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ORIGINAL PAPER

Comparative study of outcomes after ankle arthrodesis shows higher complication rates in cases operated upon by general orthopaedic surgeons

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Abstract
Introduction A functional assessment of 38 patients after ankle arthrodesis for the evaluation of the necessity of surgeons-specialisation was carried out by means of clinical evaluation and gait analysis after an average follow up of 30 months.
Methods Scores were used to grade ankle function. Gate analysis was examined to determine the effect of arthrodesis on the ankle in relation to the surgeons' experience. Under conditions of normal daily living, we found significant differences in life quality between patients operated upon by experts in orthopaedic foot and ankle surgery (group A) and patients operated by general orthopaedic surgeons (group B).
Results All patients in group A had orthograde stance. Wrong screw positioning and a failed neutral tibio-talar position were the main problems in group B. Due to this, the re-operation rate was 10%.
Conclusion Our findings may have implications for surgical training programs and for regionalisation of complex surgical procedures.

Keywords Upper ankle osteoarthritis · Upper ankle arthrodesis · Specialist · Non specialist

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Introduction

Progressive joint destruction goes along with lower quality of life. Arthrodesis is an established method to treat severe osteoarthritis of the ankle. Patients are reintegrated into a normal and fluid gait pattern [1]. There are very successful long-term results [2, 3]. No series has yet evaluated the effect of surgeons specialisation on the outcome in ankle arthrodesis.

Is specialisation necessary to prevent complications after ankle arthrodesis? Salzmann et al. report about surgeons' training in the context of complications after primary total ankle arthroplasty [4]. There were three groups with differently trained surgeons. The peri-operative records of the first ten cases of every surgeon were reviewed. The results showed that no training method had a statistically demonstrable positive impact preparing surgeons for total ankle replacement.

Haskell et al. reported that a decrease in peri-operative complication rate went along with surgeons experience in total ankle replacement [5].

There is no significant data in arthrodesis surgery regarding the surgeons' expertise [6]. Callahan et al. reviewed the relationship between volume of surgical procedures and in-hospital mortality in gastrectomy and colectomy patients [7]. The results showed a substantially lower risk-adjusted

mortality when the surgery was performed by subspecialty interested and trained surgeons.

This study presents a mid-term follow up of patients after ankle arthrodesis in which we assessed the need for surgeons who specialise in foot and ankle surgery.

Material and methods

A retrospective review of patients with isolated primary ankle arthrodesis between 2009 and 2012 was undertaken. Patients had conservative treatment before surgery. The study was conducted in accordance with the Declaration of Helsinki and the guidelines for Good Clinical Practice. Informed consent was obtained from all patients. The follow up was performed by independent observers.

We compared two cohorts with a total of 38 patients (A:B = 18:20) with 38 feet. The first cohort (A) included 18 patients (5 men/13 women) with a mean age of 59.9 years (range, 40–75 years) and a mean BMI of 27.94 ± 3.56. This group was treated by a specialist (HJT). The second cohort included 20 patients (m:w = 8:12) treated by nine general orthopaedic surgeons. Mean age was 63.6 years (range, 41–80 years) and the mean BMI was 30.98 ± 4.47. The mean follow up time was A : B = 59.94 ± 9.084 : 63.68 ± 10.667 months.

The clinical evaluation was based on an interview and physical examination. In order to evaluate the results we used the American Orthopaedic Foot and Ankle Score, despite its limitations and drawbacks [8]. Because of the patient's lack of ankle motion, the maximum reachable score was 90. The contralateral foot was used as a control. Special attention was paid to varus/valgus deformity, pes equinus and talipes calcaneus. We also examined the difference in operating time. Radiographs included weight-bearing anterior-posterior views with the leg in 20 degrees internal rotation, and lateral weight-bearing views of both entire feet to measure the exact position of the fusion with the help of the tibio-talar angle (centre tibia-centre talus) [9].

The follow-up examination was performed by two independent investigators, who were not involved in the primary treatment. The radiographs were interpreted by one investigator. For additional data a pedobarography was performed.

All pedobarographic measurements were captured with an emed®-x400 platform by Novel GmbH, Munich, Germany. Measurements were done on ground level at normal gait. The mid-gait-method was used and three measurements of every foot were taken [10]. The measurements were processed with the emed-software. The foot was divided into ten areas in which the following measurements were taken: contact area, pressure time integral, peak pressure and maximum mean pressure. For a normal example see Fig. 1.

It is mandatory to consider comorbidities [4, 11, 12], which are listed in Table 1. Patients in group A were advised to stop smoking at least three weeks preoperativly and to stop taking non-steroidal anti-rheumatics. It is not documented sufficiently if this advice was given to patients in group B.

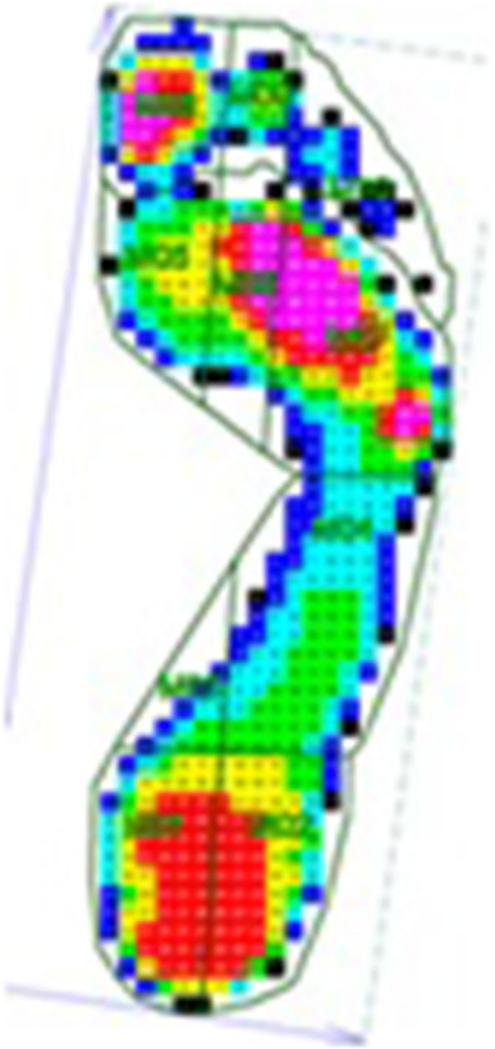

Fig. 1 The foot was separated into ten areas. M01: medial calcaneus, M02: lateral calcaneus, M03: medial midfoot, M04: lateral midfoot, M05: medial forefoot, M06: forefoot central, M07: lateral forefoot, M08: great toe, M09: second toe, M10: third-fifth toe

Surgical technique and mobilisation

The senior author (HJT) used an anterior approach. After the joint preparation, the surfaces were fixated in neutral position by three 7.3 mm (Synthes) or 6.7 mm (Arthrex) self-cutting screws. Two screws were inserted at 30° from the medial malleolus, and the third from the anterolateral tibia into the postero-lateral talus [9]. The procedure was undertaken without a tourniquet.

A below-knee split cast was applied until swelling resided. Without weight-bearing a closed knee cast was tied for one week. A clinical control and re-casting was performed after two weeks. Patients were then allowed to walk half weight-bearing. Four weeks after surgery, patients were

Table 1 Documented comorbidities of the two groups at the time of operation

Group A	Number of patients affected	Group B	Number of patients affected
Arterial hypertonia	8	Arterial hypertonia	6
Nicotine abuse	2	Nicotine abuse	5
Diabetes mellitus	1	Osteoporosis	4
Thyroid disease	1	Thyroid disease	4
Pace maker	1	Diabetes mellitus	2
AVN talus	1	Chronic cardiac dysfunction	1
PCP	1	Rheumatoid arthritis	1
Breast cancer	1	Hyper-uricaemia	1
		St.p. pulmonary embolism	1
		St.p. lower limb thrombosis	1
		Depression	1

allowed to walk fully weight-bearing. Radiographs, a clinical control and cast removal were done eight weeks post-operatively. Rehabilitation started ten weeks after surgery. The training sessions were performed once a week for a total of six weeks.

In group B we found a multitude of surgical techniques. Nine different surgeons used an anterior approach 16 times, and lateral four times. A two-screw fixation was done in 14 cases, three screws were used in four patients and four screws in two cases (Table 2). A tourniquet was applied in all cases.

The post-operative procedure was up to the surgeon. A below-knee split cast was made in the operating room. The minimum cast-time in group B was eight weeks in 11 patients, four weeks non weight-bearing, and four weeks in fully weight-bearing. Seven patients had six weeks casting without weight-bearing and six weeks fully weight-bearing. The maximum cast-time was more than 12 weeks, individually adapted to the radiographic and clinical findings.

Results

Radiographs showed an average 89° ± 2.3 tibio-talar angle (range, 86–100°) in group A. Three patients had a mild varus in 92° ± 1.2 (range, 89–93°). No valgus malposition was found. The mean operating time was 53.33 minutes.

Low volume surgeons (B) failed the 90° tibiotalar-position in 15 patients (75%). Correct positioning was achieved in 25% (Fig. 2). The mean tibio-talar angle in group B was 98° ± 5.2 (range, 82–110°). In the AP view we found five varus fixations in an average of 95.8° ± 5.8 (range, 92–97°) as well as valgus position (4) in an average of 84.2° ± 12.5 (range, 75–88°). Pes equinus was found in six patients (30%) in an average 78.8° ± 11.2 (range, 75–87°). The operation was longer than in the expert group, requiring on average 126.71 minutes. The average angle between tibia and bottom plate was 82°.

In the pedobarographic analysis, the instant of maximum force was reached significantly later (p = 0.000–0.002) in group B and the force time integral was significantly higher in this group (p = 0.002–0.027). That suggests a more fluid gait pattern in group A. All other pedobarographic parameters showed no significant differences, but difference tendencies (instant of maximum force [M10, p = 0.064] and force time integral [M7/9, p = 0.074 and 0.071]). A complete list of the p-values for every parameter can be found in Table 3.

There was no significant difference in the AOFAS. The mean AOFAS for group A was 78.78 and for group B 75.40 (p = 0.106).

All patients in group A were mobile in normal shoes. Ten patients in group B were able to walk in normal shoes, five had insoles, four wore orthotics and one patient was mobile with a modified shoe sole.

In group A we found following complications: one superficial wound healing problem, one screw removal because of skin irritation, and four subsequent sub-talar osteoarthritis.

Table 2 Screw positioning

Screw position	Number of cases
Medial lateral/lateral medial	8
Ventral dorsal/medial lateral	3
Parallel medial lateral	3
Crossed lateral medial	2
Ventral dorsal/dorsal ventral	2
Ventral dorsal/lateral medial	1
Parallel ventral dorsal	1

The choice of screw position varied immensely in group B as shown in this table

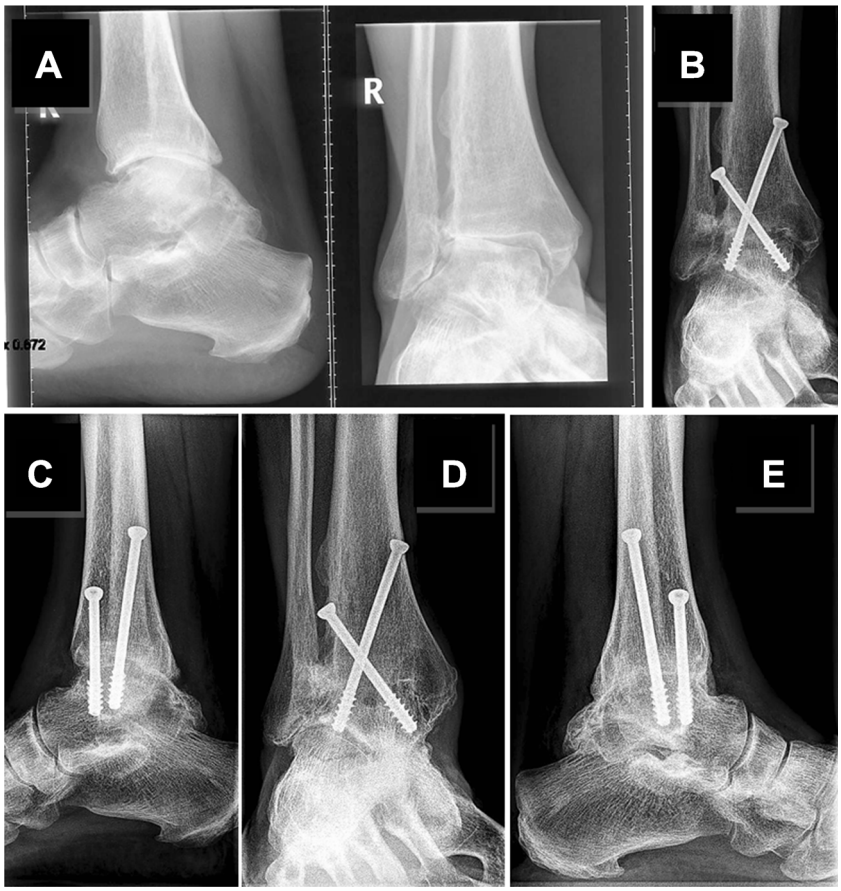

Fig. 2 One of our best cases shows pre-operativley (**a**) a valgus and advanced arthrosis in both levels. Post-operatively (**b,c**) a tibio-talar angle of 90° can be measured and the patient shows adequate bony healing. At the latest follow-up (**d,e**) the ankle is still in a good position

One patient with subtalar osteoarthritis received a tibio-talo-calcanear arthrodesis with a TTC-Nail resulting in a total of two revisions (one rearthrodesis and one screw removal) done in group A.

The main problem in group B was a failed neutral position (9 patients, 45%; see above). Eight patients (40%) had subsequent arthrosis because of incorrect screw insertion or length and extension into the sub-talar joint. Eight patients developed a painful calcaneal spur (40%). Two patients had further operations. One revision was made because of non-union and was done by a different approach (lateral) with a tibio-talo-calcanear arthrodesis (retrograde TTC-Nail). The other patient received a ventral tibio-talar plate and a screw-fixed subtalar arthrodesis because of subsequent arthrosis. Another unsuccessful case, with the urgent need for experts in foot and ankle surgery, is described in Fig. 3.

Table 3 P-values of the t-test of every region of every parameter of interest during pedobarography

Parameter	Force-time integral	Pressure-time integral	Peak pressure	Instant of max. force	Max. mean pressure
Total	0,007	0,480	0,483	0,002	0,278
M1	0,002	0,122	0,478	0,000	0,490
M2	0,023	0,111	0,565	0,000	0,606
M3	0,661	0,988	0,353	0,007	0,399
M4	0,724	0,964	0,234	0,001	0,066
M5	0,07	0,740	0,865	0,000	0,530
M6	0,026	0,556	0,728	0,000	0,657
M7	0,071	0,815	0,104	0,002	0,139
M8	0,028	0,374	0,293	0,003	0,983
M9	0,094	0,240	0,754	0,000	0,723
M10	0,010	0,146	0,649	0,064	0,684

The significant values are reported in the text

Fig. 3 One of the worst cases shows pre-operatively (**a**) an advanced equinus deformity, tibial spurs, 15° varus and severe upper ankle arthrosis. Post-operatively (**b**) it is evident that the equinus malformation was not correctly adjusted. The varus persists as well. The lateral screw is too long. At the longest follow-up (**c**) the position of the foot has not changed and we see the effect of the malposition in the subtalar joint

Discussion

Previous studies have shown that ankle arthrodesis is a promising method to treat severe osteoarthrosis [1, 2, 13]. There is no evidence related to the need for surgeons specialisation in foot and ankle surgery. Because of divergent results after ankle arthrodesis in our hospital, we asked if specialisation leads to a better outcome. We compared two cohorts after ankle arthrodesis: surgery done by experts (group A) versus non-experts (group B).

We evaluated the clinical results with the help of the AOFAS, as well as the radiographic and pedobarographic outcome. We found no significant difference in the AOFAS more than two years after surgery. Quality of life was slightly reduced in group B.

Since we observed tendencies, especially in post-operative malalignement, we have to consider the AOFAS as the best tool available to evaluate all required topics. Madeley et al. reported the AOFAS as the most common score in foot surgery, but not satisfactorily tested for its reliability or validity [14].

The operation aims to fixate the ankle joint in a neutral position to reintegrate the patient into pain-free everyday life [15]. As Kristen et al. reported, the 90° tibio-talar position is a precondition to restore a pain-free and fluid gait. The anterior approach allows a good overview, a complete cartilage removal and correct tibio-talar positioning. The use of three screws, two positioned from the medial malleolus to the lateral talus, and one screw from the ventral tibia to the dorsal talus, is the optimal method to fix the arthrodesis [9]. Oglivie et al. described a profitable compression with the three-screw method [16]. This confirms our results. We found a variety of fixation methods in the non experts group which supposedly led to the higher complication rate.

Nine patients in group B had axis deviation (varus, valgus) (45%). Additionally, we could find pes equinus in six patients (30%). Calcaneal spur might be the consequence of incorrect foot positioning and inadequate overload of the plantar fascia. To our knowledge there is no study on this matter and it should be considered for further research. These physical complications are not necessarily combined with reduced well-being or reduced activity in everyday life, as the AOFAS showed.

In 2015, Schwienbacher et al. reported on 24 patients that underwent ankle arthrodesis (TAA; 12 patients) or another joint arthrodesis (12 patients) in comparison to a control group without any pathology. Several components of car driving reactions were examined in a driving simulator. It was shown that driving and emergency break use were impaired after ankle arthrodesis [17]. This could be seen as an example of an operation influencing everyday life.

Pedobarography is an essential tool in foot surgery. We focused on contact area, force time integral, pressure time integral, peak pressure, instant of maximum force and maximum mean pressure. We could find a significant difference in the instant of maximum force ($p = 0.000–0.002$) and force time integral ($p = 0.002–0.027$). It is surprising that, despite the reported axis deviation, all other pedobarographic results were not significantly different. Despite our results when comparing pedobarographic parameters, it is proven that a 90° tibio talar fixation leads to best pedobarographic outcome [18]. So, are all these pedobarographic parameters necessary for a meaningful statement? Frigg et al. reported that pedobarographic parameters after ankle arthrodesis can be reduced to the interpretation of the midfoot index of load and the evaluation of the force/pressure time [19]. In their opinion, these parameters give the most information about foot function.

The operation time in group A was an average 74 minutes shorter than in group B. There is hardly any data about this topic.

Specialists, in contrast to surgeons in the non specialist group, did not use a tourniquet in any patient. In a meta-analysis Smith and Hing concluded that surgery without it has the following advantages: patients could leave hospital earlier, had a significantly less painful post-operative period and experienced less swelling [20]. Additionally, the risk of wound infection and deep veinous thrombosis rises with the use of a tourniquet. The specialist group had favourable results but it is not possible to link these to the decision not to use a tourniquet because we didn't encounter complications suggesting the tourniquet as the problem (such as veinous thrombosis). We conclude that a tourniquet should only be used if necessary to avoid the risk of additional complications but does not seem to have a negative effect on the outcome.

It always has to be considered if total ankle replacement (TAR) is an alternative for the patients. A restrospective long-term study in 2000–2012 compared TAR with TAA. Braito et al. evaluated 141 patients that underwent TAR (101 patients) or TAA (40 patients). Fourteen patients who received TAR had additional hindfoot arthrodesis. Post-operatively, there was no significant difference between the three groups in the AOFAS. Besides that, there was improvement in terms of subjective symptoms, activity, sports and quality of life, again without significant differences. But the kinematic analysis showed that TAA leads to hyperextension of the knee and increased stress on the adjacent hindfoot joints. The consequence is major osteoarthritis in these joints [21].

Kim et al. also did not find significant differences in the AOFAS score, comparing TAR and AAD [22].

Limited functional gains [21] and high complication rate [22] after TAR however put this technique into question.

Limitations

Our study was limited by its lack of intermediate radiographic follow-up data for group B. We did not have pre-operative data concerning radiographs and pedobarography.

Conclusion

This study shows the excellent results in patients who underwent treatment by experts in foot and ankle surgery. Operation time was half the duration low-volume surgeons needed, and the operating methods as well as the follow up were performed under uniform rules in a standardised procedure.

This is why we advocate that foot and ankle surgery, especially hind foot reconstruction, requires experts.

Compliance with ethical standards

Conflict of interest All authors declare that there is no conflict of interest.

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