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Clinical Outcome and Gait Analysis of Ankle Arthrodesis

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ABSTRACT

Background: **The purpose of our study was to describe and analyze the functional outcomes of mid-term followup patients with ankle arthrodesis.** ***Methods:*** **Twenty patients who had an isolated ankle arthrodesis were followed for a mean of 3 years after surgery. We performed physical and functional examination, radiographic examination and CT scan. Each completed standardized, self-reported outcome questionnaires SF-36, AOFAS and Mazur scores. All subjects were evaluated with a kinetic and kinematic gait analysis and a plantar pressure study.** ***Results:*** **Only one patient used a cane and seven patients required an insole to walk. We observed no relation between the scores obtained. Most of the patients showed good functional results and poor life quality scores. The joints that were significantly more degenerated were the Chopart and the subtalar joints, which were affected in 16 patients in the fused limb. The kinematic parameters showed compensatory motion in the neighboring joints and the kinetic parameters studied were similar in the arthrodesis limb and the control limb. There was no significant difference between the arthrodesis limb and the contralateral limb for plantar pressures.** ***Conclusion:*** **Although ankle arthrodesis will help to relieve pain and to improve overall function, it is considered to be a salvage procedure that causes persistent alterations in gait, with the possible development of symptomatic osteoarthritis in the other joints of the foot. Patients and treating physicians should also expect overall pain and functional limitations to increase over time.**

Level of Evidence: IV, Case Series

Key Words: Foot; Ankle; Arthrodesis; Gait; Pressure

INTRODUCTION

Symptomatic osteoarthritis of the ankle is a difficult clinical problem. Treatment options include the use of walking aids, orthotic devices, intra-articular steroids, arthroscopic debridement, periarticular osteotomy and arthroplasty. Ankle arthrodesis is still the primary treatment for disabling arthritis of the ankle that does not respond to conservative treatment.[14] Although ankle arthroplasty has been used to treat such patients, variable results have been reported and the traditional operative treatment for ankle osteoarthritis has been tibiotalar arthrodesis. Specific indications have expanded through the years but general principles remain which include correction of deformity, prevention of instability and alleviation of pain.[2,26,34] In spite of its popularity, there are disadvantages to arthrodesis including prolonged immobilization, potential for pseudoarthrosis and altered stress on the neighboring joints.[2,18,22,42]

Many reports have suggested that ankle arthrodesis reliably provides a painless, plantigrade, stable foot. These reports consist of retrospective clinical reviews with a short to mid-term followup period. Thomas et al.[35] concluded that arthrodesis for the treatment of end-stage ankle arthritis reliably relieves pain and produces good patient satisfaction, although it causes alterations in gait with a potential for deterioration due to the development of ipsilateral hindfoot arthritis. Our working hypothesis was that arthrodesis of the ankle eliminates pain and allows greater activity and a higher quality of life. The purpose of the present study was therefore to describe and analyze the functional outcomes of mid-term followup patients with ankle arthrodesis.

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PATIENTS AND METHODS

The present study was performed with the approval of the Research Ethics Board of our institutions and all participants signed an informed-consent form. A manual search identified 55 patients who had undergone ankle arthrodesis at our institution in the last 10 years. Exclusion criteria included another arthrodesis of the midfoot or hindfoot, rheumatoid arthritis, poliomyelitis, congenital deformity, Charcot joint or prosthesis in either lower limb.[20] patients treated at our institution who met the inclusion criteria were included in the study. All of the patients were workers who had suffered a workplace accident.

The mean age at the beginning of the study was 40 (range, 26 to 54) years, their mean weight was 89 (range, 54 to 117) kg, and there were 17 males and three females. The mean duration of followup was 3 (range, 2 to 9) years. The etiology of the ankle arthritis in all patients was post-traumatic. The leading causes of ankle arthritis were 13 tibial plafond fractures, six bimalleolar fractures, and one osteochondritis dissecans. Open reduction and internal fixation was performed in 19 patients and external fixation in one patient. The mean time from the first procedure to the arthrodesis was 39 (range, 6 to 204) months. The mean time of followup was 3 (range, 2 to 9) years.

The subjects were evaluated by the same physician (AFS). At the time of the latest followup, all subjects were personally interviewed about pain and overall function of the lower limbs and a complete physical examination was performed including knee and hindfoot alignment; range of motion of the knees, ankle and subtalar joints. Circumferential measurements were made from the widest diameter of both calves. Instability of the medial side of the knee was recorded in three grades and also the presence of recurvatum.

The visual analogy scale (VAS) was used in order to quantify the pain over the peroneal tendons and the subtalar joint. In addition, use of crutches, shoe modifications, smoking habits and inflammatory signs were recorded. All twenty patients completed the SF 36, AOFAS and Mazur et al (23) questionnaires. The SF-36 (Spanish version 1.4) (June 1999) (© 1995 Medical Outcomes Trust) is a reliable and validated scoring system to measure quality of life. It measures health in seven dimensions (physical functioning, role limitations, social functioning, bodily pain, mental health, vitality, and general health perception). The American Orthopaedic Foot and Ankle Society (AOFAS) Ankle Hindfoot Scale[16] measures subjective and objective factors on numerical scales to describe function, alignment and pain. Mazur et al.[23] developed a commonly accepted archetypal score in this area. This scores patients out of 100 points, with 50 for pain, 40 for function, and 10 for range of movement. It is based on the Harris Hip score and all subsequent commonly used ankle scores have followed a similar structure.

At the time of latest followup, all patients underwent radiographic examination that included bilateral AP and lateral radiographs of the foot, , bilateral mortise radiographs of the ankle and bilateral AP and lateral radiographs of the knee. We measured the position of the fusion and graded the osteoarthritis seen on each radiograph in the subtalar, talonavicular and calcaneocuboid joints. A CT scan was subsequently performed (Philips Aquilion Super 4) to confirm the consolidation of the arthrodesis and the presence of subsequent changes in the intertarsal joints. The tibiotalar angle (the angle formed by the longitudinal axes of the tibia and the talus) was determined on the standing lateral radiographs of the ankle and the foot.

Gait analysis

The gait analysis included plantar pressure distribution, kinematic motion analysis and kinetic analysis. The biomechanical parameters of the control group (contralateral healthy limb) and arthrodesis group (arthrodesis limb) were compared.

The plantar pressure distribution was studied with a pedobarographic platform (Emed, NOVEL, Germany). We collected data in barefoot static and dynamic position bilaterally. Patients were asked to walk back and forth at a self-selected velocity along the walkway to become familiar with the surroundings. In each condition, three trials were recorded and averaged for analysis.

Kinematic data were collected with a motion analysis system (CLIMA , STT, San Sebastian, Spain). Reflective markers were placed on anatomic landmarks, as described by Kadaba et al.[13] A knee alignment device was used to set the knee flexion axis during static recording. Three dimensional marker trajectories were used to determine joint angles in the sagittal (dorsiflexion-plantarflexion), coronal (inversion-eversion or varus-valgus), and transverse (external-internal or abduction-adduction) planes. Three markers were used at the foot. One was placed on the lateral malleolus (ankle marker), one on the heel and one on the dorsal surface of the foot over the second metatarsal head (the "toe" marker). Before data collection, patients were asked to perform two or three strides over the platform. The parameters obtained were double stance percentage, cadence (step/sec), speed (m/sec), stride and step length (mm). Additionally, we obtained lower extremity support time (sec) left / right, the range of motion (ROM) of hip, knee and ankle right and left (degrees), pelvic tilt left / right (degrees), hip abduction right / left (degrees) and pelvic obliquity left / right (degrees).

The kinetic parameters or ground reaction forces (GRF) were recorded using two, 90 x 60 cm, force platforms (Kistler, Winthertur, Switzerland) that were placed one in front of another. Patients were asked to walk barefoot five times over the platform. The highest force of the steps in each trial was chosen for the data analysis. We measured pressure (KPa), force (N), area (mm) and support time (msec) of both feet. Measures were standardized by height and weight of each patient. In the data analysis we mainly focused on pressures as the formula for this includes force between

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areas. We evaluated the entire foot and divided it into six anatomical regions: hindfoot, midfoot, forefoot (medial, middle and lateral) and the hallux. We studied the axial and anterior - posterior forces during barefoot walking for both extremities (Figure 1). Other parameters studied were single limb support (during gait cycle), stance phase time, double support and time to force change (when force was equal to 0 N).

Surgical technique

In 19 patients the arthrodesis was performed with 6.5-mm cannulated compression screws through an anterior approach. A transfibular osteotomy was performed in all cases. In nine cases we used autologous crest bone graft. The tibio-fibula syndesmosis fusion was performed by denuding the cartilage of the distal third of the fibula and securing it to the talus and the tibia with compression screws. Decortication was performed with a chisel. The fibula was attached to the distal part of the tibia with two cortical screws. Only in one patient was the fusion performed with external fixation. After the surgery all patients were immobilized with a knee cast for 3 months. Partial to full weightbearing was encouraged after 2 months when radiographic findings allowed it. The mean radiographic time to onset of visible fusion was 3 months.

We had two cases of superficial infection, which subsided with debridement, oral antibiotic treatment and the need for

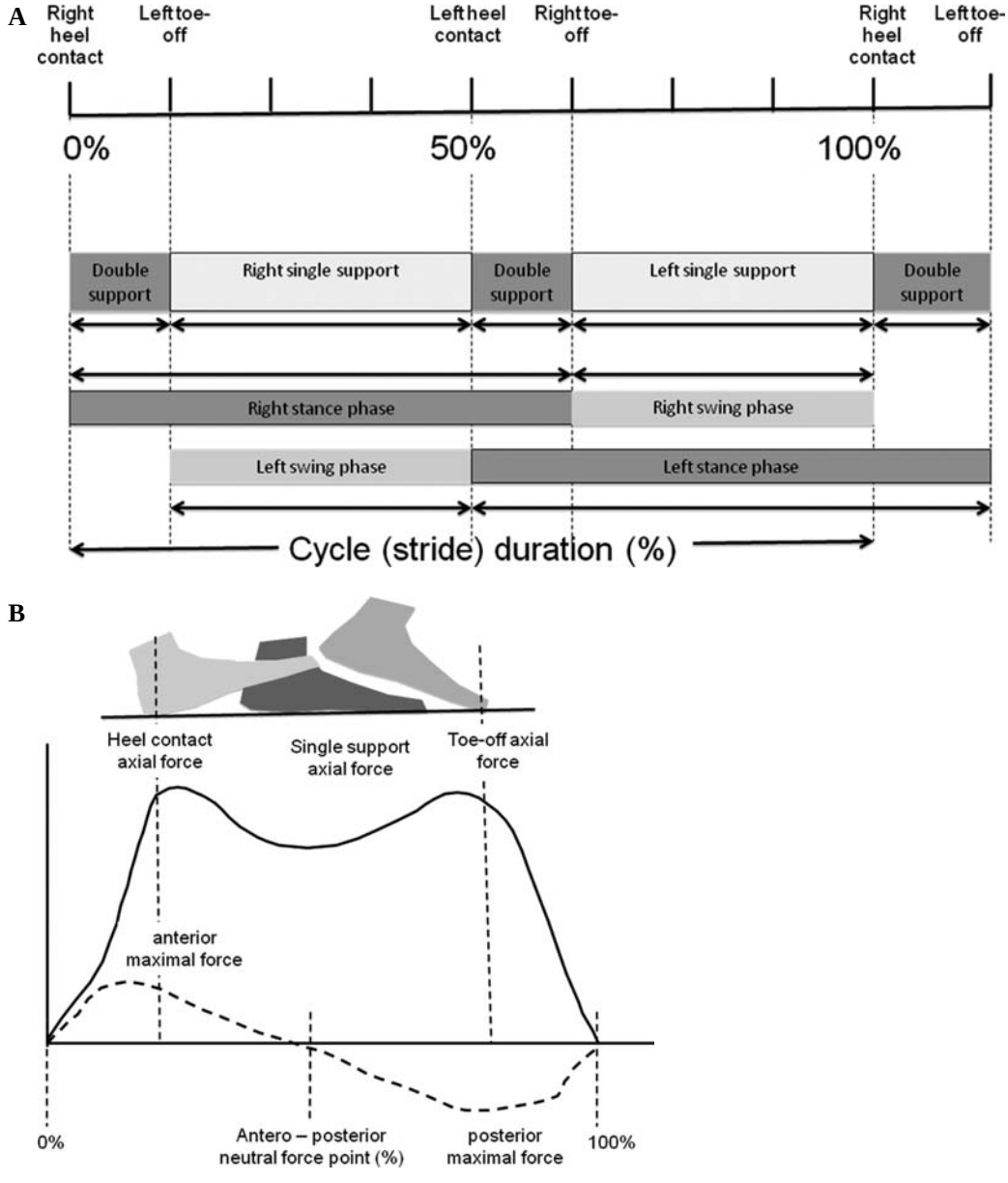

Fig. 1: **A**, Walking cycle divided in percentage. **B**, Kinetic graphic during step walking.

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skin grafting. One patient required iliac crest cancellous bone graft and in one case we had to perform re-arthrodesis. The hardware was removed in three patients and one patient required a subtalar arthrodesis.

Statistical analysis

Before we performed the study, a power analysis was done to determine adequate sample size. A Mann-Whitney test was used to compare the biomechanical parameters of the control group (contralateral healthy limb) and arthrodesis group (arthrodesis limb). Differences were considered significant when the p value was less than 0.05.

RESULTS

The majority of the patients did not use any support for walking (95%), only one patient used a cane. Seven patients required (35%) an insole to walk more comfortably. Sixteen patients (80%) had tenderness and swelling in the hindfoot. Six patients (30%) showed hyperkeratosis on the arthrodesis limb requiring periodic debridement. These hyperkeratosis were mainly located over the fifth metatarsal, the internal plantar arch of the foot, the first metatarsal head, the lateral aspect of the calcaneus and the fourth proximal interphalangeal joint. The mean difference of calf diameter between the arthrodesis limb and the contralateral limb was 2 (range, -4 to $+2$) cm. Two patients reported pain over the distal insertion of the medial collateral ligament of the ipsilateral knee and one in the contralateral knee.

The scores obtained in the specific questionnaires were worse than the SF-36 score. Most of the patients showed good functional results and poor quality of life scores and only one patient showed extremely low scores on the functional scales and high scores on the SF-36.

Only one patient reported instability in the sagittal plane. The mean inversion was 6 (range, 0 to 18) degrees, the mean eversion was 5 (range, 0 to 20) degrees and the mean external rotation was 6 (range, 5 to 10) degrees. Six patients showed a similar range of rotation of the arthrodesis limb and the contralateral limb, and 11 patients had a mean of 8 degrees of internal rotation of the arthrodesis limb. The range of motion of the Chopart joint in the coronal plane was 10 (range, 0 to 30) degrees, 6 degrees of plantarflexion (range, 0 to 30 degrees) and 4 degrees of dorsiflexion (range, 0 to 10 degrees). Six patients had 1.25 cm of limb shortening (range, 0.5 to 2 cm) of the arthrodesis limb.

Radiographic findings

The mean tibiotalar angle on the fused side, measured on a standing lateral radiograph of the foot and ankle, was 110 (range, 105 to 115) degrees (Figure 2). It tended to be higher in the healthy foot and more flattened on the arthrodesis foot.

Sixteen of the patients presented neutral values (0 degrees) or slightly valgus on the hindfoot alignment radiograph.

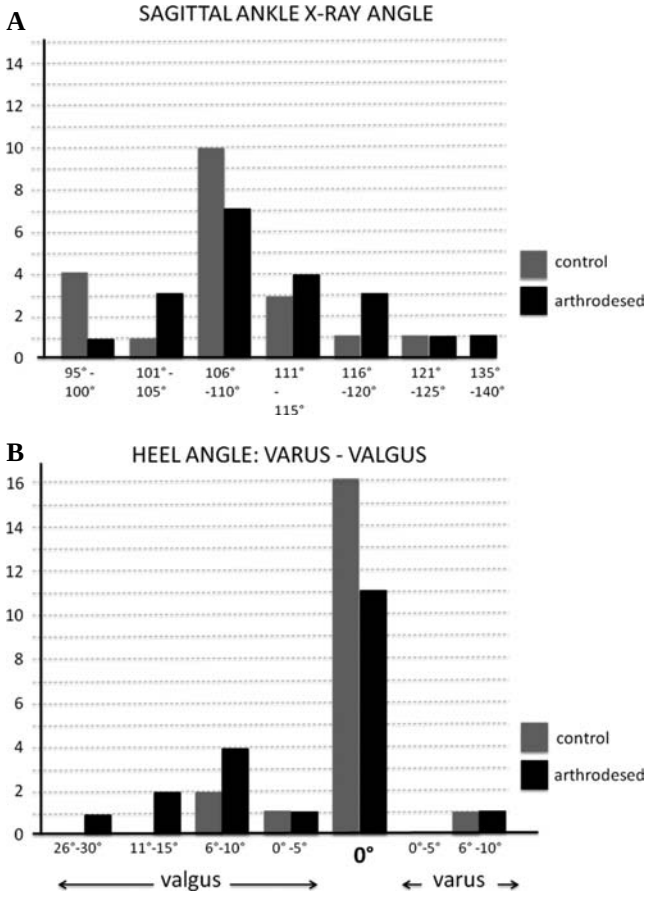

Fig. 2: **A**, Sagittal ankle X-ray angle. The arthrodesis foot tends to be fused in more equinus than the contralateral foot. **B**, Hindfoot angle distribution. The arthrodesis foot is fused in more valgus than the contralateral side.

Likewise, the calcaneotibial angle on the hindfoot alignment radiograph was situated between 6 and 10 degrees of valgus in four patients, over 11 degrees of valgus in three patients and over 26 degrees of valgus in one patient (Figure 2). Only one patient had varus alignment on the arthrodesis limb, but it was also present in the contralateral limb.

The joints that were significantly more degenerated were the Chopart and the subtalar joints, which were affected in 16 patients in the arthrodesis limb. Only one patient showed degenerative changes in the Chopart joint on the contralateral side. We observed that 95% of patients showed successful fusion by CT scan.

Gait analysis

The kinematic parameters showed a pattern of compensatory motion in the neighboring joints. In fact, the arthrodesis ankle in the sagittal plane had significant decrease in range of motion compared to the contralateral side ($p = 0.001$) (Table 1) (Figure 3). There were no significant differences between the arthrodesis limb and the contralateral side with regard to the range of motion of the pelvis or the knee joint. We observed that all the kinetic parameters studied were very similar in the arthrodesis

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Table 1: Kinematic Results Between Fused and Control Lower Extremities

	Control		Fused	
	Mean	**SD**	**Mean**	**SD**
Support time (sec)	0.8	0.1	0.8	0.1
Hip ( )	46.2	11.2	44.9	12.4
Knee ( )	65.89	10.1	64.7	7.7
Ankle ( )	20.1	5.4	15.0	3.0
Pelvis inclination ( )	6.2	3.8	5.6	3.1
Hip abduction ( )	12.7	6.3	11.5	4.6
Pelvis oblicuity ( )	7.0	4.9	6.9	4.7

, $p < 0.001$.

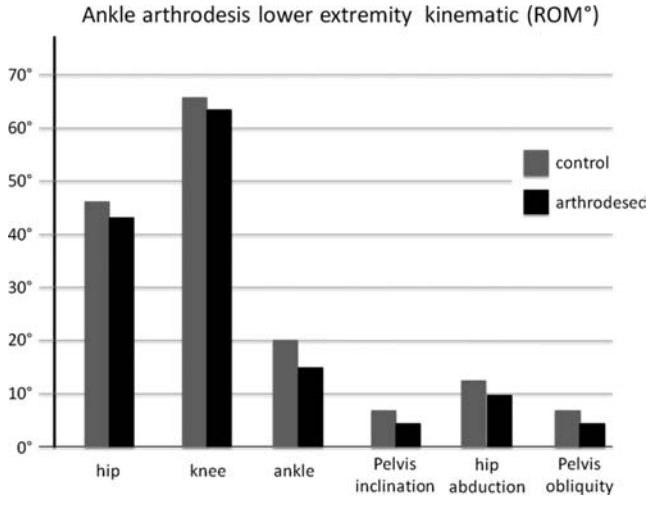

Fig. 3: Arthrodesis and contralateral foot ROM (degrees), during walking. We did not observe differences in ROM (degrees) of joints of the arthrodesis foot and contralateral healthy side.

limb and the contralateral limb (Table 2). We did not observe differences in the axial forces, or in the anterior-posterior forces (expressed as percentage) ($p > 0.05$). The percentage of single limb support of the arthrodesis limb was 58.5% (of the gait cycle) and 56.2% (of the gait cycle) in the contralateral side ($p > 0.05$). The double support was 14.3% of the cycle. The switching force point (when force is equal to 0 N) from anterior to posterior occurred in 50.4% (SD, 9.8) of the arthrodesis limb and in 41.7% (SD, 12.4) of the contralateral feet ($p = 0.067$) (Figure 4).

In the analysis of plantar pressures, there was no significant difference between the arthrodesis limb and the contralateral side, despite the fact that the statistical analysis showed a decrease in total pressure, force and total area in the arthrodesis limb. In contrast, the stance phase pressure was found to be higher in the arthrodesis limb (Table 4). We observed a decrease in the hindfoot and hallux pressures in the arthrodesis limb ($p > 0.05$); in contrast, the midfoot pressure was increased (Table 5) ($p > 0.05$). The decrease in hindfoot pressure of the arthrodesis limb responded to a similar decrease in parameters of force and area, though the increase in midfoot pressure of the arthrodesis limb responded to an increase in force and a decreased area. The forefoot pressure of the arthrodesis limb was higher than in the contralateral side ($p > 0.05$). The medial and central pressure of the forefoot in the arthrodesis side were higher than in the contralateral limb (Table 4). In contrast,

Table 2: Walking Kinetic Results (N) in Fused and Control Foot

	Control		Fused	
	Mean	**SD**	**Mean**	**SD**
Vertical force heel contact (N)	956.7	216.7	952.9	223.54
Vertical force single support (N)	736.8	165.8	717.9	149.2
Vertical toe off force (N)	939.7	191.9	939.2	186.9
Maximum anterior force (N)	125.5	55.2	116.1	50.9
Maximum posterior force (N)	148.9	48.2	147.3	51.0
Single support (%)	58.5	9.8	56.2	3.4
Change anterior to posterior forces (%)	50.4	9.7	41.7	12.4

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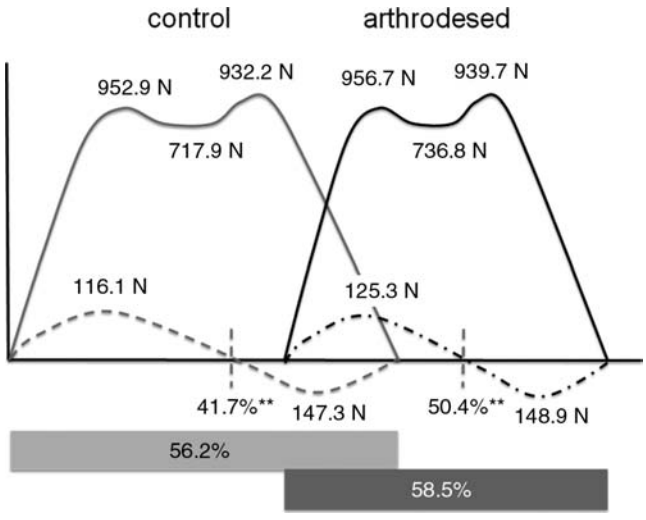

Fig. 4: Kinetic results of arthrodesis foot and contralateral foot (, $p = 0.067$). Single support percentages of arthrodesis foot (58.5% of the gait cycle) and control foot (56.2% of the gait cycle) were similar. The double support was 14.3% of the cycle. But the switching point from anterior to posterior forces occurred in 50.4% (SD, 9.8) of the fuse foot and in 41.7% (SD, 12.4) of the control foot ($p = 0.067$).

the external pressure in the forefoot was similar in both sides ($p > 0.05$) (Figure 5).

DISCUSSION

Ankle arthrodesis is still the primary treatment for disabling arthritis of the ankle that does not respond to conservative treatment.[14] The patients in the current study all had isolated post-traumatic arthritis of the ankle treated with an isolated ankle arthrodesis. The purpose of the present study was to compare the outcomes, at least 2 years after surgery, for a group of patients who had been managed with ankle arthrodesis. Despite many concomitant injuries and post-surgical complications, all patients were satisfied with their ankle arthrodesis and had no significant restrictions when performing their daily activities. Most of the patients included in the study (70%) returned to their previous work and activity level (limited to sports activities). Wearing shoes was shown to be particularly comfortable for the patients with an ankle arthrodesis, and the shoes improved the clinical outcome in all the patients. The contribution of shoes to improving clinical parameters was significant in all patients. The mean time of consolidation was 4 months[9,35] and consolidation rates of arthrodesis were between 93% and 100%.[40]

Although medium- and long-term studies have shown a clear functional impairment over time, the patient satisfaction reached up to 80%.[10,19,25,26,39] A successful outcome depends on the etiology that led to the arthrodesis. Patients in whom ankle arthrodesis was performed after infection or a neuropathic ankle were found to have worse results and a lower degree of satisfaction.[11,33]

Recent studies have shown that ankle arthrodesis improves the AOFAS score by up to 74 points.[21] We obtained a mean AOFAS score of 50 points and most of the patients (80%) showed occasional mild to moderate pain on the AOFAS and Mazur scales. The more global scales (such as the SF-36) and satisfaction with symptoms demonstrated poor results, particularly regarding the physical function subscales and the physical and emotional impact. In contrast, the functional scales showed good results in 80% of patients. We observed a direct correlation between the scores of the SF-36 scale and the range of motion after the arthrodesis. Therefore, as the range of motion increased, better results were observed on the SF-36 scale.

Early complications were uncommon but most of the patients had pain at the time of latest followup. With the SF-36 score, 12 patients had severe pain and six patients moderate pain. With the AOFAS score, 12 patients had

Table 4: Pressures (MPa) in the Forefoot Plantar Regions

	Fuse		Control	
Group	**Mean**	**SD**	**Mean**	**SD**
Forefoot - medial	278.8	155.3	331.0	202.5
Forefoot - central	615.3	208.4	522.3	236.8
Forefoot - lateral	287.0	210.6	290.8	173.2
Toe	421.3	245.3	524.8	266.2

Table 3: Results of the Foot Support in the Pedographic Patforms

	Fuse		Control	
Group	**Mean**	**SD**	**Mean**	**SD**
Total pressure (MPa)	713.5	243.1	768.0	245.4
Force (N)	999.0	194.4	1034.2	194.8
Plantar surface (mm^2)	131.9	16.8	141.8	26.9
Support time (msec)	1240.8	168.7	887.6	105.0

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Table 5: Pressures (MPa), Forces (N) and Support Surface (mm^2) in the Heel, Midfoot, and Forefoot in Arthrodesed and Control Foot

	Heel		Midfoot		Forefoot	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**
Pressure (MPa)						
Control	387.2	220.6	233.3	98.3	610.9	232
Arthrodesed	319.0	92.2	285.5	123.1	630.3	267.6
Axial force (N)						
Control	841.3	245.0	911.6	202.7	988.4	160.9
Arthrodesed	778.5	228.3	927.2	198.0	940.8	192.1
Surface (mm^2)						
Control	73.9	28.5	104.3	27.0	85.0	49.4
Arthrodesed	63.1	24.1	95.4	18.0	72.1	46.0

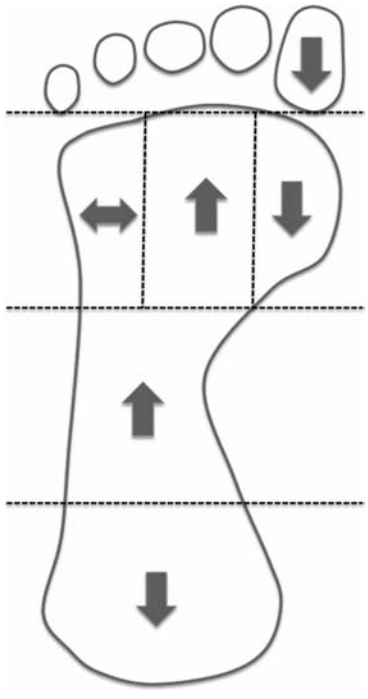

Fig. 5: Hindfoot and toe pressure while walking were lower in arthrodesis foot but midfoot pressure increased in arthrodesis foot. Medial and central pressures from fused forefoot were higher than in the control group. However, lateral pressures were similar.

severe constant pain and six patients moderate pain every day. Patients who used crutches or had pain had an angle of fusion, in the sagittal plane, higher than 95 degrees or the heel in varus.

We obtained a mean tibiotalar angle in the arthrodesis limb of 110 degrees. Caron et al.[7] recommended placing the foot in neutral position since in equinus the proximal part of the tibia is overloaded, allowing a knee-flexed motion. They also recommended a hindfoot valgus alignment of 5 degrees, avoiding varus. The foot rotation (internal or external) was determined by the position of the contralateral side. Buck et al.[6] showed that an ankle fused in valgus alignment allowed a normal gait and considered it advantageous. Said et al.[32] reviewed the gait in 11 patients and the best results were observed in patients with ankle arthrodesis at a right angle or with mild equinus, with dorsiflexion of 5 degrees or more and a plantarflexion of 20 degrees or more through the other midtarsal joints. In the current study we observed that 75% of patients had good alignment with a plantigrade foot and an aligned hindfoot. Only 5% of patients had a non-plantigrade foot with severe foot malalignment.

Gait analysis revealed that the patients in the present study had significantly decreased ankle motion in the sagittal plane, dorsi- and plantarflexion of the hindfoot and tibial rotation.[4] The foot inversion-eversion decreased a lower proportion. Although we observed hindfoot motion of 12.5 degrees in flexion-extension, the decrease in ROM of the ankle during gait did not reach the 30 needed to achieve normal gait. Astion et al.[3] quantified the motion of the hindfoot after simulated arthrodesis and reported that a fusion of the talonavicular joint severely limited the motion of the remaining joints to approximately 2 degrees. Wu et al.[42] observed an increase in the coronal plane hindfoot motion, reflecting an increase in foot eversion during the stance phase. Mann and Rongstad[21] showed a 74% of loss of motion in the sagittal plane, but more significant loss of 70% of the inversion and eversion. In a prospective study,[36] an increase of 4 degrees of motion was found in the subtalar joint and 2 degrees in the medial column. The quality of life after the arthrodesis was associated with an increase of ROM. In contrast, increased mobility of the subtalar joint was shown to narrow the posterior facet of the subtalar joint contributing to the development of osteoarthritis.[26]

A regular gait pattern requires a range of dorsiflexion of the ankle between 24 and 30 degrees (37 degrees to

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climb stairs and 55 degrees to go down stairs). In normal conditions, the motion of the distal joints contributes up to 40 degrees of plantarflexion in the sagittal plane.[36] The contribution of shoes has been shown to improve gait parameters. With adapted shoes all the patients included in the study returned to their original occupations and recreational activities. We only found limitations when patients walked barefoot. Mazur et al.[23] observed that while wearing shoes, patients who had had an ankle arthrodesis, showed excellent gait characteristics, with decreased ankle motion and altered motion within the foot on the contralateral side. However, Abdo and Wasilewski[1] did not observe significant differences between healthy feet and arthrodesis feet. Katsenis et al.[15] demonstrated that patients with a fused ankle walked with an heel-toe gait and the time from heel strike to plantigrade foot was lower in the operated side. On the other side, patients with midfoot mobility had a smoother transition from the single support to the toe-off. None of the patients had a normal transition from the center of pressure during the stance phase.[15] We did observe significant differences in the force switch point from anterior to posterior during walking. This means that there was a quick transition from heel strike to toe-off, which explains a shorter phase of single support. Thus, patients walk with a pattern from heel to toe requiring less time for posterior forces. This decrease in the single limb support phase means that the arthrodesis foot performed the change of direction 10% later than the healthy side.

In the current study, a decreased cadence and stride length were observed along with a decreased ROM of hindfoot and midfoot during the stance and swing phase of gait.[39] Rotation at the pelvis and motion at the knee were not significantly altered. We did not observe significant changes in kinematics; in fact the mobility of the foot-ankle segment was higher than expected in the arthrodesis limb. Although we found a longer oscillating phase and a lower stance phase in the arthrodesis foot, no significant differences were observed regarding the cadence. It is believed that ankle arthrodesis can have good clinical results because the midtarsal joints have compensatory motion as described by Cheng et al.[8] No significance differences were observed between the arthrodesis limb and contralateral healthy side, in part because the contralateral healthy side adapts to compensate the decreased of motion of the arthrodesis foot. Therefore, the compensatory motion is also provided by the contralateral healthy foot, which adapts to the mechanical conditions of the arthrodesis foot.

Painful joints should be radiographically evaluated before surgery and treated with selective anesthetic injections. Said et al.[32] found that all failed arthrodesis required reoperation, while other authors report a reoperation rate between 50% and 70% of cases.[11,24,33,38] In contrast, Sheridan et al.[36] believe that these studies ignore the presence of osteoarthritic changes in these joints before surgery. There exist some long-term effects of ankle arthrodesis, but these may have pre-existed. Houdijk et al.[12] observed that out of a total of 71 arthrodesis ankles, 68 had pre-existing osteoarthritic changes in the hind-or midfoot, the subtalar joint being the most commonly affected.

While gait analysis suggested an increase in motion in small joints after ankle arthrodesis,[23] radiographic studies[1] did not show significant differences between the arthrodesis foot and contralateral healthy foot. Therefore, in certain cases, the biomechanics of the knee could be altered before the arthrodesis as a result of ankle osteoarthritis or secondary to the pathology that caused the ankle degeneration. The time between the fracture and the arthrodesis could produce an abnormal gait and support for the contralateral foot.[29] We emphasize the similarity of the results obtained in the support of both groups and the disturbances observed in the contralateral healthy side. Despite the small population, we found no statistical differences between the arthrodesis limb and the contralateral healthy foot, except for the neutral switch point from anterior to posterior forces.

CONCLUSION

Ankle arthrodesis continues to be a standard operative treatment for severe post-traumatic ankle osteoarthritis. Although ankle arthrodesis will help to relieve pain and to improve overall function, it is considered a procedure that causes persistent alterations in gait, with the possible development of symptomatic osteoarthritis in the other joints of the foot. Furthermore, we found no major biomechanical differences between the arthrodesis foot and the contralateral foot, possibly because the healthy foot adapts to the conditions of its counterpart.

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