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A comparative study between triple fusion and medial double fusion in cases of neglected rigid flat foot

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Abstract

Although the exact cause of flat foot is not completely understood, the stimulus for this deformity is thought to originate from a compromised tibialis posterior tendon, resulting in the original nomenclature of posterior tibial tendon dysfunction or insufficiency. To compare functional and radiological outcomes of triple fusion and medial double fusion in treatment of neglected cases of rigid flat foot. This randomized controlled trial study conducted on 41 patients (59 feet; 23 unilateral cases and 18 bilateral cases) with rigid flat foot classified into two groups: Group A: 31 feet receiving triple hind foot fusion and Group B: 28 feet receiving medial double fusion at Kasr Al Ainy hospital from May 2018 to July 2022. There was a high statistically significant difference between AOFAS hind foot score, calcaneal pitch angle, lat Talo-MT1 angle, TN coverage angle pre and post operation in group 1 and 2. There was no statistically significant difference between studied groups as regard complications, high statistically significant difference as regard operative time and statistically significant difference as regard AP Talo-MT1 angle post operation. Arthrodesis of the subtalar and talonavicular joints through a medial approach is an equally reliable procedure for the treatment of neglected rigid flatfoot without calcaneocuboid joint degeneration as triple arthrodesis with shorter operative time.

Keywords: Flat foot, Triple hind foot fusion, Medial double fusion.

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1. Introduction

Rigid flat foot deformity was traditionally treated with triple fusion since Ryerson first described it in 1923. It consists of fusion of subtalar [1-2]. Calcaneocuboid and talonavicular joints to relief pain from arthritic, deformed or unstable joints in addition to correction of the deformity and creation of stable, balanced plantigrade foot for ambulation [3-4]. Medial double fusion is a new trend of surgical management of rigid flat foot through single medial approach and by fusion of subtalar and talonavicular joint sparing calcaneocuboid joint and avoiding lateral wound. It aims to keep few degrees of mobility through the calcaneocuboid joint decreasing long-term arthritic changed in the neighboring joints and soft tissue complications seen in triple arthrodesis. The medial double approach has been shown to allow for adequate joint preparation, provide excellent deformity correction, decrease the operative time, and provide good rates of fusion with fewer soft tissue complications [5-6]. Critical to the success of operative correction of advanced flatfoot and arthritic deformity is the realignment of the hind foot joints before fusion [7].

The aim of this study was to compare functional and radiological outcomes of triple fusion and medial double fusion in treatment of neglected cases of rigid flat foot.

2. Materials and Methods

This randomized controlled trial study conducted on 41 patients (59 feet; 23 unilateral cases and 18 bilateral cases) with rigid flat foot classified into two groups: Group A: 31 feet receiving triple hind foot fusion, 10 patients with bilateral feet and 11 patients with unilateral flat foot. Group B: 28 feet receiving medial double fusion, 8 patients with bilateral flat feet and 12 patients with unilateral flat foot at Kasr Al Ainy hospital from May 2018 to July 2022.

2.1. Ethical approval

Approval from the Local Research Ethics Committee was obtained, and all patients was provided with informed consent prior to inclusion.

2.2. Inclusion criteria

Patients with age more than 14 years suffering rigid flat foot deformity, that was symptomatic and resistant to non-operative measures.

2.3. Exclusion criteria

Flexible flat foot, asymptomatic patients, lower limb ischemia or poor skin coverage, neuropathic changes or ulcers, bad general condition that not fit for surgery, active infection and arthritis in calcaneocuboid joint.

2.4. Method

All patients were subjected to Clinical evaluation: (history taking and examination included: inspection, palpation and Special tests) and Investigations:(radiological investigation: X-Ray, computed tomography (CT) and MRI and laboratory investigations).

2.5. Surgical Techniques

2.5.1. Triple arthrodesis for group 1 cases

The lateral incision started from the tip of distal fibula to the base of the fourth and fifth metatarsal. Dissection was continued deep, until the level of the fascia overlying the extensor digitorum brevis muscle. It was reflected off of its origin on the sinus tarsi. Peroneal tendons were being retracted plantarly. The sinus tarsi were identified and excavated. Fibrofatty tissue in the sinus tarsi (Hoke's tonsil) was removed for adequate exposure of the subtalar joint. All subtalar joint attachments were released. Following the former incision distally, the calcaneal cuboid joint was identified, and its dorsal ligaments were released. Then, the medial incision was placed between the medial gutter of the ankle and extended to the inferior aspect of the navicular. The great saphenous vein was often in this area and retractable superiorly. The capsular tissue of the talonavicular joint was incised in line with the incision. Resection of the talonavicular joint was performed using a variety of methods. Curettes or osteotomes was used for cartilage resection and exposure of subchondral bone, maintaining the original contour of the joint. Once the talonavicular joint was prepared, resection then continued at the calcaneocuboid joint. Once again, curettes or osteotomes were used, or a sagittal saw was employed. If transverse plane deformity of the foot exists, a wedge of the calcaneus was taken for correction. Finally, the subtalar joint was prepared for arthrodesis. The posterior facet was prepared using curettage, osteotome, or a rotary burr to ensure adequate subchondral bone exposure. If the middle facet has been exposed, it too can be resected using this method. If a bone graft is employed for wedging, it can be placed for deformity correction. After prepping all joints, the talonavicular joint can undergo manual manipulation and then fixated temporarily using Kirschner wires or Steinmann pins. Following this, the subtalar joint and calcaneocuboid can be temporarily fixated using the same methods. Ensuring the foot is in the optimal position for fusion, the subtalar joint was then permanently fixed. For fixation, screws were used from a posterior and lateral angle on the calcaneus extending to the dorsal medial aspect of the talus. The talonavicular joint was fixed using screws from a distal and inferior aspect of the navicular into the head of the talus. The calcaneocuboid joint finally was fixed utilizing a variety of hardware options. The final position of the foot was the following: heel in neutral to slight eversion, midtarsal joint in slight valgus. Incisions were then irrigated and closed using anatomically layered closure. Skin closure was made using mattress interrupted sutures. Patients were placed in a cast and were non-weight bearing following the procedure. The tourniquet was released, with compression maintained on the wounds. After 1 minute, the pedal pulses were palpated, and digital capillary refill was assessed. The wounds were dressed with non-adherent gauze and absorptive pads. Finally, a well-padded below knee cast was applied, with the ankle was held in neutral dorsiflexion.

2.5.2. Double arthrodesis for group 2 cases

Single straight incision started 0.5 cm posterior and inferior to medial malleolus towards the medial cuniform slightly dorsal to the course of tibialis posterior tendon. The superficial deltoid ligament was incised and the tenosynovium was dissected off the tibilis posterior tendon, from the level of the medial malleolus to the navicular bone. We exposed and inspected the tendon. It can be debrided, repaired or simply excised according to the clinical symptoms and the degree of degeneration. A self-retaining retractor was used to retract the PTT tendon and to expose the spring ligament. After blunt dissection dorsal to the talonavicular joint capsule. A Hohmann retractor was placed deep to the anterior tendons neurovascular structures, the dorsal talonavicular joint capsule was transected and the medial joint capsule was divided and reflected plantarly. Then we located the talonavicular joint space and opened it. We denuded the articular cartilage with curved osteotomes and curettes, then removed the debris with copious irrigation. We used large K-wires to make multiple holes deep to the subchondral bone of the navicular bone and talus to get bleeding bone and enhance healing. Following the PTT tendon, we searched for the sustantaculum tali, then using an elevator we freed the calcaneal wall down the sustantaculum. The laminar spreader was placed over the talocalcaneal joint and the subtalar joint capsule was cut taking care not to damage the anterior fibers of the deltoid ligament. The subtalar interosseous ligament was cut, which allows further spreading of the talocalcaneal joint. The subtalar joint was reduced in a position of 0-5 degrees of valgus in relation to the long axis of the tibia. Two guide pins was inserted under C- arm for two partially threaded cannulated 6.5 screws. Before fixation, we assessed the foot position after subtalar reduction. Reduction of the talonavicular joint was achieved by manual abduction pressure to the talar head and pronatory force on the first ray. It was confirmed clinically and with fluoroscopic views. After irrigation, the attenuated, diseased portion of the calcaneonavicular spring ligament was excised, and

anatomic closure of the talonavicular and subtalar joint capsule was achieved using size 0 absorbable sutures.

2.5.3. Follow up

The patients were asked to start with foot mobilization for two weeks without weight bearing, 8 weeks postoperatively the patients were asked to start partial weight bearing with crutches and beginning of physiotherapy. At 12 weeks postoperative the patients asked for complete weight bearing without support and gradual return to normal activities. Follow up the patients every month and asked for x-ray to assess osseous union and, and screws position. After 6 months all patients were reassessed according to The American Orthopedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot Scale.

3. Results and discussion

Table 1 showed that there was no statistically significant difference between the studied groups as regard baseline data. Table 2 showed that there was high statistically significant difference between AOFAS hind foot score, calcaneal pitch angle, lat Talo-MT1 angle, TN coverage angle pre and post operation in group 1. Table 3 showed that there was high statistically significant difference between AOFAS hind foot score, calcaneal pitch angle, lat Talo-MT1 angle, TN coverage angle pre and post operation in group 2. Table 4 showed that there was high statistically significant difference between the studied groups as regard operative time. Table 5 showed that there was statistically significant difference between the studied groups as regard AP Talo-MT1 angle post operation. This table showed that there was no statistically significant difference between studied groups as regard complications. Table 6 showed that there was no statistically significant difference between studied groups as regard complications.

3.1. Case presentation

Male patient 20 years' old who was a student in faculty of engineering presented to the foot and ankle outpatient clinic at kasr Aleiny University Hospital. He was complaining from persistent left foot pain that increase with long standing and walking and did not improve by conservative treatment. By examination, there was loss of medial arch, forefoot abduction (too many toes sign), heel valgus that not corrected by tiptoeing (rigid flat foot) and tenderness on sinus tarsi and medial side of the foot. X-rays showed loss of medial arch, forefoot abduction, arthritic changes in talo-navicular joint, calcaneal pitch angle 8, lat. talo-1st metatarsal angle -2, lateral talo-calcaneal angle 43°, AP talo-1st metatarsal angle 21°, AP talo-navicular coverage angle 22° and AP talo-calcaneal angle 38°. Triple arthrodesis surgery was done, iliac crest tricortical graft with used specially in calcaneocuboid joint to elongate the lateral column and enhance union and the patient was put in below knee cast for 6 weeks. After cast removal the patient did physiotherapy for one month. Post-operative x rays showed different angles improvement as following: calcaneal pitch angle increased from 8° to 11°, lat talo-1 st metatarsal angle decreased from -2° to 5°, lat talo-calcaneal angle decreased from 43° to 36°, AP talo-1 st metatarsal angle decreased from 21° to 7°, AP talo-navicular coverage angle decreased from 22° to 4° and AP talo-calcaneal angle decreased from 38° to 13°. After six months, the patient was assessed by AOFAS and showed improvement as the score increased from 42 to 90. In this study, we found that there was no statistically significant difference between the studied groups as regard baseline data. Fadle et al. found that thirteen (all males) patients underwent double arthrodesis, while ten (nine males and one female) underwent triple arthrodesis. The mean age for double and triple arthrodesis was 20.15 ± 5.63 and 25.10 ± 8.36 years, respectively, and the mean follow-up duration was 12.46 ± 2.88 and 12.9 ± 3.07, respectively. There were no statistically significant differences between the groups in age, gender, laterality, or follow-up duration [8]. In this thesis, we illustrated that there was high statistically significant difference between the studied groups as regard operative time. Galli et al. reported similar findings. The mean procedure time was significantly shorter in double arthrodesis than triple arthrodesis (84 ± 29 vs. 104 ± 23 min, $p = 0.0033$). In this study, we demonstrated that there was statistically significant difference between the studied groups as regard AP Talo-MT1 angle post operation [9]. DeVries et al. found that on comparison of the angles between the 2 groups showed no statistically significant differences. The 1 exception was the preoperative AP talocalcaneal angle, which was significantly different statistically between the 2 groups (31.0° ± 8.3°, range 13° to 49° double versus 21.2° ± 8.3°, range 9°to 32° triple; p = .0032) [10]. In this study we found that there was high statistically significant difference between AOFAS hind foot score, calcaneal pitch angle, lat Talo-MT1 angle, TN coverage angle pre and post operation in group 1. Shams et al. found that regarding radiological evaluation after triple arthrodesis, there was a highly statistically significant difference for all angles. On the lateral view, the calcaneal pitch angle (CPA) improved from 8±2.1° (range, 5–12°) to 12.88±1.86° (range, 9–16°), with a mean correction of 4.88° (P=0.00001). The lateral talar-first metatarsal angle (T1stMTA) improved from 10.88±3.5° (range, 6–18°) to 4.06±1.34° (range, 2–7°), with a mean correction of 6.82° (P=0.00001). On the anteroposterior (AP) view, the T1stMTA improved from 15.44±4.18° (range, 11–25°) to 2.88±1.31° (range, 1–5°), with a mean correction of 12.56° (P=0.00001). The talonavicular coverage (TNCA) improved from 14.5±7.28° (range, 9–32°) to 1.19±0.75° (range, 0–2°), with a mean correction of 13.31° (P=0.00001) [11]. We cleared that there was high statistically significant difference between AOFAS hind foot score, calcaneal pitch angle, lat Talo-MT1 angle, TN coverage angle pre and post operation in group 2. Sammarco et al. showed a marked AOFAS Ankle-Hindfoot Scale improvement in the study 44.7 preoperatively to 77.0 postoperatively ($p < 0.01$). Moreover, their patients experienced improvements in pain, function, cosmetic, and shoe wear [12]. Our results showed that there was no statistically significant difference between studied groups as regard complications. DeVries et al. found that one patient (10%) in the triple arthrodesis developed lateral wound dehiscence that resolved with local wound care.

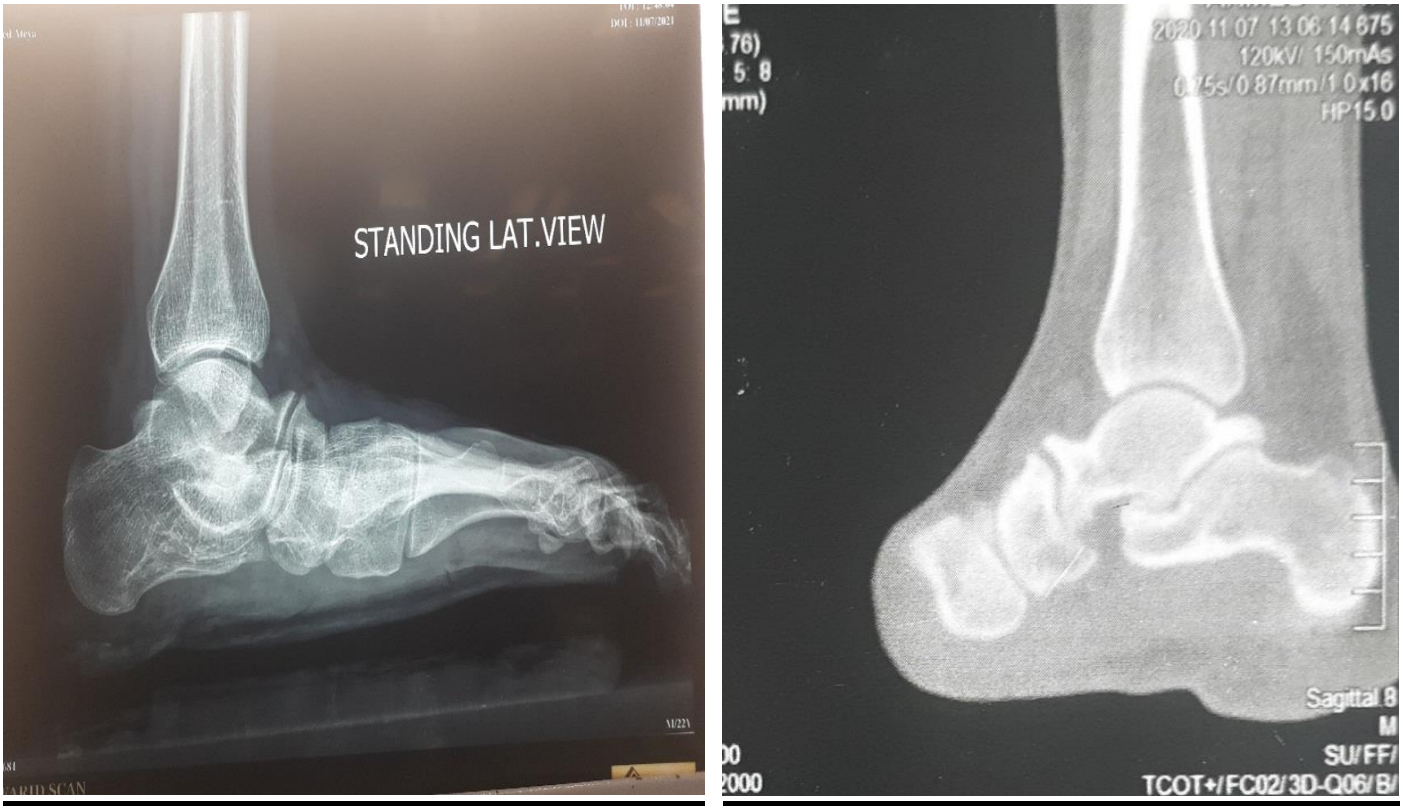

Figure 1. Preoperative x-ray and CT of foot showing flat foot deformity and arthritic changes.

Table 1. Comparison between studied cases according to baseline data

	Group A (n = 31)		**Group B (n = 28)**		**Test of Sig.**	**p**
Age (years)						
Range.	15 – 65		15 – 66		t= 2.045	0.982
Mean ± SD.	39 ± 19.9		40 ± 19.1			
Sex	No.	%	No.	%		
Female	13	41.9	12	42.8	χ^2= 0.296	0.640
Male	18	58.0	16	57.1		
Laterality						
Left	14	45.1	10	35.7	χ^2= 1.120	0.293
Right	17	54.8	18	64.2		
Comorbidities	0	0.0	0	0.0	χ^2= 0.0	1.0
Follow-up duration (m)						
Range.	8 – 17		8 – 18		t= 0.710	0.480
Mean ± SD.	11.87 ± 3.01		12.4 ± 2.8			

SD: **Standard deviation,** χ^2: **Chi square test** , **t: student t-test**, p: p value for comparing between studied groups, *: Statistically significant at $p \leq 0.05$

Table 2. Comparison between functional and radiological outcomes pre and post operation in group 1

	Pre-operation (n = 31)	**Post-operation (n = 31)**	t=	**p**
AOFAS Hind foot Score	70.5 ± 7.15	87.1 ± 9.86	12.988	<0.001*
Calcaneal pitch angle	11.27 ± 4.84	20.47 ± 8.37	9.303	<0.001*
Lat Talo-MT1 angle	-4.2 ± 0.89	2.83 ± 1.62	26.144	<0.001*
AP Talo-MT1 angle	14.6 ± 3.64	14.87 ± 3.99	0.622	0.539
TN coverage angle	24.57 ± 4.06	4.33 ± 2.72	32.301	<0.001*

SD: **Standard deviation, t: paired t-test**, p: p value for comparing between studied groups, *: Statistically significant at $p \leq 0.05$

Table 3. Comparison between studied functional and radiological outcomes pre and post operation in group 2

	Pre-operation (n = 28)	**Post-operation (n = 28)**	t=	**p**
AOFAS Hind foot Score	67.37 ± 7.87	86.57 ± 8.42	19.461	<0.001*
Calcaneal pitch angle	9.97 ± 2.14	17.67 ± 2.83	21.244	<0.001*
Lat Talo-MT1 angle	-4.47 ± 1.11	2.43 ± 2.42	17.940	<0.001*
AP Talo-MT1 angle	12.9 ± 3.97	12.4 ± 3.94	0.575	0.570
TN coverage angle	23.47 ± 4.29	3.77 ± 2.6	34.222	<0.001*

Table 4. Comparison between studied cases according to operative time and final clinical outcomes at 6 month follow up

	Group A (n = 31)		**Group B (n = 28)**		**Test of Sig.**	**p**
Operative time (min)						
Range.	52 – 131		34 – 78		t= 6.771	<0.001*
Mean ± SD.	88.32 ± 23.13		55.47 ± 12.95			
Residual pain	3	6.7	2	10.0	χ^2= 0.218	0.640
Union time (m)						
Range.	6-8		6 – 8		t= 0.756	0.453
Mean ± SD.	3.4 ± 0.56		3.27 ± 0.78			

Table 5. Comparison between studied cases according to functional and Radiological outcomes

	Group A (n = 31)	**Group B (n = 28)**	t=	**p**
AOFAS Hind foot Score				
Pre-operation	70.5 ± 7.15	67.37 ± 7.87	1.615	0.112
Post-operation	87.1 ± 9.86	86.57 ± 8.42	0.225	0.823
Calcaneal pitch angle				
Pre-operation	11.27 ± 4.84	9.97 ± 2.14	1.345	0.184
Post-operation	20.47 ± 8.37	17.67 ± 2.83	1.736	0.088
Lat Talo-MT1 angle				
Pre-operation	-4.2 ± 0.89	-4.47 ± 1.11	1.030	0.307
Post-operation	2.83 ± 1.62	2.43 ± 2.42	0.752	0.455
AP Talo-MT1 angle				
Pre-operation	14.6 ± 3.64	14.87 ± 3.99	1.730	0.089
Post-operation	14.2 ± 3.97	12.4 ± 3.94	2.411	0.019*
TN coverage angle				
Pre-operation	24.57 ± 4.06	23.47 ± 4.29	1.020	0.312
Post-operation	4.33 ± 2.72	3.77 ± 2.6	0.825	0.413

Table 6. Comparison between studied cases according to Complications

	Group A (n = 31)		**Group B (n = 28)**		**Test of Sig.**	**p**
Complications	No.	%	No.	%		
Non	13	40.0	17	63.3	χ^2= 10.158	0.254
Deep infection	2	6.7	0	0.0		
Delayed wound healing	0	0.0	2	6.7		
Failure fixation	1	3.3	0	0.0		
Residual lateral side pain	2	6.7	1	3.3		
Mal-directed screws	5	16.7	4	13.3		
Superficial infection	1	3.3	2	6.7		
Talo-navicular delayed union	3	10.0	1	3.3		
Talo-navicular non-union	4	13.3	1	3.3		


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Figure 2. Postoperative x-ray showing STJ, TNJ and CCJ fixation with partial threaded screws.

None of his patients in the double arthrodesis group developed skin complications in which there was insignificant difference between both studied groups as regards complications [10]. Sammarco et al. showed a marked AOFAS Ankle-Hindfoot Scale improvement in the study 44.7 preoperatively to 77.0 postoperatively ($p < 0.01$). Moreover, their patients experienced improvements in pain, function, cosmetic, and shoe wear [12].

4. Conclusions

Arthrodesis of the subtalar and talonavicular joints through a medial approach is an equally reliable procedure for the treatment of neglected rigid flatfoot without calcaneocuboid joint degeneration as triple arthrodesis with shorter operative time.

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