The Journal of Foot & Ankle Surgery 54 (2015) 399–405

Contents lists available at ScienceDirect

The Journal of Foot & Ankle Surgery

journal homepage: www.jfas.org

Functional and Clinical Assessment of Two Ankle Arthrodesis Techniques

Francesco Malerba, MD [1], Maria G. Benedetti, MD [2], Federico G. Usuelli, MD [1], Rossano Milani, MD [1], Lisa Berti, MD [3], Christine Champlon, MEng [1], Alberto Leardini, DPhil [3]

[1] *Unità Operativa II Divisione, Chirurgia del Piede, I.R.C.C.S. Istituto Ortopeedico Galeazzi Milano, Milano, Italy*
[2] *Medicina Fisica e Riabilitativa, Istituto Ortopedico Rizzoli, Bologna, Italy*
[3] *Laboratorio di Analisi del Movimento, Istituto Ortopedico Rizzoli, Bologna, Italy*

ARTICLE INFO

Level of Clinical Evidence: 4

Keywords:
ankle fusion
clinical scores
foot joint degeneration
gait analysis
radiographs
subtalar joint fusion

ABSTRACT

Isolated tibiotalar fusion is the preferred choice for isolated end-stage arthritis, joint destruction after infection, talar avascular necrosis, Charcot neuroarthropathy, and joint replacement failure. Combined tibiotalar and subtalar joint fusion with an intramedullary nail can achieve better alignment and save patients from prolonged non-weightbearing. The purpose of the present study was to functionally assess using instrumental gait analysis and clinically assess the effect of these 2 surgical techniques. Twelve patients with a mean follow-up duration of 70 (range 55 to 89) months after successful ankle fusion were analyzed, 6 isolated and 6 combined. The main outcome measure was the functional assessment performed using a stereophotogrammetric system and an established multisegment foot kinematics protocol. Standard clinical, imaging, and score systems were also assessed in the 2 groups, including radiographic-based classification of arthritic degeneration at the neighboring foot joints. No significant differences were found between the 2 groups using the scoring systems. Severe arthritic degeneration was found at the subtalar joint in the isolated fusion group and at the talonavicular and Lisfranc joints in the combined fusion group. From the gait analysis, no differences were found in the time-distance parameters; however, significant differences were observed in several joint rotations and planar angles. Isolated tibiotalar fusion allows for motion, however small, at the subtalar joint but can result in severe degeneration. Good clinical and functional results can also be obtained with combined tibiotalar and subtalar fusion, although this can result in degeneration of the adjacent joints of the foot.

Ankle arthrodesis has been used successfully for end-stage arthritis to relieve pain and improve function (1). Although originally devised for poliomyelitis and tuberculosis, ankle fusion is now indicated for isolated end-stage post-traumatic arthritis, residual joint destruction after infection, talar avascular necrosis, Charcot neuroarthropathy, and total ankle replacement failure (1). Since the very first case (2), the procedure has undergone numerous modifications to address clinical situations with different levels of complexity (3).

Currently, the fusion rates of isolated tibiotalar (ITT) arthrodesis range from 80% to 100%, with patient satisfaction rates around 80% (4,5). Although this has been considered a reliable procedure and the reference standard for the treatment of end-stage ankle arthritis (6), it remains a technically challenging procedure. Successful ankle fusion requires meticulous preparation of the bony surfaces, careful positioning of the joint, rigid fixation, and non-weightbearing until early bone consolidation. Prolonged postoperative non-weightbearing can be difficult for debilitated patients, and isolated ankle fusion is not always a good option for severe deformity (7).

For these patients, combined tibiotalocalcaneal (CTTC) fusion using an intramedullary nail offers a viable alternative solution. This is a 1-step straightforward operation designed to address combined tibiotalar and subtalar joint arthritis. Since its introduction in 1956 (8), the extension of operative indications has led to the development of improved instruments and techniques. Originally described for correction of a flail foot, the procedure quickly gained popularity for the treatment of arthritis and deformity secondary to talipes equinovarus, tuberculosis, and talus fractures (9).

The current techniques to achieve successful CTTC fusion include screws, external fixators, blade plates, and intramedullary nails. Single or combined incisions have been described, including medial, anterior, transmalleolar, and transverse approaches (10,11). Screw

Financial Disclosure: This study was supported by the Italian Ministry of Economy and Finance (Programme "5 per mille").

Conflict of Interest: None reported.

Address correspondence to: Alberto Leardini, DPhil, Movement Analysis Laboratory, Istituto Ortopedico Rizzoli, Via di Barbiano 1/10, Bologna 40136 Italy.

E-mail address: leardini@ior.it (A. Leardini).

1067-2516/$ - see front matter © 2015 by the American College of Foot and Ankle Surgeons. All rights reserved.
http://dx.doi.org/10.1053/j.jfas.2014.09.007

Table 1
Demographics and etiology of the 2 patient populations (mean ± standard deviation)

Variable	ITT Group*	CTTC Group*	Control Group
Preoperatively			
AOFAS score	40.7 ± 11.9	25.7 ± 14.1	100
MT&ST score	20.7 ± 10.5	30.2 ± 6.0	
Follow-up period (mo)	73.0 ± 14.5	66.8 ± 8.6	
Sex			
Male	2	6	3
Female	4	0	7
Age (y)	54.8 ± 8.9	54.3 ± 16.3	28.5 ± 6.9
Height (cm)	165.0 ± 8.6	174.7 ± 8.9	175.9 ± 6.9
Weight (kg)	62.2 ± 12.7	92.0 ± 8.3	72.7 ± 13.2
BMI (kg/m^2)	22.6 ± 2.3	30.4 ± 5.0	23.4 ± 3.5

Abbreviations: AOFAS, American Orthopaedic Foot and Ankle Society; BMI, body mass index; CTTC, combined tibiotalocalcaneal; ITT, isolated tibiotalar; MT&ST, MetaTarsal and SubTalar joint score.
* n = 6 ankles in 6 patients.

fixation has historically been the most prevalent technique for CTTC; however, our choice fixation has been the intramedullary nail (12,13). This acts as an simple guide for good limb alignment, and, because it is a load-sharing device, the postoperative non-weightbearing requirements can be sensibly reduced compared with those required after ITT, especially with the more recent improvements that allow static or dynamic compression of both arthrodesis joint sites (14).

A potentially critical drawback of CTTC is fusion of the subtalar joint, whose consequences on motion at the distal foot joints and possible associated arthritis are unknown. The purpose of our study was to compare the functional outcomes of ITT versus CTTC. In addition to the traditional clinical and radiographic assessments, state-of-the-art gait analysis using a dedicated experimental protocol for multisegment foot and ankle kinematics was performed to exactly assess patient mobility after surgery at a number of foot and ankle joints. To judge the accuracy of this functional evaluation, the same technique was performed on a group of healthy subjects as a control group.

Patients and Methods

Patients and Operative Procedures

This was a retrospective gait analysis study to assess the 2 surgical options for end-stage ankle arthritis. Fourteen medically debilitated patients who had undergone ITT or CTTC from January 2002 to June 2005 by the same surgeon at the IRCCS Galeazzi Foot and Ankle Division were recalled for evaluation at a minimum of 4 years of follow-up. These patients were consecutively included if they met the inclusion criteria (i.e., an ability to walk and available for the gait analysis test after providing informed consent). The type of operation was chosen with the patient after standard clinical and radiological analyses. One patient could not participate for medical reasons, and another patient was excluded because of fusion failure, for a final group of 12 patients analyzed (Table 1). Of the 12 patients, 6 had undergone ITT fusion using 2 crossing 7.0 cannulated screws (15), and 6 patients had undergone CTTC arthrodesis with a retrograde static compressive intramedullary nail (Biomet® ankle arthrodesis nail, Biomet Deutschland GmbH, Berlin, Germany). All of the ankle fusions were performed unilaterally.

All patients had medical comorbidities: 5 had cardiovascular insufficiency (4 ITT, 1 CTTC), 2 had diabetes (1 ITT, 1 CTTC), 1 patient was blind (CTTC), 1 patient had kidney failure and required dialysis (CTTC), and 3 had undergone a higher extremity amputation (1 ITT, 2 CTTC). A transfibular approach with grafting of the distal fibula at the arthrodesis site was used for both techniques (16,17). The clinical and imaging criteria considered at the operative decision directly by the surgeon were ankle pain, reduced ankle joint range of motion, K-M grade III (18) arthritic changes of the ankle on radiographs, the absence of clinical signs of subtalar or midtarsal joint arthritis, and no radiologic or computed tomography evidence of arthritis or cartilage defects of the subtalar and midtarsal joints.

Table 2
Metatarsal and subtalar joint score form

Variable	Score
Work	
Return to previous employment	0
Limitation	2.5
Severe limitation	5
Sport	
Return to previous sport activity	0
Limitation	2.5
Change sport	5
Walking upstairs	
Without handrail	0
With handrail	3
Unable	6
Walking uphill	
Without cane	0
With 1 cane	3
With 2 canes	6
Walking downhill	
Without cane	0
With 1 cane	3
With 2 canes	6
Shoes	
Commercial	0
With insoles	3
Custom made	6
Drugs	
Never	0
Occasionally	3
Always	6
Total	40

Postoperative Management and Postoperative Complications

The patients in the ITT group remained non-weightbearing in a protective cast for 6 weeks after surgery (19). The patients were allowed to begin weightbearing after radiologic evidence of fusion. One patient required irrigation, debridement, and oral antibiotics for wound infection, without a return to the operating room. Another patient required screw removal.

In the CTTC group, the postoperative cast was removed 3 weeks after surgery, and complete weightbearing was allowed (1). Two patients later required removal of the nail. Another patient experienced pretibial pain for the first 7 weeks after surgery. No stress fractures were reported in either group.

Outcome Measures

At the follow-up visits, the American Orthopaedic Foot and Ankle Society (AOFAS) hindfoot score and our own scoring system were used for the assessments.

The AOFAS hindfoot score (20) and the scoring system we developed, MetaTarsal and SubTalar joint score (MT&ST) were used (Table 2). The latter assesses the functional abilities during activities of daily living, with 5 points for the ability to work, 5 for sport, 6 for walking upstairs, 6 for the ability to walk uphill, 6 for walking downhill, 6 regarding the shoes worn, and 6 regarding the drugs used, for a total score of 0 to 40.

Weightbearing radiographs of the foot were obtained with the foot in the natural attitude of the gait progression angle, with the tube oriented in the dorsoplantar and

Table 3
Mean and standard deviation of time-distance gait analysis parameters

Group	Stance (% of cycle)	Stride Length (cm)	First Double Support (% of cycle)	Second Double Support (% of cycle)	Cadence (stride/min)	Cycle Time (s)	Speed (cm/s)
ITT*	63.79 ± 3.59	84.38 ± 22.98	16.03 ± 2.58	17.83 ± 5.27	43.76 ± 6.78	1.41 ± 0.25	62.84 ± 23.37
CTTC*	65.25 ± 6.07	82.89 ± 36.50	15.75 ± 4.21	17.27 ± 3.74	40.76 ± 6.63	1.51 ± 0.23	58.88 ± 33.93
Control	59.97 ± 1.96	133.14 ± 8.70	9.50 ± 2.20	9.83 ± 2.26	52.98 ± 4.56	1.14 ± 0.09	117.44 ± 11.38

Abbreviations: CTTC, combined tibiotalocalcaneal; ITT, isolated tibiotalar.
* n = 6 ankles in 6 patients