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Medium-term results of single-stage posteromedial release and triple arthrodesis in treatment of neglected clubfoot deformity in adults

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Objective: This study aimed to evaluate the implementation, in a single session, of both massive posteromedial release and triple arthrodesis for rigid neglected clubfoot deformities in adult patients, and its effects on clinical and radiological results.

Methods: The procedures were performed in one session on 15 feet of 11 patients [7 male, 4 female; mean age 26 (range: 15 to 50)]. Staples were used for fixation in all patients. For clinical assessment, the AOFAS (American Orthopaedic Foot and Ankle Society) ankle- hindfoot scale was used. Anteroposterior/lateral side talocalcaneal and talus-1st metatarsal angles were used as radiographic parameters. The mean follow-up was 7.5 years (range: 6 to 11).

Results: The mean AOFAS score rose from a preoperative 39 (range: 15 to 52) to 88 (range: 76 to 94) in the final follow up ($p<0.0001$). Among the 15 feet, 9 were evaluated as excellent, 5 as good, and 1 as fair. Significant clinical improvement was obtained between preoperative and postoperative surgical periods ($p<0.05$). Significant improvements were observed in radiographic parameters ($p<0.0001$). At final follow-up, radiographic values were within normal physiological limits. Average union time was 12.4 (range: 7 to 36) weeks. While pseudoarthrosis was not observed in any patients, delayed union developed in 2 cases, and talus avascular necrosis in 1. In the preoperative period, 5 patients had various degrees of degenerative changes. Nine patients developed degenerative changes in different joints and of different degrees.

Conclusion: The authors believe that massive soft tissue release and triple arthrodesis performed in a single session yields satisfactory results cosmetically and functionally in neglected clubfoot cases with severe deformities.

Keywords: Neglected clubfoot; posteromedial release; triple arthrodesis.

Clubfoot is a complex deformity associated with the talonavicular, calcaneocuboid and subtalar (talocalcaneal) joints. Despite much discussion on causal factors, its etiology is not yet clear.[1,2] Pathological changes in the disordered and deformed joints and bones become progressive upon tension and contraction, and lead to rigid contractures of the soft tissues in the foot medial and posterior.[3] While relations of the deformed ankle, tarsal

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and metatarsal bones are not symptomatic in the early period, they cause degeneration and resultant pain between bones in the later period.[3,4] Unless treated prior to completion of skeletal maturity, this deformity becomes more severe, as in the cases presented here.[4]

Conservative methods are very effective in the treatment of clubfoot deformity in children, with surgical treatment only preferred in cases that do not respond to conservative treatment or are neglected. In early childhood, soft tissue procedures (capsulotomies, tendon extensions, tendon transfers etc.) are common, while soft tissue releases alone do not treat deformities in adults, among whom the recurrence rate is high. Therefore, in adults, soft tissue procedures are carried out together with bone operations (several osteotomies and arthrodesis etc.) or combined soft tissue osteotomies.[1,3,5] Today, triple arthrodesis has become common in the treatment of neglected clubfoot deformity.[3]

Triple arthrodesis is the combined fusion of the talonavicular, calcaneocuboid and subtalar joints.[5] It is a safe and reliable method, used in traumatic, neurological and rheumatic disorders of the foot.[3,4,6] It aims to eliminate deforming forces, stop deformity development and, by minimizing or totally stopping device-dependent life, rearrange the foot in terms of stability and statics, thus making it possible to obtain a whole cosmetically, functionally and anatomically near-normal foot.[7-9]

This study analyzed the medium-term results of massive posteromedial soft tissue release and triple arthrodesis performed on adult patients with neglected clubfoot for which soft tissue surgery alone was insufficient. The aim of the study was to show that single stage massive medial soft tissue release and triple arthrodesis in adults is comparable to other procedures in both success and complication rate.

Fig. 1. Preoperative medial view of rigid left foot. [Color figure can be viewed in the online issue, which is available at www.aott.org.tr]

Patients and methods

The study was carried out retrospectively with data prospectively collected between 1995 and 2007. 15 feet of 11 patients (7 male, 4 female) who underwent triple arthrodesis and posteromedial release due to clubfoot were followed and checked. The patients had extremely rigid foot structures that could not be corrected through passive manipulation (Fig. 1). Of the patients, 5 had bilateral deformity. 4 had both feet operated, and 1 had one foot operated. Patient mean age was 26 (range: 15 to 50). 9 patients had left side involvement, and 6 right side. The mean follow-up was 7.5 years (range: 6 to 11) (Table 1). None of the patients had undergone any previous surgical or nonsurgical treatment.

Table 1. Patient demographics and AOFAS degrees.

No	Gender	Age	Side	Fusion time (wks)	AOFAS Ankle-Hindfoot Scale	
					Preoperative	Postoperative
1	Male	23	Left	9	39	90
2	Male	33	Left	28	40	82
			Right	12	42	80
3	Female	21	Left	8.5	48	92
			Right	9	47	92
4	Male	30	Left	10.5	28	85
			Right	11.5	30	86
5	Male	50	Right	36	15	76
6	Female	15	Left	7	52	94
7	Female	25	Left	10	44	89
			Right	10	42	89
8	Male	24	Right	9.5	37	90
9	Male	20	Left	8	37	93
10	Female	28	Left	10.5	34	88
11	Male	18	Left	7	50	94

Before operation, over-knee tourniquets were placed on all feet, and inflated after preparation of the extremity. Triple arthrodesis operations of the talocalcaneal, talonavicular and calcaneocuboid bones of all patients were carried out in a single session together with their soft tissue operations. Double incision was applied; one from the medial, and one from the lateral. The medial incision was Turco's classical posteromedial incision.[10] The incision starting at medial malleol posterosuperior was extended to the navicular bone. The neurovascular bundle was found, freed and pulled to the posterior with a Penrose drain. Next, the Achilles tendon, tibialis posterior, flexor digitorum longus and flexor hallucis longus were extended with a Z-plasty respectively, and the abductor hallucis cut.

The knot of Henry was then released, and posterior (tibiotalar and talocalcaneal) and medial capsulotomies (talonavicular, naviculocuneiform and subtalar) were carried out. The tibiotalar ligament was cut transversely, and the posterior talofibular and posterior tibiofibular ligaments were cut vertically. The calcaneofibular ligament was then cut, following which the superficial deltoid ligaments (posterior tibiotalar, tibiocalcaneal, tibionavicular and anterior tibiotalar) and spring ligaments were cut. Additionally to one phenomenon, tibialis anterior tendon extension was added. Z-plasty was applied and all tendons were sutured. Routine medial plantar fasciotomy was applied.

The second incision was lateral. A classical Ollier incision was used starting at the posterior and inferior of the Fibula lower end and reaching the 3rd-4th metatarsal bases. The lateral halves of the subtalar, calcaneocuboid and talonavicular joints were arrived at with this incision. Wedge osteotomies with openings facing lateral and top applied on the calcaneocuboid and talonavicular joints. Cavus and adduction deformities were corrected with these osteotomies. The third osteotomy was carried out on the subtalar joint. Once again, a lateral opening wedge osteotomy was performed aimed at correcting varus deformity. Osteotomies were fixated with staples. Osteotomy gaps were filled with the spongious parts of the bones removed. After the tourniquet was opened, both sides were given hemostasis. Hemovac drains were put in place and skin-subcutaneous tissues were sutured in compliance with anatomy.

All patients were casted in short leg circular plaster for 4 weeks and walking plaster for another 4 weeks. After 8 weeks with short leg plaster cast, it was necessary to use ankle supporting braces for about 4 weeks in only two cases, both of which developed late fusion. At the end of the eighth week, in the cases whose radiographs showed sufficient union, plaster fixation was ceased. Clinical and radiological examinations of the patients were carried out regularly. Monthly examinations were made in the first three months, quarterly examinations in the following one year, and subsequently six-monthly. Patients with delayed union were called for monthly examinations until union was achieved. Patients were evaluated clinically, radiologically and cosmetically. For clinical assessment, the AOFAS ankle-hindfoot scale was used to evaluate pain, function and alignment.[11] Since subtalar joint arthrodesis had been performed, the assessment was made over 94 points by taking of 6 points. The whole foot was examined and palpated thoroughly and united joints were determined. In the final controls, varus, valgus and neutral positions of feet were evaluated. Functionally, a soft moving ankle, no pain after long exercise and ability to wear a shoe easily was evaluated as a good result; pain after standing for a long time and a mild toughness in the ankle was fair, and apparent pain after walking, inability to wear shoes easily and a tough ankle was evaluated as a bad result.[12] The patients were asked whether they were satisfied with the operation or not.

Ankle (tibiotalar joint) maximum dorsiflexion and plantar flexion movements were measured by the 1st author with a standard goniometer with the patient in a sitting position. Tibial long axis and the lateral side of the foot were based as references.

The period and formation of the union was determined by clinical and radiological evaluation. Criteria such as no observation of pathological movement in the foot palpation, no feeling of pain when weight was put on the foot or while wearing shoes, and no edema or trophic changes in the foot were considered as clinical parameters. Radiological parameters were based on no detection of osteotomy lines and no pseudoarthrosis-related findings. Knowing that conventional graphs show the rate of union higher than it actually is, computerized tomography (CT) was used in cases of suspicious sufficiency of union.

Cosmetically, stepping plantigrade with no varus at hindfoot was evaluated as a good result, with mild varus as a fair, and inability to step plantigrade with apparent varus as a bad result.[12] In final controls, the feet's varus, valgus and neutral positions were evaluated clinically at stepping position.

Changes in foot length were assessed in 7 patients operated on single side. Comparative measurements of the two feet were taken with a ruler while sitting on the examination couch.

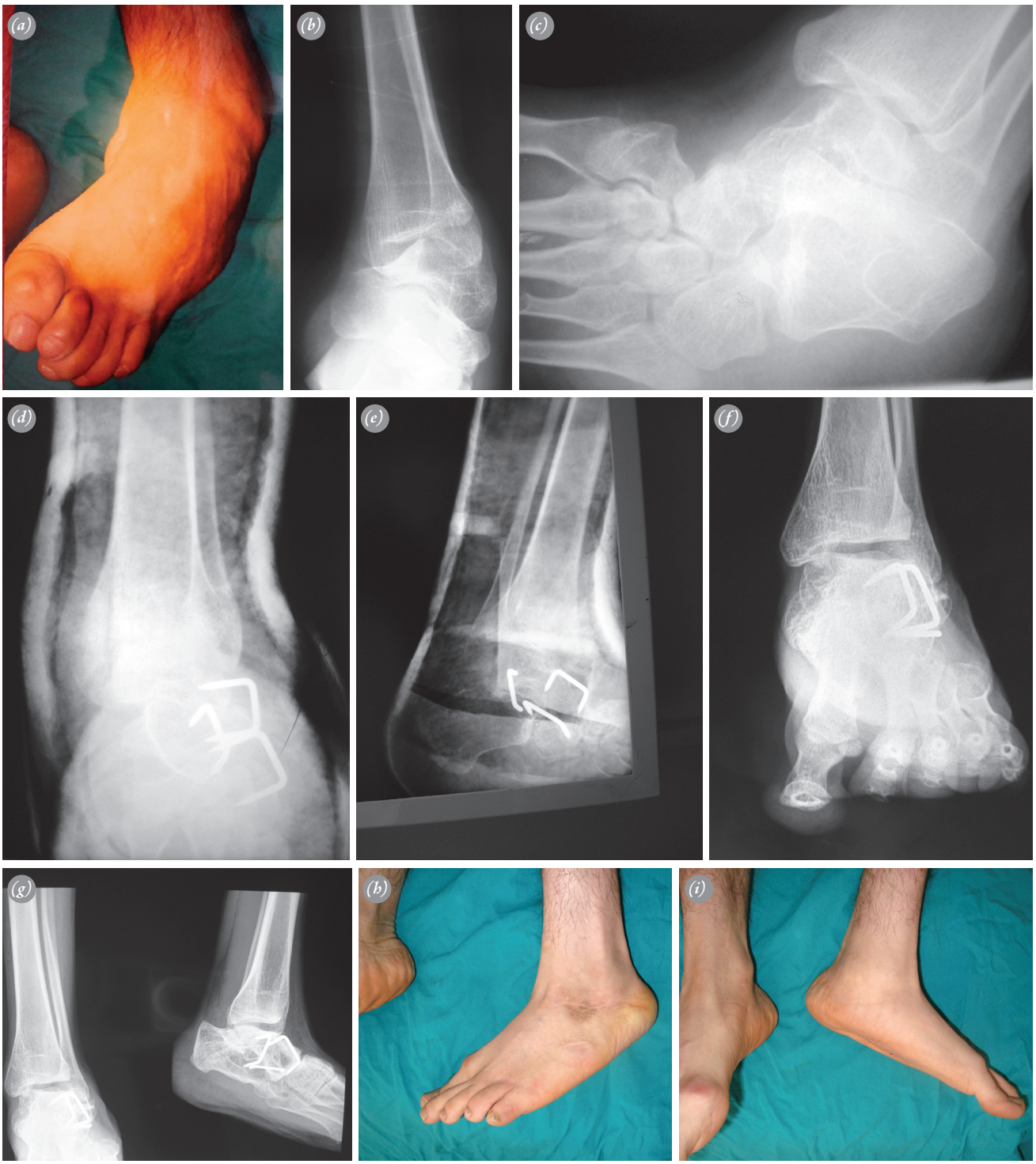

Fig. 2. **(a)** Preoperative lateral view of left foot. **(b)** Preoperative AP X-ray of left foot. **(c)** Preoperative AP X-ray of left ankle. **(d)** Early postoperative AP X-ray of left ankle. **(e)** Early postoperative lateral X-ray of left ankle. **(f)** Eight years follow-up, AP X-ray of left ankle. **(g)** Eight years follow-up, lateral X-ray of left ankle. **(h)** Eight years follow-up, lateral view of left foot. **(i)** Eight years follow-up, medial view of left foot. [Color figures can be viewed in the online issue, which is available at www.aott.org.tr]

Radiologically, standard anteropsterior/lateral and oblique graphs and standing anteroposterior/lateral and oblique graphs were taken. Valgus-varus measurements were made on these graphs. Clinical images, with preoperative and postoperative graphs, of one patient are presented in Fig. 2a-i.

Table 2. Radiographic evaluation according to Van Dijk et al.

Degree	Radiological finding
0	No abnormality or subchondral sclerosis
1	Signs of cartilage damage with or without osteophytes
2	Cartilage destruction, subchondral change such as necrosis, cysts and collapse of bone
3	Cartilage destruction accompanied by a partially or completely disappeared joint space, necrosis of the bone with deformation or subluxation

Table 3. Pre and post-op control radiographic results.

	Preoperative		Postoperative		
	Average	Range	Average	Range	p
A-P Talocalcaneal angle (°)	18	14-26	21	14-30	<0.05
Lateral Talocalcaneal angle (°)	26.1	18-45	34	22-50	<0.0001
A-P Talus-1st metatarsal angle (°)	3.5	(-4)-(+10)	0.8	(-8)-(+4)	<0.0001
Lateral Talus-1st metatarsal angle (°)	2.6	(-10)-(+13)	1.2	(-10)-(+13)	<0.0001

In A-P Planes, (-) values show abduction, (+) values show adduction; In the lateral planes (-) values show dorsal, (+) values show plantar flexion.

Radiographs were taken in company with the 1st author and were all assessed by the same person. The 1st author also carried out the surgical treatment. Talocalcaneal and talus-1st metatarsus angles in anteroposterior and lateral graphs were taken as the assessment criteria. These measurements were made over preoperative, early postoperative and final control graphs. Degenerative changes in the ankle were recorded, and assessed using the radiographic criteria of degenerative changes developed by van Dijk et al.[13] (Table 2). Statistical analyses of the results were carried out with t-test and chi-square tests. P<0.05 was accepted as the value of significance.

Results

Mean tourniquet time was 86 (range: 70 to 105), and mean operation time was 90 minutes (range: 75 to 110).

None of the patients developed subcutaneous or deep infection. Superficial infection that occurred on both feet was handled without complications through wound care and antibiotherapy. No vascular complication was faced. Wound surface necrosis approximately 4 mm-wide and 3 cm-long that occurred at the posteromedial incision area in one of the patients was treated with debridement and wound care. Loss of sense in foot anterolateral developed in three of the patients postoperatively, and was observed in one patient at the final controls. None of the patients developed pseudoarthrosis. Tibiotalar arthrodesis was not performed on the patients until the final controls. It was observed that one patient had avascular necrosis (AVN) of the talus and one had mild compression of the talus.

All three joints of all feet were united. The mean union time was 12.4 (range: 7 to 36) weeks. Union was delayed (28 weeks and 36 weeks) in two patients, one of which had 75% union and the other one 90% on CT assessment. These were considered as acceptable values.

Preoperative and postoperative early and final control radiographic measurements of the patients are given in Table 3. Normal values of these angles are presented in Table 4.[6] In the preoperative period, 10 (66.7%) of the 15 feet had grade 0, 3 (20%) had grade 1, and 2 (13.3%) had grade 2 degeneration. In the final examinations, 6 patients (40%) had grade 0, 4 (26.7%) had grade 1, and 5 (33.3%) had grade 2 degenerative changes; a one-level increase in 6 feet, and a two-level increase in three feet. It was observed that different grades of degenerative changes developed, especially in the naviculocuneiform joints of the four patients who did not have foot degeneration in the preoperative period.

Mean plantar flexion, which was 18º (range: 10° to 23°) in the preoperative period, increased in the postoperative period to 30º (range: 21° to 35°) (p<0.0001). Mean dorsiflexion, on the other hand, was 4° (range: 1°

Table 4. Normal values of the radiographic parameters.

A-P Talocalcaneal angle (°)	15-30
Lateral talocalcaneal angle (°)	25-30
A-P Talus-1st metatarsal angle (°)	0-(-10)
Lateral talus-1st metatarsal angle (°)	(-4)-(+4)

In A-P planes (-) values show abductions, (+) values show adduction; In lateral planes (-) values show dorsal.(+) values show plantar flexion.

Fig. 3. Valgus position of the hindfoot. [Color figure can be viewed in the online issue, which is available at www.aott.org.tr]

to 7°) in the preoperative period and increased to 12° (range: 6° to 18°) postoperatively ($p<0.0001$).

The preoperative foot length mean of 24.5 cm (range: 21 to 26 cm) decreased to 23.7 cm (range: 20.4 to 25 cm) postoperatively. The rate of foot shortening in 7 patients was found to be 0.8 cm (range: 0.5 to 1 cm) on average.

In final examinations, two feet were at mild valgus (4°, 6°) (Fig. 3), three feet at mild varus (3°, 3°, 5°), and the remaining ten were at neutral position.

In the preoperative period, the AOFAS hindfoot stability score in all patients was 0, meaning all were unstable. In final examinations, however, the same score was 8 ($p<0.05$).

In this study of 15 feet of 11 patients, the preoperative AOFAS score was 39 (range: 15 to 52) and final examination score was found to be 88 (range: 76 to 94) ($p<0.0001$). Considering the AOFAS scale scores in combination with the functional and cosmetic results,[12] it was concluded that among the 15 feet, 9 (60%) were excellent, 5 (34%) were good and 1 (6%) was fair. Five of the male patients expressed satisfaction with the operation as they were pain-free and could step plantigrade, while 3 of the female patients expressed satisfaction due to cosmetic correction.

Discussion

Combining posteromedial soft tissue releases with wedge resection osteotomies carried out at various levels on the lateral colon in neglected clubfoot has been suggested by many authors.[14-17] As joint faces are destroyed in this method, growing is distorted and the foot remains relatively small. Some authors, on the other hand,[12,18-20] state that applying triple arthrodesis at a young age such as 8,[20] or at any age when the ossified center of navicula occurs, is a saving interruption. Some authors, such as el-Tayeby, have carried out cuboid and/or lateral closed calcaneal osteotomy together with massive medial soft tissue release on adolescent patients (aged 4-14).[21] Although growth cartilages are not damaged in this method, one foot remains slightly smaller than the other. Some authors[5,12,22] have carried out triple arthrodesis together with two-stage massive medial soft tissue release on mature feet. For 30 years, Dobbs et al.[23] followed the 73 feet of 45 patients on whom they had performed only soft tissue procedures. Their results show that the size of soft tissue interruption is parallel with the amount of functional deformity, and that recurrent soft tissue releases cause a tough, painful and arthritic foot and decrease life quality significantly. In the long term follow-ups, small or big joint degenerations of various levels were found in the tibiotalar and tarsal joints in almost all series; pseudoarthrosis and avascular necrosis were observed, and in some, talar flattening and skin ulcers developed.[20] As is clear then, no matter the age group or method used, in almost all cases, the foot is more or less affected and complications are possible. In a manner different from all other studies, we carried out triple arthrodesis together with single stage routine massive medial release only in mature feet for saving purposes in patients for whom no treatment alternative existed, other than triple arthrodesis. In line with the related literature, some of the complications mentioned above occurred in our series as well.

It has been stated that massive soft tissue releases on the medial decrease the amount of bones to be resected from the talus neck and subtalar joint, which decreases pseudoarthrosis, talar flattening and vascular necrosis incidence as it protects vascular structures.[24] Angus and Cowell[20] obtained good results in 3, fair results in 6 and bad results in 8 of the 17 idiopathic clubfoot patients whom they treated without soft tissue release. They explained that bone osteotomies alone did not yield good results, especially in cases with severe equinus deformities. On the other hand, Penny[4] stated that when extensile medial release is carried out with triple arthrodesis, it carries a potential risk of devascularization for the talus. According to Penny, it could be applied in young children, while direct triple arthrodesis is required in adults. The same study also suggested that a more proper and faster application is possible when only triple arthrodesis is carried out, and found that there was no difference between the two methods in terms of joint thickness, growth arrest and foot size.

There are several approaches to internal fixation in triple arthrodesis operations. The aim here is to decrease movement in the fusion area, maintain the continuity of reduction, and prevent recurrence and pseudoarthrosis.[7] While some authorities use no fixation materials,[12,25,26] others use K-wires, staples and screws.[4,6,12,20,22] However, those who do not use internal fixation materials apply a plaster cast for an average period of as long as three months. Penny[4] recommended fixation with K-wires for small feet as there is not adequate space, and U staples for bigger feet. Although many authors claim that screws are more effective than staples in rigid fraction, in the biomechanical study carried out by Meyer et al., neither material proved superior. There are also articles claiming that material-related complication rates reach 25% in triple arthrodesis done using rigid internal fixation.[18] In our cases, we used staples and did not encounter any problems.

The most common complication in triple arthrodesis is pseudoarthrosis. It is most commonly observed in talonavicular, calcaneocuboid and subtalar joints respectively.[13,27] Pseudoarthrosis rates are reported in the literature as 1-33%.[2,26,28,29] Ahmed[22] did not find pseudoarthrosis in any of a two-stage series of 7 cases. de Groot et al.[9] reported a union rate of 57% in all joints in the series in which they applied only primary triple arthrodesis. This rate is given as 47% by Wülker,[29] and 81% by Saltzman.[2] We did not observe any pseudoarthrosis in our series. While our results are similar to those obtained by Ahmed,[22] who applied two stage arthrodesis, they are better than those of other studies carried out with triple arthrodesis alone. Two of our patients developed delayed union (28 and 36 weeks), one in the talonavicular and the other in the calcaneocuboid joint. Insufficient cleaning of articular cartilages, inadequate contact of bone surfaces, lack or insufficiency of internal fixation, early loading and surgical mistakes are the main reasons for pseudoarthrosis.[20,30,31] We associated our pseudoarthrosis findings with several factors: our patients were young and all non-smokers, there were no neurovascular problems, a stable fixation was applied, spongious parts of the bones removed from osteotomy lines were used as graft, and early loading was given.

Avascular necrosis of the talus is an important complication in triple arthrodesis. It is considered to occur during talus resection to correct severe deformities, and to be due especially to damage of arterial structures at the talar dome lateral.[24] AVN of the talus was found to be 6.5% by Duncan, and 9.9%[24] by Angus and Cowell,[20] who carried out triple arthrodesis alone. In our series of 15 cases, we found AVN of the talus in only one patient (6.6%), who was both the oldest case and the one with the most severe deformity. Our result is in compliance with the literature that applied triple arthrodesis alone without carrying out soft tissue release.

Also discussed in the surgical treatment of neglected clubfoot is the question of whether to conduct soft tissue releases at single or double stages, if they are to be applied together with triple. Ahmed[22] applied a-two-stage surgical treatment on a series of 7 cases: posteromedial soft tissue releases, Steindler release, and planter dissection were applied in the first stage, and in the second stage six weeks later, bone resections and triple arthrodesis were applied. He recorded excellent results in all cases and stated that no pseudoarthrosis was found. Herold-Torok[12] also expressed their satisfaction with the two-stage surgical treatment. In the literature, we did not come across any studies that applied routine massive medial release and triple arthrodesis at a single stage in the surgical treatment of neglected clubfoot. In our patients, for whom we planned massive medial soft tissue releases and osseous interruptions together, we carried out both interruptions at a single session and found that our results complied with the two-stage literature.

In 7 of the patients who had unilateral operations, average contraction of foot was 0.8 cm (range: 0.5 to 1 cm). Hudson and Catterall[32] found this ratio to be maximum 2.5 cm. While not providing an amount, Yadav,[33] on the other hand, stated that the foot contracted in wedge resections conducted on the talus lateral. The foot is expected to contract to a certain degree after wedge osteotomies are carried out. We associated our patients not having much contraction with our avoiding extreme bone resections, filling the gaps with the spongious parts of the bones removed and arranging hindfoot equinus and varus with a good posteromedial soft tissue release.

Skin problems are also of importance in the surgical treatment of neglected clubfoot. Pell et al.[28] found that they encountered problems of superficial wounds in 4 of the 183 feet on which they applied triple arthrodesis without soft tissue release.

El-Tayeby[21] recorded that skin problems occurred in some soles of the 28 feet which were given trapezoid bone resection on cuboid with massive medial soft tissue release and that they were healed with wound care in a few days. Haddad et al.[34] stated that among the 33 patients on which they performed revision triple arthrodesis, they observed superficial infection in 2, deep infection in 1, and wound opening in 1 other. In their study, Doğan et al.[26] used triple arthrodesis and applied internal fixation on 12 of 30 feet, and they recorded that 2 developed superficial skin infection and 1 deep infec-

tion and skin necrosis, and that they grafted the necrosis. In the talectomy treatment of neglected pes equinovarus deformity on the 17 feet of 11 patients with neurovascular involvement, Yalçin et al.[35] recorded superficial infection in the staple root in 4 feet, and in the incision area in 2. Infection location and incidence in our patients comply with the literature. We associate the fact that in patients for whom we added the extensile medial approach we did not observe more skin problems than those in the literature to good bleeding control, clean wound care and prophylactic antibiotic treatment.

Making the patient bedbound for a shorter period of time and having them undergo operational trauma only once are the advantages of the single-stage method over two-stage applications. On the other hand, creating a larger soft tissue trauma with double incision and increasing the risk of infection and pseudoarthrosis together with large soft tissue opening are its disadvantages. This study is limited by the lack of an adequate number of patients, long follow-up results and a comparison group, and the fact that the results were assessed by the same surgeon.

Despite these shortcomings, we believe that the study is important from two aspects: 1) routine massive soft tissue release is carried out together with triple osteotomy in a single session, and 2) unlike many studies, it was applied on a rather specific-homogenous group (patients with neglected idiopathic clubfoot) rather than different groups such as those with poliomyelitis, cerebral palsy, pes planovalgus and arthrosis of traumatic origin.

In conclusion, a medial massive release operation carried out in a single session with triple arthrodesis is, despite some complications, effective in decreasing pain in neglected clubfoot deformities in adults, and by correcting the deformity obtains a stable foot and a foot that can step plantigrade.

Conflics of Interest: No conflicts declared.

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