3.1	2-10/0-5	5 delayed wound healing
									1 iliac crest bleding+ileus
									1 valgus position
									1 osteo-necrosis
Eid et al.	AOFAS, union, radiology	16	36	np	41	16	74		1 nonunion, 1 achilles tendonitis
Elsner et al.	AOFAS, union	19	39	32.8-42	24	19	73	68.8-78	4 delayed wound healing
	VAS	19	3.4			19	1.8		
Feiwell et al.	Pain score/walking score*	25	3/3	1-6/0-4	48	24	7/4	1-10/0-5	3 nonunion;
									1 osteonecrosis talus;
									1 persisting rockerbottom;
									10 hardware removal;
									3 continuous pain

Table 8: Clinical results presented in the cohort studies (continued)

Study	Parameter	Preoperative				Postoperative			
		N	Value	SD/Range	FU	N	Value	SD/Range	Complications
Fellmann	VAS pain	36	4.4		32	36	1.1		1 nonunion 1 delayed union 2 lateral impingement 2 reflex symp dystrophy 1 donor site pain 1 tender dorsum pedis
Garras et al.	AOFAS	21	21.1	12-58	36	21	70.9	22-89	2 nonunion. 1 varus malalignment 1 persistent subfibular impingement 1 sural neuralgia
Glanzmann et al.	AOFAS	37	53	22-69	55	37	84	41-94	3 Persistent ankle pain; 1 tendinitis; 10 screw removals
Lechler et al.	AOFAS VAS	30 30	31.7 8.6	19-42	16	30 30	82.3 1.7	55-97	1 nonunion
Lee et al.	AOFAS, Angus and Cowell	16	35	24-45	30	16	84	71-94	1 nonunion with infection
Popelka et al.	AOFAS	26	48.2		54	26	88.6		1 nonunion
Van der Krans et al.	CRI FFI	20 20	46.1 49.1	12.5 14	25	20 20	79.2 22.1	13.8 15.4	2 nonunion; 3 Paresthesia or anesthesia sural nerve; 5 H plate removals
Zollinger et al.	VAS pain	36	4.4		34	30	0.9		2 reflex sympathetic dystrophy; 1 screw removal; 1 pseudoarthrosis; 1 revision for lateral impinging graft
Abu-Faraj	Plantar pressure % change Left medial hallux Left medial foot	12			12	11	 +155.2 +114.4		None

* 10 = no pain, 5 = unlimited walking. N= number of patients. FU= Follow Up in months. np= not provided

Diagnosis versus Operative Technique

In order to identify differences in outcomes related to a specific diagnosis in association with a specific operative technique, we analyzed the results for diagnostic groups combined with operative technique groups. With regard to the number of patients in each group, several diagnostic groups had a limited number of patients (<15 patients), including neurologic and neuropathic disease, post infection, clubfoot sequela, and osteonecrosis (13). Diagnostic groups with sufficient patients (>15 patients) were selected for further analysis, including post-traumatic osteoarthritis (n = 181 patients), primary osteoarthritis (n = 35), acquired flatfoot deformity (n = 49), and rheumatoid or other arthritis (n = 72). Within each of the four diagnosis groups, different operative fusion techniques were studied, including triple arthrodesis, talonavicular arthrodesis, calcaneocuboid arthrodesis, double arthrodesis, and isolated subtalar arthrodesis. We selected those studies with more than 50% of the patients belonging to one of the four above-mentioned diagnostic groups. Then, the operative technique was considered as well as patient characteristics and outcome scores to ensure comparability. Study details are summarized in Tables 5, 6 and 10, and the operative technique applied is also listed in Table 6.

Post-traumatic Arthritis

Post-traumatic arthritis and isolated subtalar fusion were found to be the most common combination of diagnosis and procedure. Eleven (68.75%) of 16 studies concerned patients with post-traumatic arthritis, and in 8 (50%) of these studies the post trauma group contributed more than 50% to the study population (7-9,14-18). After comparing patient characteristics and outcome scores, 5 (31.25%) studies were analyzed, including 3 (18.75%) that entailed 73 patients who were treated by means of arthroscopic arthrodesis (16-18) and the 2 (12.5%) that entailed 37 patients treated by means of open arthrodesis (8,9). AOFAS scores were higher after arthroscopic arthrodesis than after open arthrodesis (mean average of 83 vs 72 points), although the preoperative AOFAS values in the open subtalar arthrodesis group were lower (28 vs 42), and this may have confounded the comparison. Radiological consolidation was reached earlier after arthroscopic arthrodesis (mean 9 weeks) than after open arthrodesis (mean 18 weeks). Complications in the arthroscopic fusion group included screw removal in 10 (24.39%) of the 41 patients, 1 (2.44%) nonunion with infection, and 1 (2.44%) patient with tendinitis. Complications in the open arthrodesis group included 3 (8.1%) nonunions in the 37 patients, 1 (2.7%) varus misalignment, 1 (2.7%) subfibular impingement, and 1 (2.7%) sural neuralgia. When studying the other combinations, such as post-traumatic arthritis and triple arthrodesis two (12.5%) of 16 studies with less than 50% cases of triple arthrodesis) and post-traumatic arthritis and talonavicular arthrodesis one (6.25%) study with less than 50% cases of talonavicular arthrodesis), no conclusions could be drawn.

Table 9. Radiological quantitative parameters

Study	Parameter	Preoperative			Postoperative			
		N	Value	SD/Range	FU	N	Value	SD/Range
Prospective								
Abu-Faraj et al.	No data							
Boack et al.	Fusion data (%)				1.5	22	100	
Chen et al.	Talonavicular angle	32	6.06	5.4-6.6	64	32	7.25	6.5-7.8
Coughlin et al.	CT % rate of healing	15	0	0	3	15	48*	11-93
Cracchiolo et al	Talo-metatarsal angle	28	13	-13 to 43	44	28	6.4	-10 to 28
	Lat talo-calcaneal angle	28	47.7	31 to 70	44	28	39.2	14 to 56
	Height to Length ratio (tarsal height-foot length)	28	0.33	0.22 to 0.55	44	28	0.36	0.27 to 0.42
Eid et al.	Calc. Pitch angle increase lat. TC angle increase				16		6.25 7.42	8.3 10.2
Elsner	No data							
Feiwell et al.	Lat talo-metatarsal angle	22	22.7	-68 to 35	48	22	8.7	-16 to 28
Fellmann et al.	Fusion data (mm2)				3	36	345	0-720
Garras et al.	Talocalcaneal height	21	68.7	53 to 83	35.8	21	74.6	62 to 92
Glanzmann et al.	Fusion data (%)				3	37	100	
Lechler et al.	No data							
Lee et al.	Fusion data (%)				3	16	94	
Popelka et al.	Fusion data (%)				6	26	96	
van der Krans et al.	AP Talo metatarsal angle	20	15	8.7	25	20	4.1	3.8
	Lat talo-metatarsal angle	20	14.2	7.1	25	20	3.9	3.2
	Navicular height	20	1.9	0.6	25	20	3.0	0.4
Zollinger et al.	Fusion data (mm2)				3	30	345	0-720

FU = Follow-up in Months; N = number of feet; Values as average, except otherwise noted. * = 50% considered as consolidation

Primary Osteoarthritis (OA)

Primary arthritis and isolated subtalar fusion was described in 3 (18.75%) of the 16 studies included in our review. However, in none of these studies could the best evidence be deduced because the number of patients with primary arthritis was less than 50% of the total number of described patients. Primary arthritis and triple arthrodesis was not described in any of the selected studies. Primary arthritis and talonavicular fusion was described in 1 (6.25%) of the studies (5). Results from this study can be considered best evidence on talonavicular fusion for primary arthritis (53% of total patients). In that investigation, the AOFAS score improved from 31.7 preoperatively to 82.3 postoperatively, the VAS pain score diminished from 8.6 to 1.7, and the functional VAS score improved from 6.3 to 8.9 postoperatively.

Table 10. Results from disease group analysis

Group	Studies	N	Pre-op VAS		Post-op VAS		Pre-op AOFAS		Post-op AOFAS		deltaVAS	delta AOFAS
			Value	SD/Range	Value	SD/Range	Value	SD/(Range)	Value	SD/Range		
Posttraumatic & Subtalar arthroscopic	(16,17,18)	73	No data	No data	No data	No data	42	(14-76)	83	(41-94)	No data	41
Posttraumatic & Subtalar open	(8,9)	37	No data	No data	No data	No data	28.5	(12-58)	72.5	(22-89)	No data	46
Primary & Talonavicular	(5)	16	8,6	+/-1	1.7	+/-1.8	31.7	(19-42)	82.3	(55-97)	6.9	50.6
Flatfoot & Calcaneocuboid distraction	(6)	20	No data	No data	No data	No data	46.1	12.5	79.2	13.8	No data	33.1
Rheumatoid & Triple	(11,22)	25	2,3	1-6	7,8	1-10	No data	No data	No data	No data	4	No data
Rheumatoid & Talonavicular	(4)	26	No data	No data	No data	No data	48.2	No data	88.6	No data	No data	40.4

Flatfoot

Diagnoses of adult planovalgus and posterior tibial tendon disease (PTTD) were all considered to contribute to the adult acquired flatfoot group. The combination of flatfoot and subtalar arthrodesis was described in 7 (43.75%) of the 16 studies. Only one (6.25%) of these studies, Coughlin et al [10] had best evidence for flatfoot and subtalar fusion, as it was comprised of 71% of the total patients. An increase in the AOFAS score from a preoperative value of 46 to a postoperative value of 70 points was observed without concomitant use of low intensity ultrasound (US) bone growth stimulation, and this score went from 50 to 84 when low intensity US stimulation was used. The incidence of healing with low intensity US bone growth stimulation was higher than without US stimulation at 9 weeks as viewed on standard radiographs and at 12 weeks as viewed on CT scans. Interestingly, they also observed no correlation between radiographic consolidation of the fusion as viewed using standard films and CT scans. Flatfoot treated by means of triple arthrodesis was described in 2 (12.5%) of the studies; however, no best evidence could be deduced from the articles that we reviewed, and no study was found with flatfoot treated by means of talonavicular arthrodesis. Van der Krans et al. [6] described 20 patients with PTTD and calcaneocuboid distraction arthrodesis, and noted improvement of the AOFAS score from a preoperative mean value of 46 to a postoperative value of 79, along with structural improvement in the alignment of the foot as measured radiographically with the talar-first metatarsal angle decreasing from a preoperative value of 15º to a postoperative value of 4.1º.

Rheumatoid Arthritis (RA)

RA and subtalar arthrodesis was described in 1 (6.25%) of the 16 studies, however a best evidence synthesis could not be performed due to the small sample size in the study group. RA and triple arthrodesis was, however, a common combination. Two (12.5%) of the studies [11,26] qualified as best evidence, as they were comprised of 62% and 72% of the total patients, and the patient characteristics described in these two studies were comparable. Outcome was described in pain and function scores with pain ranging from 0 (no pain) to 10 (severe pain) and function ranging from 0 (severely limited) to 5 (best function). Pain scores improved from 2.3 to 7.8 between the preoperative and postoperative periods, and function improved from 2.8 to 3.6, during this same period of time. RA and talonavicular arthrodesis was described in two (12.5%) of the 16 studies, and only one of these [4] qualified as best evidence, since it was comprised of 100% of the total patients in this category. In this report, 26 patients who underwent talonavicular arthrodesis were described, and their preoperative to postoperative AOFAS scores went from 48.2 to 88.6 postoperatively and the incidence of union was 84%.

DISCUSSION

A literature review of arthrodesis of the tarsal joints for hindfoot complaints was conducted. According to the Newcastle Ottawa Score (NOS), the studies were of high quality, with 13 (81.25%) of 16 studies scoring 5 or 6 stars (Table 7). Due to heterogeneity of outcome measures and patient characteristics, data analysis proved to be difficult. Only four diagnosis groups had sufficient observations for separate operative techniques. This yielded some indications for the success of specific operative techniques for each of the four diagnosis groups.

In cases of post-traumatic arthritis, there were higher postoperative AOFAS scores, faster consolidation and fewer complications after arthroscopic subtalar arthrodesis than after open arthrodesis. However, when considering the AOFAS preoperative score, the open group showed greater improvement. Possibly a bias or problem in the comparison between the groups was based on the preoperative condition. It could be that the relatively better aligned cases were currently treated with arthroscopic arthrodesis while the misaligned cases were treated with open arthrodesis.

In cases of primary talonavicular arthritis, arthrodesis in one report [5] resulted in great improvement of the AOFAS, VAS pain, and VAS function scores. Where previously the technique of isolated tarsal arthrodesis was described featuring a high incidence of nonunion [12,26], the technique described in the study involved use of an angle stable mini plate with 100% union claimed at 10.9 weeks. The implant characteristics may have dramatically improved the results of this procedure in this specific study, but as only one report claimed this success, no firm conclusions can be drawn.

In cases of degenerative flatfoot disorder, subtalar arthrodesis resulted in higher AOFAS scores and faster bone healing when used in conjunction with low intensity ultrasound bone growth stimulation than without ultrasound stimulation. In cases of acquired flatfoot disorder, calcaneocuboid distraction arthrodesis showed a high mean postoperative Clinical Rating Index hindfoot score of 79.2 and fair improvement of the Foot Function Index (FFI) score (49.1 to 22.1) along with good re-alignment of the talar-first metatarsal angle [6].

In cases of rheumatoid arthritis, triple arthrodesis and talonavicular arthrodesis showed good improvement in pain and fair improvement in functional outcome scores.

Interesting was the study of Abu-Faraj [27], who reported on a quantitative technique to measure the dynamic plantar pressure distribution in hemiplegic and diplegic patients with planovalgus feet. In an effort to show measurable and quantifiable differences before and after subtalar arthrodesis, a significant increase in pressure load over the lateral midfoot was measured, indicating a successful realignment. No other study in our review used this particular outcome measure.

Although we undertook a thorough and proper review of the literature, we realize that certain limitations influence our conclusions. Firstly, in order to be able to compare groups with similar pathologies and surgical procedures, we relied on best evidence synthesis. If the contribution of the patients with the pathology of interest and the surgical procedure of interest was more than 50% of the total study population described, we used the outcome scores of the entire population. Furthermore, we pooled the mean and range estimates from different studies. The shortcoming of this approach is that if 50% of the population had different pathology, bias will weaken the conclusions. The advantage of this approach is that more relevant studies were used in the analyses, which could have improved the evidence in regard to generalizability.

Secondly, as blinding was not present in the included studies, the patient, the care provider, as well as the outcome assessor, might all have been biased, thereby affecting the results of the study. This is a problem common to most observational epidemiology. Moreover, information about the handling of dropouts was not described in most of the studies reviewed.

Thirdly, no direct comparisons were made in the studies that we reviewed. Relative effects could thus be biased due to different patient selection mechanisms associated with different baseline scores, and we tried to limit our analyzes to homogeneous diagnostic-intervention groups in order to limit this bias. Proper analysis of relative effects can, however, only be analyzed with comparative studies, either in randomized trials or observational studies based on proper methodological techniques and suitable sample sizes. The comparability item in the NOS cohort score contained prognostic factors and patient expectations, and these values were not found in the selected articles, hence no stars were scored in regard to this limitation.

Finally, we have assumed that when not reported, the pre- and postoperative sample sizes were equal and no patients were lost from the groups described in the literature that we reviewed. Underestimation of effects can occur when patients have improved significantly and do not see the need for follow-up. Underestimation of complications and overestimation of effects can occur when patients are lost to follow-up and their refusal to show originates from the complications. Still further, due to the scarcity of reports of some hindfoot pathologies, certain disease-tarsal fusion combinations could not be considered. Similarly, publication biases (failure to report nonsignificant results, for instance), exclusion of articles based on language, and the fact that we only searched electronic databases (and not seminar proceedings, lecture notes, and the like) were likely to have limited our findings. Classic limitations of systematic reviews and meta-analyses include publication bias, limiting to certain languages, and limiting just to electronic databases are well known, and have to be mentioned. For all of these reasons, more research is needed on this topic.

In conclusion, only 16 prospective case series that were designated as high quality according to the Newcastle Ottawa scale were found and reviewed. Using best evidence synthesis, three favorable combinations of specific hindfoot pathology and specific tarsal fusion procedures were identified, including: for RA, 1) triple arthrodesis, and 2) talonavicular arthrodesis show good improvement in function and pain reduction; and, for post-traumatic arthritis, 3) subtalar arthrodesis, especially when performed arthroscopically, shows good improvement in function and pain reduction. The results of this review cannot dictate a specific tarsal fusion for any particular pathology, although it does provide useful epidemiological information that can be used to design future prospective cohort studies and randomized controlled trials. One or more large scale, prospective, comparative studies are needed to assess the value of different fusion techniques for specific hindfoot pathology. We also believe that this type of information could be used in the development of a decision-making flowchart concerning tarsal fusions, and could be used to guide patients and surgeons to achieve higher satisfaction rates and better outcomes following treatment of a wide range of tarsal maladies.

review authors (MS, JTW) selected titles and abstracts independently from one another. Full text articles were obtained when eligibility could not be ascertained from the title or abstract. A Data Extraction Form was used to analyze the data from the article (Table 3). Two reviewers discussed their selections in order to achieve consensus on the studies to be included. If both reviewers could not reach consensus, a third reviewer (BvG) was consulted.

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Chapter 7

Open versus Arthroscopic Arthrodesis of the Subtalar Joint; Preliminary results of the first 18 patients.

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Chapter in the thesis

ABSTRACT

In this prospective randomized trial the primary objective is to measure the early complication rate of patients after open and after arthroscopic arthrodesis of the subtalar joint. Secondary outcome measures comprise patient satisfaction, pain and function. This preliminary report presents the follow-up of 18 patients in the first three months after surgery.

Included were adult patients with at least 6 months of pain and functional impairment located at the subtalar joint caused by primary osteoarthritis or posttraumatic osteoarthritis, who had been treated with custom made shoes and anti-inflammatory medication underwent arthrodesis of the subtalar joint. Patient age ranged from 19 to 75y. The patients underwent either an open surgical technique requiring an incision on the lateral side of the hind foot, or arthroscopic surgery requiring two or three stab incisions.

The main study parameter is the number of early complications in either of the two groups. Secondary study parameters are the Visual Analogue Score (VAS), two functional scores as the American Orthopedic Foot and Ankle Score (AOFAS) and the Foot Function Index (FFI) and the 12 item Short Form survey (SF12) and also the number of late complications. Endpoints are all scores (excluding number of complications) at 12 months postoperatively, with intermediate score times preoperative, after three, and six months.

A total of four minor complications in 18 patients (two in each group) were seen in the first three months after surgery. Sensibility loss over de lateral and plantar aspect of the heel in two cases and a pressure neuropathy caused by tight casting in another case, finally one case of hardware exchange after 6 weeks was seen. Although the baseline AOFAS and FFI scores at baseline were significantly lower in the arthroscopic group (p=.019 and.022 respectively), after three months these values had improved and were equal. Only the SF12 scores in the arthroscopic group remained significantly lower at 3 months (p=.022).

In this preliminary report arthroscopic and open arthrodesis of the subtalar joint show equal low complication rates and improved pain scores and functional scores three months after surgery. The SF12 scores are lower for the arthroscopically operated patients, pre- operatively as well as postoperatively.

INTRODUCTION

Isolated primary or secondary osteoarthritis of the subtalar joint complex is a painful condition which limits mobility. The condition originates from primary osteoarthritis (OA) or from posttraumatic OA after calcaneal or talar fracture [1] and also from secondary osteoarthritis due to rheumatoid arthritis, from neuromuscular disorders and also talocalcaneal coalitions and hindfoot deformities [2]. Conservative treatment consists of insoles or custom made shoes that limit motion of the subtalar joint in order to alleviate pain and improve function. Other conservative treatment consists of anti-inflammatory drugs and counselling. If these measures fail after at least six months of trying, surgical intervention may be contemplated.

For many decades open arthrodesis of the subtalar joint has been performed [3]. Subsequent early complications after this intervention are wound problems due to necrosis, wound infections, hematomas and nerve damage [4,5]. The number of early complications after open arthrodesis is reported to range from 1% to 30% [2,6]. Late complications are thrombosis and pseudarthrosis as well as fixation material causing pain and requiring repeated surgery [2]

To improve the surgical treatment of subtalar osteoarthristis, the technique of arthroscopic subtalar arthrodesis was first published by Scranton, Sammarco and Tasto in the late 1990 [3,7,8]. This arthroscopic (often named: closed) technique was based on good results of arthroscopic arthrodesis of the ankle. The number of early complications for the closed technique is reported to be very low [1,2,9].

The aim of this study is to investigate whether arthroscopic subtalar arthrodesis has at least the same pain relief, functional outcome and patient satisfaction but lower early complication rates as open subtalar arthrodesis.

PATIENTS AND METHODS

From August 2013 to March 2015 18 patients were included, the mean age was 49 years (19-75). Subjects were randomly allocated to one of the two treatment groups (open or arthroscopic surgery). The study is designed as an open randomized prospective trial with one year follow up.

The inclusion criteria were: Isolated subtalar osteoarthritis, diagnosis primary osteoarthritis or posttraumatic osteoarthritis, 6 months duration of symptoms, age 18-80y, less than 15 degrees valgus or 5 degrees varus of the hindfoot.

The exclusion criteria were previous surgery of the subtalar joint, osteonecrosis, diagnosed with rheumatoid arthritis, complex regional pain syndrome, or neurological impairment.

8 Patients had posttraumatic arthritis of the subtalar joint after calcaneal or talar fracture. 10 patients had osteoarthritis of which 2 with tarsal coalitions, 1 with a clubfoot and 1 with a degenerative flatfoot. There were 7 males and 11 females. 8 Patients underwent open and 10 patients underwent arthroscopic surgery (table 1). Measurement points in this preliminary study were preoperative and 3 months after surgery.

The 10 patients in the arthroscopic surgery group were younger than the 8 patients in the open surgery group (mean age 45.3 years versus 56.5 years. The arthroscopic surgery group also contained more subjects that are female and more patients who smoke. However, these differences were not significant (table 2).

Surgical technique

Open arthrodesis is a surgical procedure of the foot where an incision is made on the lateral side to gain access to the subtalar joint. After exposure and clearance of the sinus tarsi and the tarsal canal the remaining cartilage is removed and the subchondral surface

Table 1. Patient Characteristics

Case	Age (yr)	Gender	Smoking	Diagnosis	Group*
1	75	M	N	Primary OA	O
2	75	F	N	Posttraumatic OA	A
3	53	F	N	Posttraumatic OA	A
4	21	M	Y	Posttraumatic OA	A
5	19	M	Y	Tarsal coalition with OA	A
6	29	F	N	Tarsal coaltition with OA	A
7	47	F	N	Posttraumatic OA	A
8	33	M	N	Primary OA	O
9	59	F	N	Primary OA	A
10	52	F	N	Primary OA	O
11	35	F	Y	Posttraumatic OA	A
12	66	F	N	Posttraumatic OA	O
13	60	M	Y	Posttraumatic OA	A
14	41	M	Y	Clubfoot with Osteo Arthritis	O
15	49	F	N	Primary OA	A
16	68	F	N	Posttraumatic OA	O
17	55	F	Y	Primary OA	O
18	58	M	N	Posttraumatic OA	O

* O = Open surgery, A = Arthroscopic surgery. OA = OsteoArthritis

is scaled with an osteotome and with an awl to create a bleeding cancellous surface to enhance fusion. Subsequently, two 7.3 mm screws are inserted to compress the bone of the talus and the calcaneus in order for consolidation to occur.

The arthroscopic technique uses two or three stab incisions around the hindfoot. Similar to the open technique, after visualizing the posterior aspect of the subtalar joint the remaining cartilage is removed and a decorticated cancellous bone surface is created with an acriomionizer after which the talus and the calcaneous are compressed with two 7.3 mm screws.

The main study parameter is the early complication rate (< 6 weeks) after surgery. The following early complications were monitored specifically: wound healing disturbance caused by necrosis of the skin, superficial wound infection, deep wound infection, nerve damage caused by the skin incision and operative technique, and tendon lacerations. Secondary study parameters/endpoints are the number of late complications (≥ 6 weeks), patient satisfaction, pain and function after arthrodesis. Apart from the number of late complications, these parameters were measured preoperatively (excluding satisfaction), and after 3, 6, and 12 months after surgery. Randomisation was performed by a data manager at our research department. This data manager is not involved in the study or in the treatment of the patients. Randomisation is performed by use of stan-

Table 2. Differences in baseline characteristics between the Open and Arthroscopic group

	Open surgery (N=8)	**Arthroscopic surgery (N=10)**	**P-value**
Age (yr)	56.5 (14.3)	45.3 (18.3)	.174
Body Mass Index	25.6 (3.2)	26.8 (4.7)	.538
Gender (M/F)	4/4	3/7	.387
Smoking (Yes/No)	2/6	4/6	?
Operation time (minutes)	58 (12)	110 (20)	<.001*
Sterility disturbances during surgery	0	0	1
Complications during surgery	0	0	1
VAS pain at baseline	6.8 (2.0)	6.7 (1.1)	.946
AOFAS at baseline	38.1 (14.6)	52.6 (8.69)	.019*
FFI pain at baseline	41.4 (10.4)	61.9 (20.9)	.022*
FFI activity limitations at baseline	46.5 (15.3)	55.5 (21.1)	.326
SF12 PCS at baseline	49.0 (14.5)	38.9 (22.5)	.300
SF12 MCS at baseline	72.5 (11.8)	58.6 (24.0)	.157
SF12 Total at baseline	63.4 (11.1)	50.7 (20.4)	.138

Values are giving as mean ± standard deviation
Values are giving as median and range
* Statistical significance P<.05

dard randomisation software. After informed consent, pain and function were measured pre-operatively using scores and questionnaires (VAS, AOFAS, FFI, SF12). After this the patients underwent one of the two surgical techniques similar to those in normal care. After surgery, all questionnaires (together with a questionnaire for patient satisfaction) were filled in at regular check-up visits at 3, 6 and 12 months post-operatively. In this report only the 3 months follow up is presented.

All statistical analyses were performed using Stata 13.0. Descriptive statistics were used to describe the main characteristics of the study groups. For the clinical parameters, t-tests were used for continuous variables or the Mann-Whitney U-test when the variables were not normally distributed. A Chi-square test was used for dichotomous variables. A p-value < 0.05 was considered to indicate statistical significance.

RESULTS

18 Patients had 4 minor complications in the first three postoperative months. 2 Complications occurred in the open technique group and 2 in the arthroscopic technique group.

Two patients (closed technique) had sensibility loss and a slight prickling sensation over the lateral plantar aspect of the heel. One patient (open technique) had a temporary diminished sensation over the third and fourth digit, possibly associated with the cast pressure on the forefoot. Another patient (open technique) had a screw exchange after 6 weeks because of a protrusion in the talar neck, just in front of the ankle joint. No infections were seen. No wound problems occurred. The intraoperative circumstances as far as door movements, number of personel in the operating room (OR) and complications were equal. No bone grafts were used (table 1).

The mean pre-operative VAS score was 6.8 for the closed group and 6.7 for the arthroscopic group. Preop AOFAS and FFI scores are different between the two groups AOFAS 38.1 vs 52.6 (table 2). The arthroscopic group has worse scores than the open group. Contrary to the preoperative baseline scores, the 3 month postoperative AOFAS, VAS and FFI scores are not different between the two groups, signifying a higher and faster improvement in the arthroscopic group (table 3). Postoperative scores show worse QOL (SF12) scores in the arthroscopic group (p=0.22).

Surgery time was significantly different between the two study groups. In the open subtalar arthrodesis group surgery time was 58.3 minutes with SD 11.7 minutes. The arthroscopic group showed a significantly longer surgery time of 109.5 minutes SD 19.9 minutes.

Table 3. Outcome measures at 3 months of the Open and Arthroscopic group

	Open surgery (N=8)	**Arthroscopic surgery (N=10)**	**P-value**
Early complications* (Yes/No)	0/8	2/8	.180
Late complications‡ (Yes/No)	0/6	1/7	.357
VAS pain at 3 months	2.9 (2.9)	3.0 (2.4)	.916
AOFAS at 3 months	68.1 (18.1)	67.6 (19.3)	.954
FFI pain at 3 months	-	-	-
FFI Activity at 3 months	25.6 (11.5)	21.1 (20.0)	.613
SF12 PCS at 3 months	57.0 (13.0)	47.1 (16.8)	.190
SF12 MCS at 3 months	75.5 (6.0)	57.5 (20.1)	.027*
SF12 Total at 3 months	68.1 (7.9)	53.5 (14.6)	.022*

* Early complications: <6wk
‡ Late complications: >6wk
* Statistical significance P<.05

DISCUSSION

This study is the first prospective randomized trial to compare open to arthroscopic subtalar artrodesis and aims to clarify whether a difference exists for the early complication rate and patient satisfaction. Although the baseline pain, function and Quality Of Life (QOL) measurements show worse outcome in the arthroscopic group, at follow up both groups have improved and show equal pain and function scores. Only the QOL scores of the arthroscopic group continues to show lower scores as measured with the SF12 score (p=.022). Only 4 minor complications were seen, 2 in each group (three neuropathy cases and one hardware exchange) and no wound infection or wound healing disturbances were seen.

The preliminary findings in our study are consistent with the literature, showing good results of both open and arthroscopic subtalar arthrodesis. The complications rate remains well within the range described in the literature. A challenge remains for surgeons to choose the proper surgical procedure for subtalar arthrodesis, as scientific proof for a preferred technique is scarce. Retrospective research claims good result for open and arthroscopic subtalar arthrodesis [7]. However a drawback of these studies is that both the groups and pathologies described are often heterogeneous [2]. Several prospective studies claim excellent results after arthroscopic subtalar arthrodesis and show relatively short surgical procedures to be possible [1,10,11]. However, most of these studies have a low number of subjects and a short follow up [2].

A proper prospective comparison of the two techniques has to the best of our knowledge not been performed [2,11-13]. Only one retrospective study was found comparing open versus arthroscopic subtalar arthrodesis [7]. This study concluded that there were no specific advantages for either of the two techniques. However, based on previous studies it is expected that the advantage of the closed technique is the low number of early complications [1,2,6,9], and thus a smoother early recovery period. In the long term, it is expected that the results in both groups will not differ, although comparative data on pain and recovery after surgery is to the best of our knowledge not available. To get a better assessment of the proper surgical technique for subtalar osteoarthritis, a long term prospective randomized trial is needed to improve the treatment of patients suffering from subtalar osteoarthritis.

We estimated the sample size for both groups to be 26 patients per group. With the number of patients that are now included in the study (18) we have insufficient power to do statistics, thus we have decided to only report on the preliminary results with a follow up of three months. We have a slow inclusion in this study as a result of the inclusion criteria. Still we feel that limiting the number of diagnosis to osteoarthritis and posttraumatic arthritis will add to the value of our study.

The operative time was found to be significantly longer in the arthroscopic group than in the open technique group. A similar long operative time for arthroscopic arthrodesis was also reported by Boack [2] stating that surgery in the first 10 patients took an average of 151 minutes, and the next ten patients were operated in only 81 minutes. The removal of cartilage in the narrow subtalar space is indeed time consuming and a learning curve is expected to play a role. In our view it is important to use the third portal (sinus tarsi portal) well to check the cartilage removal from the anterior side and possibly in the future we will compare the ASTA and PASTA methods for arthroscopic subtalar arthrodesis for operative time.

CONCLUSION

This preliminary description of the first 18 patients of a prospective randomised trial comparing open and arthroscopic subtalar arthrodesis shows few minor complications of neuropathy (3/18) and a hardware exchange (1/18). In the arthroscopic group there were two cases of sensibility loss and a slight prickling sensation over the lateral plantar aspect of the heel. In the open technique group one patient had a temporary diminished sensation over the third and fourth digit (due to cast pressure) and another patient had a screw exchange after 6 weeks because of a protrusion in the talar neck. No infections or wound healing disturbances were seen, and the objective outcome scores show good

improvement in both study groups. A clear difference is noted in baseline parameters between the groups, in the longer operating time in the arthroscopic group, and in patient satisfaction being lower in the arthroscopic group. We need more patients in our study groups to have enough power for further recommendations concerning open or closed arthroscopic subtalar arthrodesis.

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Chapter 8

Development and Evaluation of a QUOTE Foot Osteo-arthritis Questionnaire for the Assessment of Surgical Treatment.

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Submitted for publication

ABSTRACT

Objectives

Incorporating the patient's view of treatment and outcome is crucial for improving quality of care. A quality of care through the patient's eyes (QUOTE) instrument for patients with foot osteoarthritis (OA) was developed to obtain information on expectations and experiences concerning quality of care.

Methods

First, a questionnaire containing 33 items about general and disease-specific care was developed after focus group discussions involving five surgical patients treated for OA of the foot. The 33 items were then divided into four categories: (1) General Care, (2) Specific Request for Help, (3) Outpatient Clinic and (4) Rehabilitation. The resulting two-part questionnaire measures expectations (part A) and experiences (part B) of patients before and after surgery, respectively. Next, the questionnaire was given to 111 OA surgical patients between October 2010 and February 2014. A factor analysis of the structure of the questionnaire was performed and internal consistency (Cronbach's α) was examined. Feasibility was evaluated by calculating impact scores (Q scores), and items of improvement of care were indicated.

Results

Principal factor analysis indicated a two-factor solution. The assumed taxonomy was not confirmed; however, the internal consistency of the four categories was moderate to good, with Cronbach's α ranging from 0.69 (Outpatient Clinic) to 0.82 (Rehabilitation). Cronbach's α of the total questionnaire was 0.88, confirming good internal consistency. The highest Q scores (items to be improved) were pain reduction, foot function and waiting time for surgery.

Conclusion

The QUOTE Foot Osteoarthritis has good reliability and is useful for evaluating and improving the quality of care. Patient focus groups will analyse the questionnaire regularly to ensure its continuous improvement.

Keywords

patient views, quality of care, osteoarthritis, tarsal arthrodesis, QUOTE

INTRODUCTION

Since the introduction of Total Quality Management (TQM) and Continuous Quality Improvement (CQI) in hospitals, greater recognition is being given to patient satisfaction as an important measure of health system performance and outcome. As an early Patient Reported Outcome Measure (PROM), Zastowny et al. [1] empirically examined satisfaction as a system input or output, concluding that reaction to and evaluation of care are likely to be related to patient compliance and may affect the likelihood of use of the same provider for subsequent health care.

In our experience, the assessment tools most frequently used (e.g. American Orthopaedic Foot and Ankle Society (AOFAS) score, Visual Analogue Scale, Short Form-36 and Foot Function Index) to measure outcome after triple arthrodesis seem not to reflect the levels of clinical change and satisfaction actually experienced by patients [2]. Van Campen and Sixma stated that patients have a view of the quality of health care that differs from that of health care professionals, and for this reason a reliable and valid assessment of every patient's view is necessary [3,4]. Also, in a meta-analysis of 49 different outcome rating scales in foot and ankle surgery, no single rating scale was identified that demonstrated reliability, validity and responsiveness in patients with a variety of foot and ankle conditions [5]. A more recent study by Hunt and Hurwit [6] described 139 unique outcome scores, of which only a small proportion is used consistently in the literature. The score used most often is the AOFAS score; however, this score is not validated [6]. These studies stress the need for a paradigm shift towards consistent use of valid and reliable outcome scores.

The recent development of numerous PROMs, for example the Dutch version of the Foot and Ankle Outcome Score (FAOS) [7] or the Self-reported Foot and Ankle Score (SEFAS) [8], is a positive step towards incorporating the patient's view in outcome assessment. It was in this context that we decided to develop a QUOTE instrument for patients with foot osteoarthritis (OA). QUOTE questionnaires were originally developed within a research project on quality of care from the patient perspective in The Netherlands [9]. We consider this instrument to be an additional and complementary means of measuring patients' expectations and experience, with the aim of improving quality of care. Quality of care is defined as the degree to which perceived performances of health care services (experience) meet the needs of patients with respect to important aspects (expectations) [1].

QUOTE questionnaires now exist for several categories of patients with severe physical limitations: QUOTE-Rheumatic-Patients [3], QUOTE-Elderly [4], QUOTE Cataract [10], QUOTE-HIV [11], QUOTE lower limb prosthetic care [12]. When developing a QUOTE questionnaire

the patient is given a central position. A QUOTE-questionnaire contains three dimensions: (1) the importance (I) of certain aspects as determined by the patient; (2) the patient's experience with the performance (P) of certain health care aspects, and (3) a quality impact factor (Q) obtained by multiplication of the I and P values. These impact factors are expressed as quality improvement scores. Because patients themselves participate in the development of this instrument, the questionnaire reflects the multidimensionality of the care giving process and includes patient-determined generic and category-specific quality aspects [4,13]. Patients with OA of the foot participated in the development of the QUOTE Foot Osteoarthritis instrument described in this paper.

METHODS

Development and content of the QUOTE questionnaire

As with the development of previous QUOTE instruments, we used a focus group approach to help determine the content of our new QUOTE Foot Osteoarthritis [9]. Five OA patients who had undergone hindfoot surgery in our hospital were invited to formulate items they thought to be of importance in both the pre- and postoperative phases of hindfoot or midfoot arthrodesis surgery. The five patients (mean age 57 years, range 46-79) were selected based on their range of experiences with the surgery, including three who were re-operated: one patient for treatment of an infection, one who had additional OA of an adjacent joint, and one patient with hardware complaints.

The QUOTE questionnaire must fulfil two important general requirements: first, the subjects in the questionnaire have to correspond to the experiences of the patient category for which the instrument is intended, and second, patients have to be involved in the development process of the instrument from the outset [13]. As a starting point, we used the Dutch Quote Instrument for Lower Limb Amputees, which contains 24 general importance and performance indicators [12]. Based on that questionnaire, the focus group formulated specific items for OA patients and pre- and postoperative treatment. Then, an independent aide more precisely formulated and divided the items into four categories: (1) General Care items, (2) Specific Request for Help, (3) Outpatient Clinic items, and (4) items concerning Rehabilitation. Thereafter, the focus group discussed these items in a second focus group meeting. Some items were either deleted or further specified, which resulted in a final list of 33 items (Table 1).

Administering and scoring of the QUOTE questionnaire

Patients were enrolled into the study beginning in October 2010 and ending in February 2014.

Table 1. Importance, Performance and Quality improvement scores of the 91 patients with foot osteoarthritis

	I	P	Q
General Aspects of Care			
1. The outpatient clinic must be easy to reach physically	6.7	0.01	0.1
2. The outpatient clinic must be easy to reach by phone	6.1	0.00	0.0
3. Immediate extensive physical examination at first visit	5.2	0.01	0.1
4. Immediate extensive diagnostics at first visit	6.0	0.00	0.0
5. Waiting time for first outpatient visit should not be long	7.3	0.05	0.4
6. Waiting time for surgery should not be long	7.6	0.15	1.2
7. The patient should have influence on the choice of treatment	7.6	0.02	0.2
8. Appointments, education and paperwork should be as planned	7.1	0.01	0.1
9. The patient should be helped in gathering information concerning the surgery	7.5	0.01	0.1
10. In the outpatient setting the wound dressing should be well attended	8.4	0.02	0.2
11. Cast comfort should be well monitored by the care givers	8.1	0.01	0.1
Specific Request for Help			
12. Barefoot walking after surgery	7.3	0.24	1.8
13. Improvement of functionality of the foot	8.8	0.18	1.6
14. Improvement of foot pain after surgery	9.0	0.11	1.0
15. Lessening of pressure sores after surgery	8.3	0.14	1.2
16. Less back pain, hip pain and knee pain	8.5	0.24	2.0
17. Able to drive a car after surgery	8.2	0.10	0.8
18. Wear normal shoes after surgery	7.6	0.21	1.6
19. Able to work after surgery, no workers' compensation	7.9	0.15	1.2
20. Able to walk after surgery	7.6	0.21	1.6
21. Able to cycle long distance after surgery	7.8	0.08	0.6
22. Able to stand after surgery	7.8	0.20	1.5
Outpatient Clinic			
23. The surgeon should inform me about the risks	7.3	0.05	0.3
24. The surgeon should take the time to answer my questions	8.4	0.00	0.0
25. The surgeon should be interested in my experiences	7.7	0.04	0.3
Rehabilitation			
26. Clear information about the course and duration of the rehabilitation	6.5	0.08	0.5
27. Sufficient information about complications before and during rehabilitation	8.1	0.13	1.1
28. Good internal communication amongst the care givers	8.0	0.14	1.1
29. The care givers should follow the same rehabilitation protocol	7.9	0.10	0.8
30. The care givers should inform the patient of do's and don'ts	8.8	0.05	0.5
31. Extensive phyical examination if complaints after surgery	8.7	0.10	0.9
32. The outpatient visits after surgery should not be far apart	7.6	0.06	0.4
33. Always a possibility to visit the outpatient clinic	7.4	0.05	0.4

The questionnaire consists of two parts. Part A was presented to the patients preoperatively and part B was completed through e-mail correspondence 1 year after surgery. In part A, the participants were asked to rate the importance (expectation) of each item on a 4–point scale (1='not important', 2='fairly important', 3='important', 4='extremely important'). These values were processed by linear transformation of standardised values (Z-scores) to obtain values between 0 ('unimportant') and 10 ('extremely important') [9]. In part B, the same 33 items were presented but the participants were asked if they had positive or negative experiences concerning these items. This 4-point scale ranges from no to yes (1='no', 2='not really', 3='on the whole yes', 4='yes'). These values were dichotomised into percentages of "yes" and "no". The performance score shows the percentage of patients who were not satisfied with the delivered care. Finally, we had the patients complete a short questionnaire to obtain information regarding their age, gender and disease-specific items.

Analysis

To assess internal consistency, exploratory factor analysis followed by a varimax rotation was conducted to explore the factor structure of the questionnaire. To determine the number of factors, a screeplot was studied and the Kaiser rule (Eigenvalue>1) was applied. A P-factor was defined as having at least four items that each loaded (>0.40) on that factor. Each item was categorised in the factor on which it had the highest (absolute) loading. Moreover, Cronbach's α was calculated for the four categories as well as the total questionnaire. Because the experience scores in our data set were highly skewed, reliability and validity were primarily evaluated from the importance scores.

Feasibility was evaluated by calculating impact scores. The impact score of each item was determined by multiplying the importance value (expectations) and the performance (experience) value. A high impact score means that better care is recommended. Analyses were performed using Stata version 13.

RESULTS

Of the 111 consecutively enrolled patients, 91 completed both forms A and B. Twenty patients were lost to follow-up for the following reasons: one patient was wrongly included, seven were excluded because they underwent no surgery, one patient underwent a revision surgery, five patients refused to complete form B, and six were lost to follow-up for unknown reasons (Figure 1). Of the properly included patients who actually underwent surgery, the net loss to follow-up was 11/102 (10.8%). Of the remaining 91

Table 2. Diagnoses of the 91 patients with foot osteoarthritis

Diagnosis	**Proportion of patients** (%)
Ankle	27
MTP1	26
Tarsal joints	23
Subtalar joint	9
Midfoot	6
Ankle and subtalar	4
Talonavicular	3
Calcaneocuboid	1
IP hallux	1

patients, 67 underwent mid- or hindfoot surgery and 24 underwent forefoot surgery to treat their disabling OA (Table 2).

Factor analysis was performed on the expectation form (form A) because, as it turned out, the results from the experience form (form B) were highly skewed. Relevant outcomes are given in Table 3. Principal factor analysis showed that three factors accounted for 55% of the total variance. The assumed taxonomy was not confirmed: 15 items were added to the first factor (General Aspects of Care) and one item to the second factor (Specific Request for Help). The third factor was excluded because it had fewer than four items loading (>0.40) on it. Four items did not load on any of the three factors and therefore were excluded; these items are item 3 (immediate extensive physical examination at first visit), item 4 (immediate extensive additional medical testing at first examination), item 7 (the patient must have influence on the choice of treatment), and item 14 (foot pain must be alleviated through surgery).

The internal consistency, as shown by Cronbach's α, was moderate to good for the dimensions General Aspects of Care and Specific Request for Help. It was moderate for Outpatient Clinic and good for Rehabilitation (Table 4).

Table 1 shows the Importance, Performance and Quality improvement scores of the 91 patients with foot OA.

The mean Importance score ranged from 5.2 to 9.0 (0 equals not important). Improvement in foot pain after surgery was rated as the most important item. Functionality of the foot, less back pain, hip pain and knee pain, and fewer pressure sores were also of high importance. Wound care and cast comfort scored high, as did information about complications, good internal communication amongst the care workers, and good

Table 3. Factor loadings of the QUOTE foot osteoarthritis questionnaire (n=91)

	Factor 1[a]	Factor 2[b]	Factor 3
General Aspects of Care			
1. The outpatient clinic must be easy to reach physically	**0.40**	0.16	0.16
2. The outpatient clinic must be easy to reach by phone	**0.48**	-0.13	0.22
3. Immediate extensive physical examination at first visit	0.21	-0.12	**0.44**
4. Immediate extensive diagnostics at first visit	0.24	0.15	**0.51**
5. Waiting time for first outpatient visit should not be long	**0.46**	-0.06	0.23
6. Waiting time for surgery should not be long	**0.61**	0.12	0.30
7. The patient should have influence on the choice of treatment	0.13	**0.44**	0.19
8. Appointments, education and paperwork should be as planned	**0.42**	-0.36	0.31
9. The patient should be helped in gathering information concerning the surgery	**0.63**	-0.43	0.24
10. In the outpatient setting the wound dressing should be well attended	**0.58**	-0.23	0.14
11. Cast comfort should be well monitored by the care givers	**0.55**	-0.35	-0.02
Specific Request for Help			
12. Barefoot walking after surgery	**0.48**	0.20	0.30
13. Improvement of functionality of the foot	**0.50**	0.20	0.03
14. Improvement of foot pain after surgery	0.19	0.10	-0.23
15. Lessening of pressure sores after surgery	0.29	**0.47**	0.35
16. Less back pain, hip pain and knee pain	**0.50**	0.38	0.04
17. Able to drive a car after surgery	0.31	**0.64**	-0.02
18. Wear normal shoes after surgery	**0.47**	0.35	-0.10
19. Able to work after surgery, no workers' compensation	0.19	**0.48**	-0.13
20. Able to walk after surgery	0.35	**0.43**	-0.26
21. Able to cycle long distance after surgery	0.35	**0.73**	0.20
22. Able to stand after surgery	0.38	**0.42**	-0.11
Outpatient Clinic			
23. The surgeon should inform me about the risks	**0.59**	-0.21	0.05
24. The surgeon should take the time to answer my questions	**0.67**	-0.21	-0.23
25. The surgeon should be interested in my experiences	**0.68**	0.01	-0.13
Rehabilitation			
26. Clear information about the course and duration of the rehabilitation	**0.48**	-0.12	-0.36
27. Sufficient information about complications before and during rehabilitation	**0.61**	-0.21	-0.30
28. Good internal communication amongst the care givers	**0.48**	0.06	-0.18
29. The care givers should follow the same rehabilitation protocol	**0.60**	-0.08	-0.21
30. The care givers should inform the patient of do's and don'ts	**0.50**	-0.22	-0.20
31. Extensive phyical examination if there are complaints after surgery	**0.47**	-0.14	-0.08
32. The outpatient visits after surgery should not be far apart	**0.54**	0.11	-0.12
33. Always a possibility to visit the outpatient clinic	**0.54**	-0.17	-0.18

[a] Factor 1: General Aspects of Care

[b] Factor 2: Specific Request for Help

information about do's and don'ts after surgery. In the case of problems postoperatively, an extensive physical examination was deemed important by the patients.

The mean Performance scores range from 0.00 to 0.24 (0 equals good performance, as in none of the patients were unsatisfied with that specific item). The highest percentages of dissatisfaction were found concerning the aspects of walking barefoot after foot surgery and improvement of hip, knee and back pain after surgery. Also, the (in)ability to wear normal shoes and walking capacity after foot surgery proved to be disappointing items to the patients.

The Quality improvement scores range from 0 to 2.0 (0 equals no improvement necessary). The highest Q scores were found in the aspects improvement of hip, knee and back pain after foot surgery and in the item barefoot walking after foot surgery. Improved function of the foot through surgery is desired, including better walking, better standing and being able to work, and the outcomes regarding these items needed improvement according to the patients. The ability to use normal shoes after surgery and waiting time before surgery needed improvement as well. Finally, patients want more information regarding the complications and better communication from care workers.

Patients' additional remarks confirm the importance and the lack in performance of waiting time for surgery. Also, disappointment concerning the long rehabilitation and the lack of physiotherapy in the early post-operative phase was reported. Several items in the questionnaire were found not to be applicable by some patients. Two patients explicitly stated they would have liked more expectation management. Two other patients complained about complications which had occurred that had not been explained pre-operatively.

Table 4. Crohnbach's α

	Cronbach's α
General Aspects of Care	0.75
Specific Request for Help	0.80
Outpatient Clinic	0.69
Rehabilitation	0.82
Total questionnaire	**0.88**

DISCUSSION

In an effort to develop a disease-specific patient-reported quality of care instrument for patients with foot OA, we used the QUOTE methodology to create a consistent, valid and reliable score. The QUOTE Foot Osteoarthritis instrument provides several items to improve the care for this patient group at a specific hospital location. Improvement can be achieved by actually improving the care technically, such as by diminishing the waiting time for surgery and improving information concerning complications and footwear. A higher quality of care can also be achieved through expectation management concerning the improvement (or better, the lack of improvement) regarding back pain, hip pain and knee pain resulting from surgery of the foot. Also important is to check the success of surgery with more objective outcome scores to ensure correct surgical technique and reach a low complication rate. With the help of patient focus groups a score can be developed for each surgical procedure related to the specific pathology causing the physical impairment. This concept can serve as an addition to the already used general outcome scores and PROMS, but with the objective to improve the quality of care for patients in a specific hospital setting. Many authors underline this concept [3,4,10,11], while others warn that these outcome scores should be evaluated rigorously to ensure that surveys of patient views are valid and have an actual effect on care [14]. We noticed that the highest quality improvement scores are directly related to the lowest performance scores. This link is less clear with the importance scores, thus indicating there is a complex relationship between expectations and performance. This was also noted in a study of patients undergoing one-level spinal surgery: satisfaction correlated only with positive outcomes, and not with pre-operative patient expectations [15]. However, patients did not participate in the setup of the study.

A limitation of the present study is the 19% total loss to follow-up of participants. Eight patients did not have surgery after filling out form A. One patient underwent hallux valgus surgery (not an OA case) and was excluded for this reason. If these patients are not included in the lost to follow-up group, then the net loss to follow-up of 10.8% is more acceptable. Additional remarks from the patients who refused to fill out form B after surgery led us to understand that some patients did not agree with the positive outcomes as represented in the list of items whilst they had complications and felt disappointed. This is congruent with our finding that the performance (experience) list is skewed. Some other patients regarded the B list as not applicable because of their age and retirement from work. Interesting in this respect is that the scoring list was created by patients themselves, which challenges the concept that there exists a homogeneous group of patients. One patient specifically remarked that more expectation management is needed.

Factor analysis did not support the use of the initial four dimensions in the questionnaire. Only two dimensions remain, and four items can be deleted from the list. To improve the present QUOTE Foot Osteoarthritis questionnaire, we will again invite a patient focus group to discuss the questionnaire and formulate new items within the two dimensions of General Aspects of Care and Specific Request for Help. In this way the QUOTE questionnaire will be updated, tackling the issues at hand in our hospital for this specific diagnostic group undergoing foot surgery for OA. In a subsequent study, in analogy with the study reported by Schnurr et al. [16], we will aim to identify patients at risk for dissatisfaction after surgery by measuring their (high) expectations preoperatively. As stated by Harris et al. [17]: "if surgeons overestimate the likelihood of postoperative patient satisfaction, they may be more likely to recommend surgery". This risk is higher if outcome instruments are used that do not contain patient views.

In conclusion, the QUOTE Foot Osteoarthritis has good reliability and is useful in evaluating and improving the quality of care. This instrument is self-improving through regular analysis and involvement of patient focus groups. In our specific setting, higher quality of care can be attained by improving the organisation of care, expectation management and patient education.

KEY MESSAGES

The quality of foot OA surgical care can be improved by using a QUOTE Foot Osteoarthritis instrument.

Regular review of the importance and performance scores allows for improvement of the QUOTE Foot Osteoarthritis instrument.

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Chapter 9

Summary, Answers to the questions, General Discussion and Implications for future research

This thesis aims to clarify existing controversies in tarsal fusion by evaluating diagnostic strategies and outcome of different surgical procedures, contributing to a better and more patient centered quality of care for this patient group as well as a better understanding of success and failure of the different procedures.

Chapter 1 presents an overview of the background of tarsal pathology, diagnostics, surgical technique and outcome measurement of a tarsal fusion. Also the aims and outline of the thesis are described. Seven research questions were introduced:

1. *"What is the short-term (1-3 years) outcome after triple arthrodesis in the different diagnostic groups?"*
2. *"Does triple arthrodesis at mid-term (5-8 years) follow-up lead to osteoarthritis in the ankle joint? Does the position/alignment of the hindfoot influence the outcome?"*
3. *"What are the preferences of Dutch orthopedic surgeons specialized in foot and ankle surgery for diagnostic modalities in tarsal fusion and how do these relate to the value of diagnostic tools as described in the literature?"*
4. *"Is pain reduction after intra-articular anaesthesia indicative for a successful outcome of tarsal fusion?"*
5. *"Which specific tarsal fusion technique is most effective with regard to which specific pathology?"*
6. *"Can the results of a randomized prospective study comparing open to arthroscopic subtalar arthrodesis help to establish the correct indications and limitations of both procedures?"*
7. *"Can a questionnaire measuring patient expectations and experience be constructed and validated, in order to improve the quality of care in tarsal arthrodesis?"*

1. This project started by studying a single surgeon cohort of patients after triple arthrodesis in our hospital. In **Chapter 2** this cohort is described specifically answering the first question.

Included were 87 fusions in 75 patients with a mean age of 40.5 years (range 14-79). The patients were allocated to 5 different diagnostic groups; degenerative, posttraumatic, reumatoid arthritis, neurologic, neuromuscular, congenital. 94% Of the patients were moderately to well satisfied. The improvement shown by the Foot Function Index (FFI) was minor but statistically significant. This outcome seems not to reflect the true benefit of this procedure for the individual patients. Between the different diagnostic groups no statistically significant difference was found.

2. This cohort of patients after triple arthrodesis was further studied in **Chapter 3**, specifically to answer the second question.

After 7.5 years follow-up the frequently reported marked increase of ankle OA as a result of adjacent triple fusion was not confirmed. Given adequate correction, achieving good alignment and sufficient stability, the quality of the ankle joint appears to remain

equal over time. The outcome scores (AOFAS and FFI) also remained stable over time. Further prospective follow-up of these patients is being performed and long term results will be reported in future.

3. In the diagnostic workup and the post-operative management of a tarsal fusion it can be difficult to choose the right diagnostic tool, especially in the case of multilevel pathology, but also because of the varying underlying pathology. In **Chapter 4**, question 3 was answered. The preoperative radiological workup concerning weight bearing X-ray examination and CT scanning for tarsal fusion is used according to the consensus in the literature by Dutch foot and ankle surgeons. In the postoperative assessment of fusion, X-ray studies that are used as a standard by the surgeons, are of little value according to the literature consensus and CT scanning should be implemented as a standard. MRI scanning is not used often, and only for the diagnosis of active arthritis a match with the literature exists. In our survey we found that experienced and/or high volume surgeons measure outcome significantly more often than less experienced surgeons.

4. The technique to find a symptomatic tarsal joint using anesthetic injections was studied in **Chapter 5** by answering research question 4.

Several studies in the literature claim good results after a positive injection into the affected joint. However, in this study of 74 patients who had fluoroscopically guided and contrast confirmed anesthetic joint injections for diagnostic reasons, pain reduction after injection did not seem to be indicative for a good result of subsequent fusion surgery. All patients that underwent surgery had a good outcome, regardless whether the injection was positive or negative. This observation was made through a group of patients with a negative injection who still had surgery.The role of a positive anaesthetic injection in the diagnostic workup for arthrodesis in the foot may not be as important as previously anticipated. We recommend that a careful history, a thorough physical examination and adequate radiological imaging will provide the necessary information to plan surgery and achieve a good outcome for the patient.

5. As the results of the studies in Chapter 2 and 3 did not answer the research question whether the various diagnostic groups have different outcome after tarsal fusion, a systematic review of the literature was performed and described in **Chapter 6**. This led to a review study answering question 5

In our extensive literature search, only 16 prospective case series were found to match the quality standards according of the Newcastle Ottawa Scale (NOS). Through best evidence synthesis three favorable combinations between specific hindfoot pathology and specific tarsal fusions were described: The combination of rheumatoid arthritis and triple arthrodesis (1) and rheumatoid arthritis and talonavicular arthrodesis (2) show good improvement in function and pain reduction. In posttraumatic arthritis, subtalar

arthrodesis (3), especially when performed arthroscopically, shows good improvement in function and pain reduction.

6. In an effort to act on this last implication a new study was started and the preliminary results are described in **Chapter 7**, which addresses question 6.

This study is the first prospective randomized trial to compare open to arthroscopic subtalar artrodesis and this study aims to clarify whether a difference exists for the early complication rate and patient satisfaction. Although the baseline outcome measurements show lower scores in the arthroscopic group, after three months follow up, both groups have improved compared to pre-operatively, and show equal scores. Only the quality of life scores of the arthroscopic group still show lower scores after three months as measured with the SF12 score. Only 4 minor complications were seen, 2 in each group (neuropathy and hardware exchange) and no wound infection or wound healing disturbances were seen.

7. As shown in the observational studies of chapter 2 and 3, there is a discrepancy between the patient satisfaction and the outcome scores such as FFI and AOFAS. While patient satisfaction was very high, only minor (but significant) improvement was seen in the scores. In **Chapter 8** a study is described on the development and evaluation of a disease-specific patient-reported quality of care instrument for patients with OA, in order to answer question 7

We used the QUOTE methodology to create a consistent, valid and reliable score. With the help of patient focus groups a score can be developed for each surgical procedure related to the specific pathology causing the physical impairment. This concept can serve as an addition to the already used general outcome scores and PROMS, but with the objective to improve the quality of care for patients in a specific hospital setting. The QUOTE Foot Osteoarthritis provides several items to improve the care for this patient group at a specific hospital location. Improvement can be achieved by actually improving the care logistically, such as by diminishing the waiting time for surgery and improving information concerning complications and footwear. A higher quality of care can also be achieved through expectation management concerning the improvement (or better, the lack of improvement) regarding back pain, hip pain and knee pain resulting from surgery of the foot. Also important is to check the success of surgery with more objective outcome scores to ensure correct surgical technique and reach a low complication rate. The QUOTE Foot Osteoarthritis has good reliability and is useful in evaluating and improving the quality of care. This instrument is self-improving through regular analysis and involvement of patient focus groups. In our specific setting, higher quality of care can be attained by improving the organisation of care, expectation management and patient education. In **Chapter 9** a summary of the chapters in this thesis is given, and a general discussion with implications for future research is provided.

GENERAL DISCUSSION AND FUTURE RESEARCH:

Diagnostic strategies

Although, as in all healthcare, a thorough medical history and physical examination provides very valuable information, additional diagnostic tools to ascertain the diagnosis and make the treatment plan are mandatory. The pre-operative workup with X-ray examination and CT scanning as performed by the Dutch foot and ankle surgeons matches with the consensus in the literature (chapter 4). It was also found that in the determination of fusion of the tarsal joints, CT scanning is only used to confirm the diagnosis of non-union and instead X-ray examination is the standard. This finding does not match with the consensus in the literature: X-ray examination is inaccurate and CT scanning should be standard of care. It is therefore recommended to use CT scanning postoperatively instead of X-ray examination if union after arthrodesis is to be determined. For other diagnostic examinations such as MRI, Ultrasound and Bone scan, no consensus in the literature could be found. Many articles contain anecdotal evidence and expert opinion, providing only weak evidence to substantiate diagnostic and therapeutic strategies. Diagnostic injections in the hip joint are considered a specific and sensitive test [1]. Although diagnostic injections in foot and ankle are used often, the true predictive value of this technique was evaluated and found to be absent. (Chapter 5). Although the patients had good results after arthrodesis, a control group made clear that the pain relief after injection was not predictive of a good result of the operation, a finding also mentioned in a similar study on wrist injections [2]. Other studies in the literature that show good value of this technique in the foot and ankle joints are in our view biased for failing to have a control group [3,4]. No positive recommendation for intra-articular injections can be given.

Treatment

In this thesis the treatment is focussed on operative tarsal fusion. The literature shows good results after tarsal arthrodesis in general (chapter 2), but unfortunately there is little evidence on which technique should be used for which specific diagnosis. A review of the literature according to the Newcastle Ottawa Score showed three favourable combinations, found through best evidence synthesis (chapter 6). In rheumatoid arthritis talonavicular and triple arthrodesis show good results. In posttraumatic arthritis, subtalar arthrodesis is a good solution, and there are indications in the literature that arthroscopic arthrodesis has better outcome than open arthrodesis [5,6]. In studying a cohort of patients after triple arthrodesis, it was surprising that although the patients were satisfied, the validated FFI score improved only little. Also the concept that one outcome score could have the sensitivity and specificity for diagnoses as different as neurologic impairment and reumatoid arthitis should be re-evaluated (chapter 2).

Although OA of the ankle joint generally is considered a late effect of tarsal arthrodesis, this had not increased at the follow-up study after 7.5 years. A correlation was found between good alignment and a stable minor degree of OA (chapter 3).

Outcome measurements

In the diagnostics study in chapter 4 it was found that experienced high volume surgeons statistically more often measure outcome continuously. In order to improve the care for patients in need of tarsal fusion, it is imperative to measure outcome continuously. Unfortunately, most of the outcome scores and PROMS are being questioned for validity and have raised concern [7]. A recent systematic review found 139 unique clinical outcome scores of which only 5 are used consistently and the first two scores AOFAS and VAS are not validated or have low sensitivity. It is stated there is a need for a paradigm shift towards consistent, valid and reliable outcome instruments that can be widely used and is clinically meaningful [8]. The present interest in Patient Related Outcome Measurement (PROM) is promising because research has long been researcher or doctor oriented and to a lesser extent patient oriented. Patient´s views and doctor´s views on the quality of health care in hip and knee prosthesis differ [9,10]. Involving patients in outcome measurement may prove to be a great step forward in evaluating the quality of care [11].

In our effort to prospectively follow a cohort of patients after triple arthrodesis, it was found that patient satisfaction was greater than the improvement shown by the Foot Function Index. In this thesis, the Quote method was used to incorporate patient views into outcome instruments for tarsal fusion. The fact that a Quote instrument is always specific concerning the diagnosis, the intervention and the location, makes it a great tool to improve care in a continuous process. New and efficient points of improvement of care were generated. Changes in patient logistics, patient counselling and expectation management are implemented. A QUOTE score can be updated by repeating a focus group meeting after analysis. It should be clear that a QUOTE score is to be used in addition to more objective outcome scores and has the purpose to improve care (chapter 7).

FUTURE RESEARCH

Based on this thesis, future studies in the diagnostics field could include an X-ray examination protocol incorporating the positioning of the foot, as this changes the angles measured significantly [12]. Also the long axial view, that was found to be superior to the Salzman view should be implemented for malaligned hindfoot cases [13]. A chance to better control the intended correction of the hindfoot intra-operatively may lie in the Computer Assisted Orthopedic Surgery (CAOS) as described by Richter [14,15], more research is needed in this field. Also interesting is the concept that standard CT scanning

after arthrodesis could customize the aftertreatment and shorten the period of cast immobilisation for the patient [16]. Finally, PET/CT and Spect/ CT scanning is an interesting new technique in the diagnostic workup of tarsal arthrodesis, and more research is needed on the value of these hybrid (functional and anatomical) diagnostic technique to reach consensus in the literature [17].

Future studies in the treatment of tarsal pathology should in our view contain large patient groups, preferably of one diagnostic group, treated with a single surgical technique according to a well described protocol (chapter 5). It would be interesting to compare the less invasive single arthrodesis to triple arthrodesis, and open versus arthroscopic techniques in tarsal arthrodesis such as the OASIS study (chapter 7). Also the development of subtalar and talonavicular prostheses is important to provide patients with pain relief in combination with functional improvement, also recommended by Beimers [18].

Future outcome measurement should be more sensitive and specific to the underlying pathology, the specific treatment and should incorporate the patients´ views. The use of patient focus groups is an efficient and reliable method to achieve this and new insight in the quality of care will emerge (chapter 8). Important for proper comparison between different studies is a shift towards validated outcome scores [8]. Surgeon-patient discordance (mostly surgeons are more satisfied than patients) as described by Harris [10] can be diminished if the patients´ views are better incorporated in outcome scores. This will lead to less tendency to overestimate the succes after surgery and to less unsuccessful and thus unneccesary surgery.

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Chapter 10

Samenvatting, Beantwoording van de onderzoeksvragen, Algemene discussie en Implicaties voor toekomstig onderzoek

Het doel van dit proefschrift is het ophelderen van bestaande controverses bij operatieve fusie van de tarsus door middel van een evaluatie van de diagnostische strategie en van de resultaten van verschillende operatieve behandelingen. Hiermee wordt bijgedragen aan betere en meer patiënt gerichte kwaliteit van zorg voor deze patiëntengroep en ook aan een beter begrip van succes en falen van de verschillende chirurgische behandelingen.

Hoofdstuk 1 toont een overzicht van de achtergronden van tarsale pathologie, diagnostiek, operatieve techniek en het meten van de resultaten van fusie van de tarsus. Ook de doelen en opbouw van het proefschrift worden beschreven. Zeven onderzoeksvragen worden geïntroduceerd:

1. *"Hoe zijn de korte termijn resultaten(1-3 jaar) na triple arthrodese voor verschillende diagnostische groepen?"*
2. *"Leidt triple arthrodese op de middellange termijn(5-8 jaar) tot arthrose in het enkel gewricht? Is de positie of het alignement van de achtervoet van invloed op het resultaat?"*
3. *"Welke zijn de voorkeuren van Nederlandse orthopedisch chirurgen gespecialiseerd in voet en enkel chirurgie voor diagnostisch onderzoek bij fusie van de tarsus en kunnen deze voorkeuren gerelateerd worden aan de waarde die door de literatuur aan dit onderzoek wordt toegeschreven?"*
4. *"Is pijn reductie na een intra-articulaire anesthesie van voorspellende waarde voor een goed resultaat na operatieve fusie van de tarsus?"*
5. *"Welke specifieke operatie-techniek voor operatieve fusie van de tarsus is het meest effectief bij welke specifieke pathologie?"*
6. *"Kunnen de resultaten van een gerandomiseerde prospectieve studie naar de vergelijking tussen open en arthroscopische arthrodese helpen om de correcte indicaties en beperkingen van beide operatieve technieken duidelijk te maken?"*
7. *"Kan een vragenlijst die patiënt verwachtingen en ervaringen meet worden gemaakt en gevalideerd, met als doel het verbeteren van de kwaliteit van zorg van fusie van de tarsus?"*

1. Dit onderzoeksproject is gestart met het bestuderen van een patiëntengroep na triple arthrodese, geopereerd in ons ziekenhuis. In **Hoofdstuk 2** wordt deze groep beschreven en wordt de eerste vraag beantwoordt.

Er werden 87 triple arthrodeses bij 75 patiënten geïncludeerd, en de gemiddelde leeftijd van de patienten was 40,5 jaar (range 14-79). De patiënten werden in zes diagnostische groepen ingedeeld; degeneratief, posttrauma, reumatoïde arthritis, neurlogisch, neuromusculair en congenitaal. Een gemiddelde tot hoge mate van tevredenheid werd gevonden bij 94% van de patiënten. De verbetering die gemeten werd met

de Foot Function Index (FFI) was bescheiden maar statistisch significant. Deze resultaten stroken niet met de daadwerkelijke verbetering voor de individuele patiënt. Tussen de diagnostische groepen werd geen verschil gemeten.

2. Het hierboven beschreven cohort van patienten na een triple arthrodese werd verder gevolgd en beschreven in **Hoofdstuk 3**, en de tweede vraag werd hiermee beantwoord.

Na een follow-up van 7,5 jaar kon de vaak beschreven toename van arthrose als gevolg van de triple arthrodese niet worden bevestigd. De kwaliteit van het enkelgewricht lijkt stabiel te blijven in de tijd, mits er een goede correctie van alignement is, en voldoende stabiliteit. De uitkomst scores AOFAS en FFI blijven eveneens stabiel in de tijd. Dit cohort van patiënten zal in de toekomst verder worden gevolgd en de resultaten zullen worden gepubliceerd.

3. In de pre-operatieve diagnostische work-up en in de postoperatieve behandeling na een fusie van de tarsus is het kiezen van het juiste diagnostisch onderzoek soms lastig, vooral in het geval van pathologie op meerdere niveaux, maar ook door de sterk uiteenlopende onderliggende pathologie. In **Hoofdstuk 4** wordt de derde onderzoeksvraag beantwoordt. In de pre-operatieve voorbereiding is het gebruik van belaste röntgenfoto´s en CT-scans door Nederlandse orthopedisch chirurgen in overeenstemming met de consensus in de literatuur. De postoperatief standaard aangevraagde röntgenfoto´s zijn volgens de consensus in de literatuur van weinig waarde en CT-scans moeten worden ingevoerd als een standaard controle onderzoek. MRI-scans worden weinig aangevraagd en volgens de literatuur consensus is er slechts bij actieve arthritis een indicatie voor dit onderzoek. In dit onderzoek werd tevens gevonden dat ervaren en hoog volume orthopeden vaker uitkomsten na behandeling meten dan minder ervaren orthopeden.

4. De lokalisatie van een symptomatisch gewricht met behulp van pijnstillende injecties werd bestudeerd in **Hoofdstuk 5** en hiermee wordt vraag 4 beantwoordt.

Verschillende onderzoeken uit de literatuur beschrijven goede resultaten van arthrodese na een positief resultaat van een pijnstillende injectie. Echter, in deze studie van 74 patienten die röntgengeleide anesthetische injecties met contrast kregen toegediend in de diagnostische work-up voor een arthrodese, bleek dat een positieve injectie niet een garantie is voor een goed resultaat. Alle patiënten die geopereerd werden hadden een goed resultaat, onafhankelijk of de injectie een positief of een negatief resultaat had. Deze observatie kon worden gedaan vanwege het feit dat er een groep patiënten bleek te bestaan die na een negatief resultaat van injectie toch een operatie hadden ondergaan. Een positieve pre-operatieve pijnstillende injectie speelt waarschijnlijk een minder grote rol in het voorspellen van een goed resultaat van een arthrodese dan eerder

werd aangenomen. Wij doen de aanbeveling dat een goede anamnese, een gedegen lichamelijk onderzoek en adequate radiologische beeldvorming voldoende informatie verschaft om een operatieve ingreep te plannen en een goed resultaat voor de patiënt te voorspellen.

5. Aangezien de resultaten van de studies in Hoofdstuk 2 en 3 de onderzoeksvraag naar verschillende resultaten door verschillende pathologie niet kon beantwoorden werd een systematisch review van de literatuur uitgevoerd. Dit onderzoek wordt beschreven in **Hoofdstuk 6** en beantwoordt vraag 5.

In een uitvoerig literatuur onderzoek werden 16 prospectieve onderzoeken gevonden die aan de kwaliteits standaard van de Newcastle Ottawa Scale (NOS) voldoen. Door het toepassen van `best evidence synthesis` werden drie gunstige combinaties gevonden tussen specifieke voetwortel pathologie en specifieke fusie technieken; De combinatie van reumatoïde arthritis en triple arthrodese (1), en van reumatoïde arthritis en talonaviculaire arthrodese (2) laten een goed resultaat zien in functie verbetering en pijn reductie. De combinatie van posttraumatische arthrose en subtalaire arthrodese (3) vooral wanneer arthroscopisch geopereerd laat eveneens goede resultaten zien in functie verbetering en pijn reductie.

6. In een poging meer bewijs voor deze laatste stelling te leveren werd een nieuwe studie ontworpen en de voorlopige resultaten worden beschreven in **Hoofdstuk 7**, waarbij vraag 6 beantwoord wordt.

Deze studie is de eerste prospectieve gerandomiseerde studie die open en arthroscopische subtalaire arthrodese vergelijkt en deze studie heeft als doel om aan te tonen of er verschil bestaat in vroege complicaties en patiënt tevredenheid bij een van beide operatie technieken. Hoewel de baseline resultaten pre-operatief slechter zijn in de arthroscopische groep wordt na drie maanden follow-up gezien dat beide groepen gelijke scores bereiken, en dat de arthroscopische groep dus meer verbetering in dezelfde periode bereikt. Op het gebied van de quality of life scores laat de SF-12 zien dat de arthroscopische groep na drie maanden lagere scores houdt. Slechts 4 complicaties worden gezien na drie maanden, twee in elke groep bestaande uit neuropathie en osteo-synthese materiaal wissel. Er is geen infectie of wondgenezingsstoornis gezien in de eerste drie maanden.

7. Zoals bleek uit de observationele studies in Hoofdstuk 2 en 3 bestaat er een discrepantie tussen de patiënt tevredenheid en uitkomst scores zoals de FFI of de AOFAS score. Terwijl de patiënt tevredenheid erg hoog is laten de scores een kleine maar wel significante verbetering zien. In **Hoofdstuk 8** wordt een studie beschreven over de ontwikkeling en de evaluatie van een ziekte specifiek en patiënt gericht kwaliteitsinstrument voor patiënten met arthrose van de voet. Hiermee wordt vraag 7 beantwoordt.

De QUOTE methode werd gebruikt om een consistente, valide en betrouwbare score te ontwikkelen. Met de hulp van zogenaamde patiënt focus groepen kan een

score worden ontwikkeld voor elke operatieve ingreep gerelateerd aan een specifieke pathologie die lichamelijke beperkingen oplevert. Dit concept kan dienen als een toevoeging bij de reeds bestaande algemene uitkomst scores en PROMS, met als doel om de kwaliteit te verbeteren voor patiënten in een specifieke ziekenhuisomgeving. De QUOTE Voet Arthrose gaf aanleiding om de zorg voor patiënten op meerdere punten te verbeteren. Deze verbeteringen kunnen worden bereikt door logistieke maatregelen zoals het verkorten van de wachttijden voor operatie, en ook door het verbeteren van de informatie betreffende complicaties en het dragen van schoenen na de ingreep. Een hogere kwaliteit van zorg kan ook bereikt worden door verwachtingen management pre-operatief betreffende de te verwachten verbetering, over het optreden van rugklachten, heup en kniepijn in de postoperatieve fase. Van belang is ook om het succes van de chirurgische ingreep met meer objectieve scores te meten om de correcte chirurgische techniek te bewaken en een laag complicatie percentage te bereiken. De QUOTE Voet Arthrose heeft een goede betrouwbaarheid en is nuttig bij de evaluatie en verbetering van de kwaliteit. Dit instrument is regelmatig te verbeteren door analyse en de inzet van nieuwe focus groepen. In onze specifieke setting kan een hogere kwaliteit van zorg bereikt worden door de organisatie van de zorg, het verwachtingen management en patiënten educatie te verbeteren.

In **Hoofdstuk 9** wordt een samenvatting gegeven van de hoofdstukken gevolgd door een algemene discussie en implicaties voor toekomstig onderzoek.

ALGEMENE DISCUSSIE EN TOEKOMSTIG ONDERZOEK:

Diagnostische strategie

Ofschoon, zoals in de gehele gezondheidszorg, een grondige anamnese en lichamelijk onderzoek erg waardevolle informatie oplevert, is het meestal noodzakelijk additionele diagnostisch onderzoek in te zetten om een diagnose te onderbouwen en een behandelplan op te stellen. De keuze van Nederlandse orthopedisch chirurgen om bij de pre-operatieve work-up voor een voetwortel arthrodese Röntgen onderzoek en CT-scans uit te voeren komt overeen met de consensus in de literatuur (Hoofdstuk 4). Ook werd gevonden dat bij het vaststellen van consolidatie van arthrodese van de tarsus, de CT-scan vooral worden ingezet om de verdenking op een non-union te bevestigen en dat Röntgen onderzoek het standaard diagnosticum is. Deze bevinding strookt niet met de consensus in de literatuur: Röntgen onderzoek om consolidatie te bevestigen is niet accuraat en de CT-scan zou het onderzoek van voorkeur dienen te zijn. De aanbeveling is om in de postoperatieve fase de CT-scan als standaard onderzoek in te zetten in plaats van Röntgen onderzoek als het om het aantonen van consolidatie gaat. Ten aanzien

van andere diagnostische onderzoeken zoals MRI, echo en bot scintigrafie werd geen consensus in de literatuur gevonden. Er zijn veel artikelen die anekdotisch bewijs of expert opinion bevatten, en hiermee wordt slechts zwak bewijs geleverd om specifieke diagnostische en therapeutische strategieën te onderbouwen. Diagnostische injecties in het heupgewricht worden beschouwd als een specifieke en sensitieve test [1]. Hoewel diagnostische injecties in de voet en enkel vaak worden toegepast, blijkt na onderzoek dat de voorspellende waarde van deze injectie voor een goed resultaat na arthrodese niet gevonden kan worden (Hoofdstuk 5). Hoewel de patiënten na de arthrodese een goed resultaat hadden, werd het door een controlegroep duidelijk dat pijn reductie na injectie niet voorspellend was voor een goed resultaat na operatie; een bevinding die ook werd gemeld in een vergelijkbare studie naar de voorspellende waarde van injecties in het polsgewricht [2]. Een aantal andere studies die aan de injectie techniek een voorspellende waarde toekennen zijn hebben naar onze mening een bias omdat er geen controle groep werd beschreven [3,4]. Op grond van dit onderzoek wordt geen positieve aanbeveling gegeven voor intra-articulaire injecties.

Behandeling

In dit proefschrift is de focus op de operatieve behandeling van voetwortel pathologie. Over het algemeen worden in de literatuur goede resultaten beschreven na arthrodese van de tarsus (hoofdstuk 2), maar helaas is er weinig bewijs over welke techniek het best kan worden aangewendt bij welke specifieke diagnose. Een review van de literatuur volgens de regels van de Newcastle Ottawa Score bracht door `best evidence synthesis` drie voordelige combinaties aan het licht (hoofdstuk 6). In het geval van reumatoïde arthritis wordt een goed resultaat beschreven voor talonaviculaire en voor triple arthrodese. In het geval van post traumatische arthrose is er good resultaat bij een subtalaire arthrodese, waarbij er ook aanwijzingen zijn dat een arthroscopisch uitgevoerde arthrodese betere resultaten geeft dan de open techniek. [5,6]. Na bestudering van een cohort van patiënten na een triple arthrodese was het opvallend dat hoewel de patiënten een hoge mate van tevredenheid hadden, de FFI score maar weinig verbeterde. Het idee dat een enkele uitkomst score de sensitiviteit en specificiteit kan hebben om voor diagnoses die ver uiteen liggen zoals neurologische beperking en reumatoïde artritis ingezet te worden moet worden herzien. (hoofdstuk 2). Hoewel arthrose van het enkel gewricht beschouwd wordt als een laat effect van arthrodese van de tarsus, werd geen toename van arthrose gevonden na een follow up van 7,5 jaar. Een correlatie werd gevonden tussen goed alignement en een stabiele lage graad van arthrose (hoofdstuk 3).

Uitkomst metingen

In de diagnostiek studie van hoofdstuk 4 werd gevonden dat ervaren orthopeden statistisch gezien vaker standaard de uitkomsten van operaties meten dan minder ervaren

collega´s. Om de kwaliteit van de zorg voor patiënten die een arthrodese operatie van de tarsus ondergaan te verbeteren, is het noodzakelijk om de uitkomst continue te meten. Helaas is het een feit dat de meeste uitkomst scores en PROMS weinig valide blijken te zijn en bezorgdheid oproepen [7]. Een recent gepubliceerd systematisch review beschrijft dat van de 139 gevonden scores, er maar 5 vaker gebruikt worden in studies, en dat de twee meest gebruikte scores AOFAS en VAS niet gevalideerd zijn of lage sensibiliteit hebben. Er is een paradigma verschuiving noodzakelijk naar uitkomst instrumenten die consistent worden gebruikt en valide en betrouwbaar zijn zodat deze overal gebruikt kunnen worden en klinisch betekenisvol zijn [8]. De huidige belangstelling voor Patient Related Outcome Measurement (PROM) is veelbelovend omdat het onderzoek naar uitkomst scores van oudsher dokter georiënteerd is geweest en minder op de patiënt gericht was. Het gezichtspunt van patiënten en artsen op de kwaliteit van de zorg in heup- en knieprothesiologie verschilt [9,10]. Het betrekken van patiënten in uitkomst metingen zal een grote stap voorwaarts betekenen voor de evaluatie van de kwaliteit van de zorg [11].

In onze poging prospectief een cohort na triple arthrodese te volgen werd gevonden dat de patiënt tevredenheid hoger was dan de verbetering die gemeten werd met de Foot Function Index. In dit proefschrift wordt de QUOTE methode gebruikt om de zienswijze van de patiënt te incorporeren in een nieuw uitkomst instrument voor tarsale fusie. Het feit dat een QUOTE instrument altijd specifiek is voor de diagnose groep, de interventie en de locatie, maakt dat het een geschikte tool is om de zorg continue te verbeteren. Nieuwe en efficiënte verbeterpunten voor de zorg werden gevonden. Er zijn veranderingen in patiënt logistiek, patiënt voorlichting en verwachting management geïmplementeerd. Een QUOTE instrument kan worden verbeterd of gemoderniseerd door in aansluiting op analyse een focus groep bijeenkomst te organiseren. Het moge duidelijk zijn dat een QUOTE score gebruikt moet worden in combinatie met meer objectieve uitkomst metingen en als doel heeft de zorg continue te verbeteren (hoofdstuk 7).

Toekomstig onderzoek

Toekomstige studies op het gebied van diagnostiek dienen, gebaseerd op dit proefschrift, een Röntgen onderzoek protocol te bevatten waarbij de positie van de belaste voet beschreven wordt, omdat hierdoor de te meten hoeken sterk beïnvloed wordt [12]. In het geval van malalignment dient de lange axiale opname van de achtervoet, die superieur werd bevonden boven de Salzmann opname gebruikt te worden [13]. Mogelijk is er betere intra operatieve controle te bereiken door het gebruik van Computer Assisted Orthopedic Surgery (CAOS) zoals beschreven door Richter [14,15], en het is aan te bevelen meer onderzoek te verrichten. Een interessante toekomstige ontwikkeling ligt in het op de individuele patiënt inrichten van de nabehandeling door gebruik te maken van standaard CT-scan onderzoek volgens het protocol van Dorsey [16] waarbij de duur van immobilisatie

voor de patiënt kan worden bekort. Tot slot kan worden aanbevolen meer onderzoek te doen naar de combinatie van hybride diagnostiek waarbij PET met CT en SPECT met CT wordt gecombineerd en zo functionele en anatomische beeldvorming tot betere diagnostiek leidt en consensus in de literatuur kan worden bereikt [17].

Toekomstig onderzoek in de behandeling van pathologie van de tarsus zou kunnen bestaan uit het opzetten van studies van grote patiënt groepen bij voorkeur van één diagnostische groep, die worden behandeld met één chirurgische techniek volgens een goed beschreven studie protocol (hoofdstuk 5). Het zou van belang zijn om de minder invasieve enkele arthrodese te vergelijken met triple arthrodese, en om open versus arthroscopische technieken te vergelijken zoals de OASIS studie uit hoofdstuk 7. Ook zou de ontwikkeling van een subtalaire of talonaviculaire prothese van belang zijn om patiënten een combinatie van pijn reductie en functie verbetering te bieden, zoals eerder aanbevolen door Beimers [18].

Toekomstige uitkomst metingen dienen meer sensitief en specifiek te zijn voor de onderliggende pathologie, de specifieke behandeling en zouden de zienswijze van patiënten moeten incorporeren. Het gebruik van focus groepen is een efficiënte en betrouwbare methode om dit te bereiken en nieuwe gezichtspunten op de kwaliteit van zorg zullen hierdoor naar voren komen (hoofdstuk 8). Van belang voor een juiste vergelijking tussen verschillende studies is een verschuiving naar gevalideerde uitkomst scores [8]. Het niet overeenkomen van het oordeel van chirurgen en patiënten over de bereikte gezondheidsverbetering (meestal zijn chirurgen meer tevreden dan patiënten) zoals beschreven door Harris [10] kan verbeteren als de zienswijze van patiënten beter worden geïncorporeerd in uitkomst metingen. Dit kan leiden tot minder neiging om succes na chirurgie te overwaarderen en daardoor onnodige en daardoor niet succesvolle chirurgie te vermijden.

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Chapter 11

Zusammenfassung, Beantwortung der Fragen, Allgemeine Diskussion und Implikationen für die zukünftige Forschung

Ziel der vorliegenden Doktorarbeit ist es, in Bezug auf die tarsale Arthrodese bestehende Kontroversen durch Evaluation diagnostischer Strategien und Ergebnisse verschiedener chirurgischer Verfahren zu klären und auf diese Weise zu einer verbesserten, stärker patientenzentrierten Qualität der Versorgung dieser Patientengruppe beizutragen sowie die Gründe für Erfolg bzw. Misserfolg der erwähnten verschiedenen Verfahren deutlicher herauszuarbeiten.

Kapitel 1 gibt einen Überblick über den Hintergrund von tarsaler Pathologie, Diagnostik, chirurgischen Verfahren sowie Ergebnismessung bei tarsaler Arthrodese. Außerdem werden Ziele und Gliederung der vorliegenden Doktorarbeit beschrieben. Es werden insgesamt sieben Forschungsfragen gestellt:

1. *„Welches kurzfristige Ergebnis (1-3 Jahre) wird nach einer Triple-Arthrodese in den verschiedenen diagnostischen Gruppen beobachtet?“*
2. *„Führt Triple-Arthrodese zum Zeitpunkt der mittelfristigen Verlaufskontrolle (5-8 Jahre) zu Osteoarthritis im Sprunggelenk? Beeinflusst die Position/Ausrichtung des Rückfußes das Ergebnis?“*
3. *„Welche Präferenzen haben niederländische orthopädische Fuß- und Sprunggelenkchirurgen in Bezug auf die diagnostischen Modalitäten bei tarsaler Arthrodese und in welchem Zusammenhang stehen diese zu dem Wert der in der Literatur beschriebenen diagnostischen Tools?“*
4. *„Deutet Schmerzreduktion nach intraartikulärer Anästhesie auf ein erfolgreiches Ergebnis der tarsalen Arthrodese hin?“*
5. *„Welches spezifische Verfahren bei tarsaler Arthrodese ist hinsichtlich welcher spezifischen Pathologie am effektivsten?“*
6. *„Können die Ergebnisse einer randomisierten prospektiven Studie, bei der offene und arthroskopische subtalare Arthrodese verglichen werden, dabei helfen, die korrekten Indikationen und Grenzen beider Verfahren zu ermitteln?“*
7. *„Ist die Entwicklung und Validation eines Fragebogens zur Messung der Patientenerwartungen und -erfahrungen möglich, mit dem sich die Qualität der Versorgung bei tarsaler Arthrodese verbessern lässt?“*

1. Am Anfang dieses Projekts stand die Untersuchung einer einzigen chirurgischen Kohorte von Patienten nach Triple-Arthrodese in unserem Krankenhaus. In **Kapitel 2** wird diese Kohorte in Beantwortung der ersten Frage beschrieben.

Untersucht wurden 87 Arthrodesen bei 75 Patienten mit einem Durchschnittsalter von 40,5 Jahren (Streuung 14-79). Die Patienten wurden 6 verschiedenen diagnostischen Gruppen zugeteilt; degenerative, posttraumatische, rheumatoide Arthritis, neurologisch, neuromuskulär, kongenital. 94 % der Patienten waren mäßig bis sehr zufrieden. Die durch den Foot Function Index (FFI) angezeigte Verbesserung war geringfügig, aber

statistisch signifikant. Dieses Ergebnis scheint den tatsächlichen Vorteil dieses Verfahrens für den einzelnen Patienten nicht widerzuspiegeln. Zwischen den verschiedenen diagnostischen Gruppen wurde kein statistisch signifikanter Unterschied festgestellt.

2. Die Patientenkohorte nach Triple-Arthrodese wurde weiterhin untersucht, siehe **Kapitel 3**, insbesondere zu dem Zweck, die zweite Frage zu beantworten.

Bei der Verlaufskontrolle nach 7,5 Jahren wurde die häufig berichtete deutliche Zunahme der Osteoarthritis des Sprunggelenks infolge angrenzender Triple-Arthrodese nicht bestätigt. Bei adäquater Korrektur, die zu guter Ausrichtung und ausreichender Stabilität führt, scheint die Qualität des Sprunggelenks über die Zeit unverändert zu bleiben. Die Outcome-Scores (AOFAS und FFI) blieben über die Zeit ebenfalls stabil. Die Patienten werden weiterhin beobachtet. Über die langfristigen Ergebnisse wird zu gegebener Zeit berichtet.

3. Bei diagnostischer Abklärung und postoperativem Management einer tarsalen Arthrodese kann es schwierig sein, das richtige diagnostische Tool auszuwählen, insbesondere bei Multi-Level-Pathologie, aber auch bedingt durch die unterschiedliche zugrunde liegende Pathologie. In **Kapitel 4** wurde Frage 3 beantwortet. Die präoperative radiologische Abklärung hinsichtlich Röntgenuntersuchung unter Belastung und CT-Scanning bei tarsaler Arthrodese wird von niederländischen Fuß- und Sprunggelenkchirurgen entsprechend dem in der Literatur bestehenden Konsens durchgeführt. Bei der postoperativen Beurteilung der Arthrodese sind Röntgenuntersuchungen, die von den Chirurgen standardmäßig angewendet werden, gemäß Literaturkonsens von geringem Wert. Hierbei sollte CT-Scanning als Standard implementiert werden. MRT-Scanning kommt nicht oft zum Einsatz. Eine Übereinstimmung mit der Literatur gibt es nur im Hinblick auf die Diagnose der aktiven Arthritis. Unsere Umfrage ergab, dass erfahrene und/oder High-Volume-Chirurgen das Ergebnis signifikant häufiger messen als weniger erfahrene Chirurgen.

4. Dem Verfahren zur Identifizierung eines symptomatischen tarsalen Gelenks unter Anwendung von anästhetischen Injektionen wurde in **Kapitel 5** im Rahmen der Beantwortung von Frage 4 nachgegangen.

In der Literatur finden sich mehrere Studien, die von guten Ergebnissen nach einer positiven Injektion in das betroffene Gelenk berichten. Aus der Studie, bei der 74 Patienten zu diagnostischen Zwecken fluoroskopisch geführte und mit Kontrastmittel bestätigte anästhetische Gelenkinjektionen erhielten, ging jedoch nicht hervor, dass die Schmerzreduktion nach der Injektion auf ein gutes Ergebnis bei einer anschließenden chirurgischen Arthrodese hindeutete. Bei allen Patienten, die sich einem chirurgischen Eingriff unterzogen, war das Ergebnis gut, unabhängig davon, ob die Injektion positiv

oder negativ war. Diese Beobachtung wurde anhand einer Gruppe von Patienten gemacht, die eine negative Injektion erhielten und ebenfalls operiert wurden. Die Rolle der positiven anästhetischen Injektionen bei der diagnostischen Abklärung im Hinblick auf die Arthrodese des Fußes könnte demnach weniger bedeutend sein als zunächst erwartet. Wir empfehlen eine sorgfältige Anamnese, eine gründliche körperliche Untersuchung und eine adäquate radiologische Bildgebung, um die für die Planung des Eingriffs notwendigen Informationen zu erhalten und ein gutes Ergebnis für den Patienten herbeizuführen.

5. Da die Ergebnisse der in Kapitel 2 und 3 behandelten Studien die Forschungsfrage, ob die verschiedenen diagnostischen Gruppen nach der tarsalen Arthrodese unterschiedliche Ergebnisse aufweisen, nicht beantwortet haben, wurde eine systematische Prüfung der Literatur durchgeführt und in **Kapitel 6** beschrieben. Dies führte zu einer Review-Studie, mit der Frage 5 beantwortet werden konnte.

Bei unserer umfassenden Literatursuche fanden wir nur 16 prospektive Fallserien, die den Qualitätsstandards gemäß der Newcastle-Ottawa-Scale (NOS) entsprachen. Durch Synthese der besten Evidenz wurden drei günstige Kombinationen von spezifischer Rückfußpathologie und spezifischen tarsalen Arthrodesen beschrieben: Die Kombination von rheumatoider Arthritis und Triple-Arthrodese (1) sowie rheumatoider Arthritis und talonavikularer Arthrodese (2) ergibt hinsichtlich Funktion und Schmerzreduktion gute Verbesserungen. Bei posttraumatischer Arthritis erbrachte die subtalare Arthrodese (3) gute Ergebnisse hinsichtlich Funktion und Schmerzreduktion, besonders, wenn diese arthroskopisch durchgeführt wurde.

6. In dem Bemühen, auf diese letzte Implikation einzugehen, wurde eine neue Studie begonnen. Die vorläufigen Ergebnisse sind in **Kapitel 7** beschrieben, das sich mit Frage 6 beschäftigt.

Diese Studie ist der erste prospektive randomisierte Versuch, bei dem die offene mit der arthroskopischen subtalaren Arthrodese verglichen wurde. Ihr Ziel ist es, zu klären, ob ein Unterschied hinsichtlich Frühkomplikationsrate und Patientenzufriedenheit besteht. Obwohl die Baseline-Ergebnismessungen geringere Werte bei der arthroskopischen Gruppe ergaben, haben sich beide Gruppen im Vergleich zum präoperativen Zustand bei der Verlaufskontrolle nach drei Monaten verbessert und weisen gleiche Werte auf. Nur die Werte für die Lebensqualität fallen bei der arthroskopischen Gruppe zu diesem Zeitpunkt bei Messung mit dem SF12-Fragebogen noch niedriger aus. Es wurden nur 4 geringfügige Komplikationen beobachtet, 2 in jeder Gruppe (Neuropathie und Hardware-Austausch). Wundinfektionen oder Störungen der Wundheilung wurden nicht festgestellt.

7. Wie die in Kapitel 2 und 3 behandelten Beobachtungsstudien zeigen, besteht eine Diskrepanz zwischen Patientenzufriedenheit und Outcome-Scores wie FFI und AOFAS. Obwohl die Patientenzufriedenheit sehr hoch war, zeigte sich an den Werten nur eine

geringe (aber signifikante) Verbesserung. In **Kapitel 8** wird zwecks Beantwortung von Frage 7 eine Studie zur Entwicklung und Evaluation eines erkrankungsspezifischen, auf Patientenangaben basierenden Instruments zur Bewertung der Versorgungsqualität für Patienten mit Osteoarthritis beschrieben.

Wir verwendeten die QUOTE-Methode (QUality Of care Through the patients' Eyes), um zu einem konsistenten, validen und zuverlässigen Outcome-Score zu kommen. Mit Hilfe von Patientenfokusgruppen kann ein Outcome-Score für jedes chirurgische Verfahren entwickelt werden, das sich auf die spezifische Pathologie bezieht, die die körperlichen Beschwerden verursacht. Dieses Konzept kann als Ergänzung zu den bereits verwendeten allgemeinen Outcome-Scores und PROMs dienen, jedoch mit dem Ziel, die Versorgungsqualität von Patienten in einer spezifischen Krankenhausumgebung zu verbessern. Die QUOTE-Methode für Osteoarthritis des Fußes bietet mehrere Items, mit denen die Versorgung dieser Patientengruppe in einem spezifischen Krankenhaus verbessert werden kann. Fortschritte lassen sich durch die Verbesserung der Versorgung in logistischer Hinsicht erzielen, etwa durch Verkürzung der Wartezeit bis zum Eingriff und genauere Information der Patienten über Komplikationen und geeignetes Schuhwerk. Die Qualität der Versorgung kann auch erhöht werden durch Erwartungsmanagement im Hinblick auf die Verbesserungen (oder genauer: deren Ausbleiben) in Bezug auf Rücken-, Hüft- und Knieschmerzen, die infolge der Fußoperation auftreten. Wichtig ist auch, den Erfolg der Operation anhand objektiverer Outcome-Scores zu überprüfen, um das angemessene chirurgische Verfahren auszuwählen und eine niedrige Komplikationsrate zu erreichen. Die QUOTE-Methode für Osteoarthritis des Fußes ist sehr zuverlässig und nützlich, wenn es um die Evaluation und Verbesserung der Versorgungsqualität geht. Dieses Instrument verbessert sich selbst durch regelmäßige Analyse und Einbeziehung von Patientenfokusgruppen. In unserer spezifischen Umgebung kann eine Erhöhung der Versorgungsqualität durch Verbesserung von deren Organisation, durch Erwartungsmanagement und Patientenaufklärung erzielt werden. **Kapitel 9** enthält eine Zusammenfassung der Kapitel der vorliegenden Doktorarbeit sowie eine allgemeine Diskussion mit Implikationen für die zukünftige Forschung.

ALLGEMEINE DISKUSSION UND ZUKÜNFTIGE FORSCHUNG:

Diagnostische Strategien

Obwohl - wie in allen Bereichen des Gesundheitswesens - eine gründliche medizinische Anamnese und körperliche Untersuchung sehr wertvolle Informationen liefern, sind zusätzliche diagnostische Tools zur Sicherung der Diagnose und Erstellung des Behandlungsplans unverzichtbar. Die präoperative radiologische Abklärung mit Röntgenuntersuchung und CT-Scanning, wie sie von den niederländischen Fuß- und

Sprunggelenkchirurgen angewendet wird, entspricht dem Konsens in der Literatur (Kapitel 4). Festgestellt wurde auch, dass bei der Überprüfung der Arthrodese der tarsalen Gelenke CT-Scanning nur angewendet wird, um die Diagnose der Nonunion zu bestätigen und stattdessen Röntgenuntersuchung der Standard ist. Diese Feststellung stimmt nicht mit dem in der Literatur bestehenden Konsens überein: Röntgenuntersuchungen sind ungenau. Versorgungsstandard sollte CT-Scanning sein. Postoperativ wird daher CT-Scanning anstatt Röntgen empfohlen, um die nach der Arthrodese erzielte Union zu beurteilen. In der Literatur besteht kein Konsens hinsichtlich anderer diagnostischer Untersuchungsmethoden wie MRT, Ultraschall und Knochenscan. Viele Artikel enthalten anekdotische Evidenz und Expertenmeinungen, aber nur schwache Evidenz, die diagnostische und therapeutische Strategien begründet. Diagnostische Injektionen in das Hüftgelenk werden als spezifischer, sensitiver Test angesehen [1]. Obwohl diagnostische Injektionen in Fuß und Sprunggelenk oft zur Anwendung kommen, hat sich der tatsächliche prädiktive Wert dieses Verfahrens bei Evaluation nicht bestätigt. (Kapitel 5). Zwar zeigten sich bei den Patienten gute Ergebnisse nach der Arthrodese, an einer Kontrollgruppe wurde jedoch deutlich, dass die Schmerzlinderung nach der Injektion keinen Hinweis auf ein gutes Operationsergebnis darstellte. Diese Feststellung wird auch in einer ähnlichen Studie zu Handgelenkinjektionen erwähnt [2]. Andere Studien in der Literatur, die von einem hohen Nutzen dieses Verfahrens bei Fuß- und Sprunggelenk berichten, sind unserer Ansicht nach verzerrt, da es keine Kontrollgruppe gibt [3,4]. Es kann keine klare Empfehlung für intraartikuläre Injektionen gegeben werden.

Behandlung

Die vorliegende Doktorarbeit fokussiert sich auf die Behandlung durch operative tarsale Arthrodese. Die Literatur berichtet von guten Ergebnissen nach tarsaler Arthrodese im Allgemeinen (Kapitel 2), aber leider gibt es wenig Evidenz dafür, welches Verfahren bei welcher spezifischen Diagnose angewendet werden sollte. Eine Prüfung der Literatur nach der Newcastle-Ottawa-Skala ergab drei günstige Kombinationen, die durch Synthese der besten Evidenz ermittelt wurden (Kapitel 6). Bei rheumatoider Arthritis zeigen talonavikulare und Triple-Arthrodese gute Ergebnisse. Bei posttraumatischer Arthritis ist subtalare Arthrodese eine gute Lösung, und es gibt in der Literatur Hinweise darauf, dass die arthroskopische Arthrodese bessere Ergebnisse erbringt als die offene Arthrodese [5,6]. Bei der Untersuchung einer Patientenkohorte nach Triple-Arthrodese überraschte die Feststellung, dass, obwohl die Patienten zufrieden waren, der validierte FFI-Wert (Foot Function Index) nur gering verbessert war. Auch das Konzept, dass ein Outcome-Score die Sensitivität und Spezifität für so verschiedene Diagnosen wie neurologische Beeinträchtigungen und rheumatoide Arthritis haben könnte, sollte neu bewertet werden (Kapitel 2). Obwohl Osteoarthritis des Sprunggelenks im Allgemeinen als eine Spätfolge tarsaler Arthrodese angesehen wird, trat OA bei der Verlaufskontrolle nach 7,5 Jahren

nicht verstärkt auf. Es wurde eine Korrelation zwischen guter Ausrichtung und einem stabilen, geringfügigen Grad von OA festgestellt (Kapitel 3).

Ergebnismessungen

Bei der in Kapitel 4 beschriebenen Diagnosestudie wurde festgestellt, dass erfahrene High-Volume-Chirurgen statistisch häufiger Ergebnisse kontinuierlich messen. Um die Versorgung von Patienten zu verbessern, die sich einer tarsalen Arthrodese unterziehen müssen, ist die kontinuierliche Messung der Ergebnisse von größter Wichtigkeit. Leider wird die Validität der meisten Outcome-Scores und PROMS in Frage gestellt und gibt Anlass zu Bedenken [7]. Eine vor kurzem durchgeführte systematische Prüfung ergab, dass es 139 spezifische klinische Outcome-Scores gibt, von denen nur 5 konsistent verwendet werden, wobei die ersten beiden Scores, AOFAS und VAS, nicht validiert oder nicht sensitiv genug sind. Hier wird die Notwendigkeit eines Paradigmenwechsels hin zu konsistenten, validen und zuverlässigen Instrumenten zur Messung der Ergebnisse betont, die breit eingesetzt werden können und klinisch aussagekräftig sind [8]. Das gegenwärtige Interesse an Patient Related Outcome Measurement (PROM) ist vielversprechend, denn lange war die Forschung auf den Forscher oder Arzt ausgerichtet, weniger auf den Patienten. Die Ansichten von Patienten und Ärzten zur Qualität der Gesundheitsversorgung bei Hüft- und Knieprothesen weichen voneinander ab [9,10]. Die Einbeziehung von Patienten bei Ergebnismessungen kann sich als großer Schritt vorwärts bei der Evaluation der Versorgungsqualität erweisen [11].

In unserem Bemühen, eine Patientenkohorte nach Triple-Arthrodese prospektiv zu überwachen, stellten wir fest, dass die Patientenzufriedenheit höher war als die durch den Foot Function Index angezeigte Verbesserung. In der vorliegenden Doktorarbeit wurde die QUOTE-Methode angewendet, um Patientenmeinungen in Instrumente zur Ergebnismessung bei tarsaler Arthrodese mit einzubeziehen. Die Tatsache, dass ein QUOTE-Instrument grundsätzlich spezifisch im Hinblick auf Diagnose, Intervention und Ort ist, macht es zu einem nützlichen Tool zur Verbesserung der Versorgung im Rahmen eines kontinuierlichen Prozesses. Es wurden neue, effiziente Punkte für die Versorgungsverbesserung generiert. Veränderungen in der Patientenlogistik, Patientenberatung und Erwartungsmanagement werden implementiert. Ein QUOTE-Score kann durch Wiederholung eines Fokusgruppentreffens nach der Analyse aktualisiert werden. Es sollte sich von selbst verstehen, dass ein QUOTE-Score zusätzlich zu objektiveren Outcome-Scores verwendet werden sollte und den Zweck verfolgt, die Versorgung zu verbessern (Kapitel 7).

Zukünftige Forschung

Basierend auf der vorliegenden Doktorarbeit könnten zukünftige Studien im diagnostischen Bereich ein Protokoll für Röntgenuntersuchungen umfassen, das

die Positionierung des Fußes beinhaltet, da dies die gemessenen Winkel signifikant verändert [12]. Auch der „Long Axial View“, der sich als dem Saltzman-View überlegen herausgestellt hat, sollte in Fällen von Fehlausrichtung des Rückfußes implementiert werden [13]. Eine Möglichkeit, die gewünschte Korrektur des Rückfußes intraoperativ zu überwachen, könnte in der Computer Assisted Orthopedic Surgery (CAOS) liegen, wie sie von Richter [14,15] beschrieben wurde. In diesem Bereich ist weitere Forschung notwendig. Interessant ist auch das Konzept, nach dem sich die Nachbehandlung dank standardmäßigem CT-Scanning nach der Arthrodese individuell anpassen ließe und die Zeit der Gipsimmobilisierung des Patienten verkürzt werden könnte [16]. Schließlich ist auch PET/CT und Spect/CT ein interessantes neues Verfahren bei der diagnostischen Abklärung tarsaler Arthrodesen. Weitere Forschung ist notwendig, um den Wert dieses hybriden (funktionellen und anatomischen) diagnostischen Verfahrens zu ermitteln und diesbezüglich einen Konsens in der Literatur zu erzielen [17].

Zukünftige Studien zur Behandlung der tarsalen Pathologie sollten unserer Ansicht nach große Patientengruppen umfassen, vorzugsweise einer diagnostischen Gruppe, die mit einem einzigen chirurgischen Verfahren nach einem gut beschriebenen Protokoll behandelt wird (Kapitel 5). Es wäre interessant, die weniger invasive Single-Arthrodese mit der Triple-Arthrodese und offene mit arthroskopischen Verfahren zur tarsalen Arthrodese zu vergleichen, wie es die OASIS-Studie tut (Kapitel 7). Wichtig ist auch die Entwicklung von subtalaren und talonavikularen Prothesen, die für Schmerzreduktion in Kombination mit funktioneller Verbesserung sorgen. Diese werden auch von Beimers [18] empfohlen.

Zukünftige Ergebnismessungen sollten sensitiver und spezifischer im Hinblick auf die zugrunde liegende Pathologie und die spezifische Behandlung sein und die Meinungen der Patienten berücksichtigen. Die Einbeziehung von Patientenfokusgruppen ist eine effiziente, zuverlässige Methode, um dies zu erreichen und neue Einblicke in die Qualität der Versorgung zu gewinnen (Kapitel 8). Wichtig für die Anstellung korrekter Vergleiche der verschiedenen Studien ist die zunehmende Verwendung validierter Outcome-Scores [8]. Differenzen zwischen Chirurgen und Patienten (meist sind die Chirurgen zufriedener als die Patienten), wie sie von Harris [10] beschrieben werden, können sich verringern, wenn die Ansichten der Patienten in höherem Maße in die Outcome-Scores mit einbezogen werden. Dies wird die Tendenz, Erfolge nach chirurgischen Eingriffen zu überschätzen, verringern, und zu weniger erfolglosen und somit unnötigen chirurgischen Eingriffen führen.

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ABOUT THE AUTHOR

Mark Stegeman was born and raised in the city of Oldenzaal, the Netherlands, on the 6th of June 1969. He attended the Twents Carmel Lyceum and graduated in 1987. During Medical School at the University of Amsterdam (1987-1996) he was accepted into a research internship (1989-1990) at the Artificial Heart Laboratory in Salt Lake City (supervisor Prof. Willem J. Kolff). He did his final internships in orthopedics and traumatology at the Onze Lieve Vrouwe Gasthuis in Amsterdam (Supervisor Prof. van der Eijken and dr. Luitse). In 1998 Orthopedic specialty training followed in the Rijnstate ziekenhuis in Arnhem (supervisor dr Feith and later dr Rijnberg), in the Sint Maartenskliniek in Nijmegen (supervisor dr. Pavlov and later dr. Wymenga) and in the Radboud University Medical Centre in Nijmegen (supervisor Prof. Veth). In April of 2004 Mark continued his training with a fellowship Foot and Ankle Surgery in the Sint Maartenskliniek (supervisor dr Louwerens) and in November he continued with an Arthroplasty fellowship in the same clinic (supervisor dr Spruit). In July of 2005 Mark was offered the opportunity to start a new clinic for the Sint Maartenskliniek in Woerden, the Netherlands. Since 2005 he has worked as an orthopedic surgeon in chief and head of the department of orthopedics, specialized in foot and ankle surgery and hip arthroplasty and revisions. In july of 2015 Mark gave up his management position in Woerden to fully concentrate on this thesis. Mark Stegeman is married to Jurgen Maurer and lives in Woerden, the Netherlands.