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ORIGINAL ARTICLE

Early Functional and Anatomical Results of Surgical Management of Symptomatic Tarsal Coalition

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ABSTRACT

Background: Tarsal coalition represents a common cause of foot and ankle pain in adolescents. It is often overlooked in patients with foot and ankle pain. Talocalcaneal coalition management is still controversial. There are few long-term studies evaluating tarsal coalition resections. This study aimed to assess the early results of surgical management of symptomatic cases suffering from Tarsal Coalition Radiologically and clinically regarding pain relief and functional outcome.

Methods: In this study, 20 feet in 18 patients from both sexes suffering from symptomatic tarsal coalition were analyzed in a retrospective cohort study, presented to the Zagazig University Orthopedic Department between September 2021 and December 2022. Surgery was indicated for symptomatic tarsal coalition cases with flatfoot and heel valgus deformity, with a follow-up of 2 years.

Results: There were 11 males (61.1%) and seven females (38.9%) in the study group, with an average age of 15 years (between 11 and 19 years). A full history and clinical examination were done for all patients, pain assessment was performed using the VAS score, functional assessment was performed using the AOFAS score, and then radiological assessment was performed using X-rays and CT. The Procedure performed was coalition excision and triple arthrodesis. A combination of coalition resection with triple arthrodesis showed statistically significant improvement in functional, radiological, and foot alignment.

Conclusions: Surgical treatment of symptomatic cases suffering from tarsal coalition provides good clinical and functional outcomes. Triple arthrodesis is found to be an excellent surgical option in treating complicated cases of tarsal coalition with altered hindfoot biomechanics and heel valgus, causing clinical improvement.

Keywords: Talocalcaneal, Calcaneonavicular , Tarsal Coalition**.**

INTRODUCTION

Tarsal coalition is an anomaly of the foot described as an abnormal fusion between two or more tarsal bones, and it's considered a common cause of foot and ankle pain in childhood and early adulthood; however, it's often overlooked, and diagnosis is commonly missed in many patients especially in early stages **[1]**, it occurs mainly due to genetic error in the process of division of the tarsal bones during fetal development also abnormal differentiation and segmentation of primitive mesenchyme and failure of joint formation. Also, there are less common acquired causes, including trauma, inflammation, degeneration, or infection of the midfoot or hindfoot **[2]**. Although many studies were performed regarding tarsal coalition, the true prevalence of the condition is still unknown. The estimated range is from far less than 1% of the population to 1%- 2%; about 50% of these individuals have the anomaly in both feet and slight male predominance **[3]**. The most common type is calcaneonavicular coalition, followed by the talocalcaneal coalition, which represents nearly 90% of cases **[2]**.

Tarsal coalition is also classified according to the morphology of the bridging or the connection it can be bony(synostosis), fibrous (syndesmosis) or cartilagenous (synchondrosis) or combination of those depending on the timing of discovery and Imaging as the pathogenesis of the condition best described as progressive ossification of the bridging with increasing age**[4]**.

The onset of symptoms related to the tarsal coalition is variable; patients commonly present in the second decade of life with the progressive course as symptoms become more pronounced with the progression of the ossification of the coalition, Calcaneonavicular coalitions typically ossify sooner than do talocalcaneal coalitions thus the manifestations of CN coalition presented earlier than TCC (children aged 8–12years vs 12–16 years), however many cases are not diagnosed until early adulthood **[5]**.

Most patients present with mid-foot or hindfoot pain and stiffness, which is often first noted after trauma, weight gain, or an increase in athletic activity; physical examination often reveals decreased hind foot motion with preplans and hind foot valgus, which leads to a painful, rigid flatfoot deformity (loss of foot longitudinal arch). The forefoot is in abduction, and supination tarsal coalition can also be completely asymptomatic **[6]**.

Talocalcaneal (TC) can be detected in plain X-ray films in case of the presence of a bony coalition. Calcaneonavicular can be seen in oblique view; the diagnostic "anteater nose" sign can be seen, While talocalcaneal is best seen on the lateral view find the C-sign, which is due to the complete posterior ring around the talus while the beak sign due to impaired subtalar movement, coronal cuts computed tomography (CT) can detect type and location of tarsal coalitions. Also, 3-D CT analysis can be used in order to evaluate the morphological characteristics, while MRI is superior in the detection of early cases where there's a cartilaginous coalition (ossification has not yet occurred) **[7]**.

Tarsal coalition treatment can be conservative or operative treatment. Conservative methods in painless mobile patients include cessation of the athletic effort, provoking the condition with anti-inflammatory medications, foot orthosis, ankle stabilizing orthosis, and even cast immobilization can be beneficial.

Surgical options in advanced cases include excision of calition alone or corrective osteotomy of flat foot, arthroreisis even arthrodesis and fusion of hind foot **[2]**. The aim of this study is to assess early results of surgical management of symptomatic cases suffering from Tarsal Coalition Radiologically and clinically regarding pain relief and functional outcome.

METHODS

A retrospective cohort study was conducted between September 2021 and December 2022 after approval from the Zagazig University Hospital's ethical committee (IRB# 9531/11-5-2022). The sample size of the study was calculated to be 18 patients from both sexes; there were 11 males 61.1% and 7 females 38.9% in the study group with average age 15 years old between 11 - 19 years, with follow up 2 years.

Sample size

In this study 20 feet in 18 patients from both sexes, there were 11 males 61.1% and 7 females 38.9% in the study group with average age 15 years old (between 11 - 19 years).

Inclusion criteria were patients with flatfoot deformity due to calceneonavicular or talocalcaneal coalition, age between 10-20 years old, symptomatic patients only, and resectable or nonresectable coalition. The exclusion criteria include patients with flatfoot deformity of other etiology, age more than 20, surgically unfit patients, and Patients with symptoms and/or signs of infection.

Pre-operative assessment

Full history and clinical examination, including Foot & Ankle examination, was performed, as pain assessment using the visual analog scale (VAS) functional assessment using the American Orthopedic Foot and Ankle Score (AOFAS) described by **Kitaoka [8]**; this scale grades ankle, subtalar, talonavicular, and calcaneocuboid joint levels, then radiological assessment using X-rays were taken for pre-operative assessment of the planovalgus deformity and assessment of the correction postoperatively, those parameters include [Calcaneal pitch angle, Talofirst metatarsal angle lateral (Meary's angle), Talo first metatarsal angle AP, Talonavicular coverage angle (simmon's angle)]. Computed Tomography (CT) is very important for pre-operative assessment to detect the classification and configuration of coalition & extent of arthritis and also to differentiate resectable from nonresectable coalition. The procedure performed was coalition excision and triple arthrodesis. A combination of coalition resection with triple arthrodesis showed statistically significant improvement in functional, radiological, and foot alignment.

Surgical technique

Resection of Coalition with concomitant flatfoot reconstruction and Triple fusion, the technique is similar to the one described by Albert M D'Angelantonio.

The procedure is performed under Spinal or General anesthesia; the Patient was positioned supine on an operating table with all bony prominences well padded; pre-operative prophylaxis by antibiotics (3rd Generation Cephalosporin) was done. The leg was prepped and draped free after application of a mid-thigh tourniquet. The toes and forefoot were covered using a surgical glove or iodine adhesive plastic to prevent contamination from debris from the toenails. The lateral approach was used (Ollier approach), the lateral incision allows for exposure of the subtalar, sinus tarsi, calcaneal cuboid, and lateral talonavicular joint articulations, and a single approach was used instead of dual (medial & lateral) approaches to reduce wound complications.

The incision begins 1cm distal to the tip of the lateral malleolus along the lateral margin of the floor of the sinus tarsi and ends along the base of the fourth metatarsal **Figure 1A**.

The line is parallel and between the course of the intermediate dorsal cutaneous and sural nerves. Occasionally, a communicating branch between these two nerves may be seen and maybe carefully resected if it was traumatized during surgery. Lateral dissection is typically initiated. First, the peroneal tendons should be identified as running along the lateral inferior aspect of the calcaneus and calcaneal cuboid articulation and retracted inferiorly. Next, the extensor digitorumbrevis muscle belly is identified. The deep fascial, capsular, and periosteal tissues overlying the subtalar and calcaneal cuboid joint are opened simultaneously as one layer through an Inverted-L–shaped flap. The flap is then reflected distally. There may be a large venous plexus along the distal extent of the extensor digitorumbrevis muscle belly, so care should be taken to achieve proper hemostasis to prevent possible postoperative complications **Figure 1B**.

The sinus tarsi may now be visualized; the contents of the sinus tarsi are evacuated by using a hand rongeur or by placing a 15 blade along the osseous constraints of the talus and calcaneus and carefully moving the blade in a circular fashion. Care should be taken to remove all intertarsal ligaments to allow the calcaneus to be reduced from its valgus position. Visualization of the posterior facet of the subtalar joint can now be made through the void in the sinus tarsi **Figure 1C**.

A lamina spreader is then placed within the subtalar joint to allow wider exposure. Joint resection along the lateral extent of the foot is initiated through a technique referred to as contoured resection. This technique allows for the complete removal of all cartilage and subchondral plates from the joint surfaces, with an effort being made to maintain the anatomic contour. Maintaining the anatomic contour results in less shortening. The technique mainly uses hand instrumentation, including curettes and osteotomes. Power instrumentation, such as a rotary burr, may be used; however, fine anatomic structures may be sacrificed. Power instrumentation must be used carefully because overuse also enhances the thermal necrosis of bone **Figure 1D**.

Once appropriate resection of the subtalar joint and calcaneal cuboid joints has been performed, Use the Hohmann retractor to visualize the talonavicular joint, then use osteotome or blade to evacuate the joint and remove remnants of articular cartilage **Figure 1E.**

Once the cartilage and subchondral plate have been resected, the bone begins to display a speckled red appearance, also described as a paprika sign, indicating appropriate preparation of the joint surfaces. The bone surfaces may then be further prepared by fenestration with multiple small drill holes via a 0.62 K-wire or via fish scaling of the joint surfaces with an osteotome, which help to increase the vascularity and surface area, respectively, of the fusion sites.

Outpatient follow-up

Proper antibiotic and analgesics in the first 48 hours had been given postoperatively. Postoperative ankle and foot X –ray films were done for assessment of angle correction. Drain removed (if present) and wound dressing changed after 48 h before patient discharge.

The follow–up strategy focused on clinical assessment of pain (VAS), function (AOFAS), alignment also and Radiological assessment had been done by the different radiologic. For the subjective assessment a questionnaire had been completed for patient satisfaction with best score of 7 and worst score of 35.

STATISTICAL ANALYSIS

Data were fed to the computer and analyzed using IBM SPSS software package version 20.0 (Armonk, NY: IBM Corp). Qualitative data were described using number and percent. The Shapiro-Wilktest was used to verify the normality of distribution. Quantitative data were described using range (minimum and maximum), mean, standard deviation, median, and interquartile range (IQR). The significance of the obtained results was judged at the 5% level.

RESULTS

The total number of participants was 18 patients, 11 Males and 7 females. The average age was 15 years old, between 11-19 years. In the current study, the right-sided lesions were 10 of a total number, corresponding to 6 left-sided lesions, and 2 cases had lesions on both feet. (Table 1)

Regarding clinical assessment, there was functional improvement according to AOFAS scoring, which improved from 39.0 (33.0 – 46.0) preoperatively to 89.0 (84.0 –96.0) at the final follow-up six months postoperative, with a statistically significant difference between both values (Table 2)

As for Pain, assessment was done pre-operative, and at 1 and 6 months postoperative using VAS, the results show statistically significant improvement in pain. (Table 3)

Regarding radiological evaluation, there was an improvement in CPA from 7.50 (5.0 –9.0) pre-operative to 19.0 (17.0 –20.0) postoperative, with a statistically significant difference between both values. (Table 4)

Talo-1st Metatarsal angle in Lateral view (Meary's angle) improved from 18. 0 (16.0 – 19.0) pre-operative to 7.0 (5.0 –10.0) postoperative with statistically significant difference between both values (Table 5)

Talo-1st Metatarsal angle in anteroposterior view improved from 15.5 (14.0 –17.0) pre-operative to 7.5 (5.0 –9.0) postoperative, with a statistically significant difference between both values. (Table 6)

Talo-navicular coverage angle improved from 17.50 (15.0 –20.0) pre-operative to 7.50(5.0-10.0) postoperative, with a statistically significant difference between both values (Table S1).

Outcome: In spite of rate differences and various methods of fixation, all cases managed to achieve union (Table S2).

Complications: three feet (15%) were complicated by superficial wound infection, which was treated by daily dressing. One (5%) was complicated by the return of the loss of medial arch & recurrence and valgus mal-alignment, and the patient is scheduled for revision fusion. Two (10%) were complicated by ankle stiffness due to postoperative immobilization, which improved with physiotherapy. A statistically significant relation was found between wound infection and long operative time (Table S3).

Case Presentation

15-year-old male student complaining of left foot and ankle pain. Examination showed loss of the medial arch of the foot & heel valgus, limited subtalar motion, negative heel-rise test, AOFAS 38, VAS 7. Pre-operative imaging CPA 8, TN coverage 20, Meary l at 17, Meary Ap 18, valgus 23 (figure S1).

Procedure: Coalition resection and flat foot reconstruction and fixation with k. Wires & staples (figure S2).

Follow-up: Calcaneal pitch angle 15, Talonavicular coverage10, Talus 1st Metatarsal angle AP 4, Talus 1st Metatarsal angle lateral 9, Valgus angle 10, AOFAS Score 94, VAS Score 2 (figure S3).

Table 1: Age distribution in the study

Age (years)	**No.**	**%**
Min. – Max.	11.0 –19.0	
Mean ± SD.	15.22 ±2.21	
Median (IQR)	15.0 (14.0 –17.0)	
Side of the lesion in the study		
Right	10	55.6
Left	6	33.3
Bilateral	**2**	**11.1**

IQR: Inter quartile range, SD: Standard deviation

Table 2: Comparison between the pre-operative and final functional assessment according to AOFAS (n = 20)

AOFAS	**Pre-operative**	**Final**	**t**	**p**
Min. – Max.	33.0 –46.0	84.0 –96.0	70.030*	<0.001*
Mean ± SD.	39.65 ±4.28	89.50 ±2.95		
Median (IQR)	39.0 (35.0 –44.0)	89.0 (87.0 –91.0)		

t: Paired t-test: p-value for comparing between pre- and final, SD: Standard deviation
*: Statistically significant at $p \leq 0.05$, IQR: Inter quartile range

Table 3: Comparison between the three periods according to VAS (n=20)

VAS	**Pre-operative**	**One month**	**Final**	**Fr**	**p**
Min. – Max.	6.0 –9.0	4.0 –6.0	1.0 –3.0	39.519*	<0.001*
Mean ± SD.	7.55 ±0.94	5.25 ±0.79	2.0 ±0.79		
Median (IQR)	8.0 (7.0 –8.0)	5.0 (5.0 – 6.0)	2.0 (1.0 – 3.0)		
Sig. bet. periods	p_1=0.003*, p_2<0.001*, p_3=0.001*				

Fr: Friedman test, Sig. Bet. periods was done using the Post Hoc Test (Dunn's)
p: p-value for comparing between the different periods
p_1: p-value for comparing between pre and one-month
p_2: p-value for comparing between pre and final
p_3: p-value for comparing between 1 month and final
*: Statistically significant at $p \leq 0.05$
IQR: Inter quartile range SD: Standard deviation

Table 4: Comparison between the pre & postoperative CPA (n = 20)

CPA	**Pre-operative**	**Post-operative**	**t**	**p**
Min. – Max.	3.0 –12.0	13.0 –22.0	30.788*	<0.001*
Mean ± SD.	7.30 ±2.54	18.35 ±2.32		
Median (IQR)	7.50 (5.0 –9.0)	19.0 (17.0 –20.0)		
Mean correction	11.05 ±1.61			

t: Paired t-test p: p-value for comparing between pre and post-operative
*: Statistically significant at $p \leq 0.05$

IQR: Inter quartile range SD: Standard deviation

Table 5: Comparison between the pre & postoperative Talo-1st Metatarsal angle lateral view (n = 20)

MEARY LAT	Pre-operative	Post-operative	t	p
Min. – Max.	14.0 –23.0	4.0 –13.0	20.910*	<0.001*
Mean ± SD.	17.80 ±2.35	7.50 ±2.63		
Median (IQR)	18.0 (16.0 –19.0)	7.0 (5.0 –10.0)		
Mean correction	10.30 ±2.20			

t: Paired t-test
p: p-value for comparing between pre and post-operative
*: Statistically significant at $p \leq 0.05$
IQR: Inter quartile range SD: Standard deviation

Table (6): Comparison between the pre & postoperative Talo-1st Metatarsal angle AP view (n = 20)

MEARY AP	Pre-operative	Post-operative	t	P
Min. – Max.	12.0 –19.0	4.0 –12.0	35.600*	<0.001*
Mean ± SD.	15.45 ±2.06	7.50 ±2.44		
Median (IQR)	15.50(14.0 –17.0)	7.50 (5.0 –9.0)		
Mean correction	7.95 ±1.0			

t: Paired t-test p: p-value for comparing between pre and post-operative
*: Statistically significant at $p \leq 0.05$ IQR: Inter quartile range SD: Standard deviation

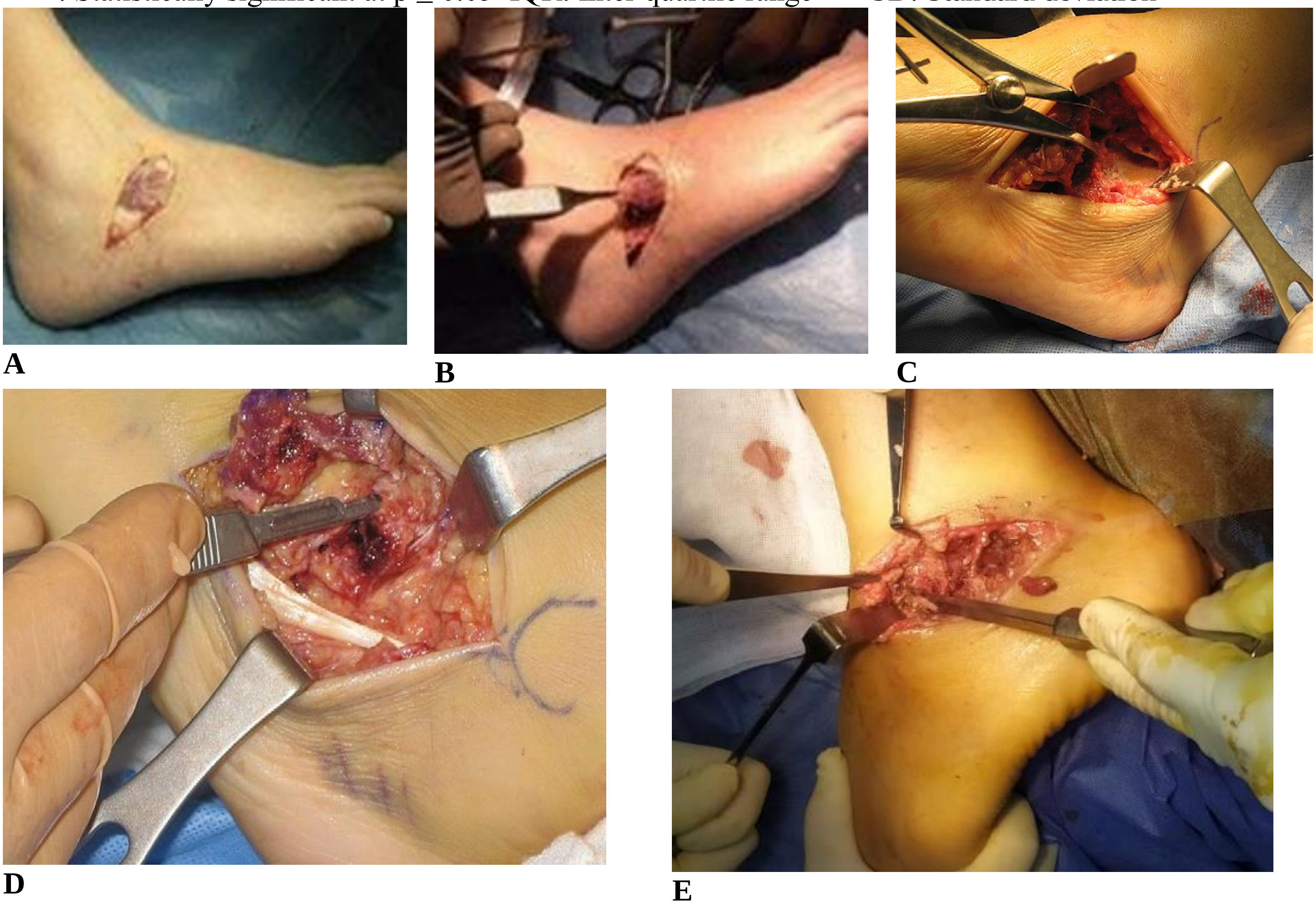

Figure 1: **A;** Skin incision of Ollier's approach, **B;** Reflection of EDB belly, **C;** Subtalar joint exposure. **D;** Visualization & evacuation of sinus tarsi, **E;** Exposure& evacuation of talonavicular joint

DISCUSSION

The study was conducted on 20 feet from 18 patients (11 males, 7 females) with flatfoot and valgus deformity secondary to Tarsal coalition with mean age 15±2.6 years (range, 11–19 years).

Frost et al. [9] studied 23 patients (30 feet) with rigid flatfoot, where 11 (15 feet) of them were secondary to tarsal coalitions. The mean age was 15.7 years (range 11.85–20.86 years). In **Javier Masquijo et al. [10]**, 13 patients (14 feet) were evaluated. Seven patients (eight feet) underwent simultaneous resection of the coalition and reconstruction (group I), and six patients (six feet) underwent isolated reconstruction (group II) with a mean age of 14 years.

First, regarding the evaluation of the function of the hindfoot:

The mean AOFAS score in this study improved from 39.65 ±4.28 (range, 33–46) to 89.50±2.95 (range, 84–96); in the study of **Doğan *et al.* [11]**, the mean AOFAS score improved from 39.3 to 90.8. In **Javier Masquijo *et al.* [10]**, this score in group I improved from 45 to 98 and improved in group II from 60 to 92.3.**deWouters *et al.* [12]** the study included nine adolescent patients with painful tarsal coalition treated by surgical resection, and this score improved from 68.4 to 92.22. **Giannini *et al.* [13]** studied 14 feet in 12 adolescent patients with painful talocalcaneal coalition treated by surgical resection and subtalar arthrodesis, and this score improved from 29.43 to 89.78. Our result is in agreement with **Doğan *et al*. [11], Javier Masquijo *et al.* [10],** and **Giannini *et al.* [13]** but against **de Wouters *et al*. [12]** because resection only can't restore normal foot alignment and function.

Second, regarding pain assessment:

Mubarak et al. [14] studied 69 patients (96 feet) with calcaneonavicular coalition performing coalition excision and fat graft transposition. VAS score improved from 6.7±1.9 to 0.3±1.9.

In our study, the VAS score improved from 7.55 ±0.94 (range, 6–9) to 2.0 ±0.79 (range, 1–3). There was significant improvement in pain using both methods.

Radiological evaluation:

Regarding CPA, **Child et al. [15]** recorded improvement in the mean angle from 14.2±5.64° (range,1.1–2.8°) to 16.34±5.4° (range, 5.9–27°), with a mean correction of 2.14°. **Frost et al. [9]** recorded improvement in this angle, with a mean correction of 8.3°. In the study by **Javier Masquijo et al. [10]**, this angle in group I improved from 11.57±1.4° to 20.14±0.9°, with a mean correction of 8.57°, and in group II, it improved from 12±3.1° to 21.5±2.5°, with a mean correction of 9.5°. **Quinn et al. [16]** recorded improvement in this angle from 16± 6° to 16.4±6°, with a mean correction of 11.05 ±1.61°.

In the current study, CPA also improved from 7.30 ±2.54° (range, 3–12°) to 18.35 ±2.32° (range, 13–22°) with a mean correction of 8.9°. The result is in agreement with **Child et al. [15], Frost et al. [9],** and **Javier Masquijo et al. [10]** but against **Quinn et al. [16],** as in triple arthrodesis, the medial arch could be corrected, but it could not be corrected after resection in **Quinn et al. [16]**.

Regarding the lateral T1stMTA, **Child *et al.* [13]** recorded improvement in the mean angle from 17.63± 8.10° (range, 3.8–34.7°) to 6.54±4.82° (range, 0.5–17.3°), with a mean correction of 11.09°. In the study of **Doğan *et al.* [17],** this angle improved from 6.2° to 1.8°, with a mean correction of 4.4°. **Frost *et al.* [9]** recorded an improvement in this angle, with a mean correction of 15.4°. The study of **Horton and Olney [18]** recorded an improvement in this angle, with a mean correction of 23°. In the study of **Quinn *et al.* [16]**, this angle improved from 9.1±8.3° to 9.4±7.6°, with a mean correction of –0.3°.

In this study, lateral T1stMTA improved from 17.80±2.35° (range, 14–23°) to 7.50±2.63° (range, 4–13°), with a mean correction of 10.30 ±2.20°.

Regarding AP T1stMTA, **Child *et al.* [19]** reported that the mean AP T1stMTA improved from 17.22±8.8° (range, 2.1–36.5°) to 8.73±5.97° (range, 0–25.2°), with a mean correction of 11.25°; **Doğan *et al*.[17]** reported that this angle improved from 14.7° to 3.9° with a mean correction of 10.8°; and **Frost *et al.* [9]** the mean correction of this angle was 9.1°; in Javier **Masquijo *et al.* [10],**

The mean AP T1stMTA in group I improved from 20.14±4.95° to 7.57±1.13°, with a mean correction of 12.57°, and in group II, it improved from 22.83±4.22° to 7.67±1.37°, with a mean correction of 15.16°. In **Quinn *et al.* [16]**, this angle improved from 14.7±9° to 13.7±10°, with a mean correction of 1°.

The angle in this study improved from 15.45±2.06 (range, 12–19°) to 7.50 ±2.44° (range, 4–12°), with a mean correction of 7.95 ±1.0°. Our result matches with **Child *et al.* [13]**, **Doğan *et al.* [17], Frost *et al*. [9]**, and **Javier Masquijo *et al.* [10]** but was against **Quinn *et al*. [16]**, as in our study, the abduction of forefoot and midfoot was corrected in all patients but was not corrected in **Quinn *et al.* [16]**.

Regarding the AP TNCA, **Quinn *et al.* [16]** recorded improvement in the mean angle from 22.9° to 18.9°, with a mean correction of 4°.

In the current study, this angle improved from 17.25±3.01° (range, 12–22°) to 7.35±2.35° (range, 3–11°), with a mean correction of 9.90 ±1.52°.

Our result is against **Quinn *et al*. [16],** which could be explained by lateral talar subluxation could be corrected by stable arthrodesis of the talonavicular joint in contrast to resection in **Quinn *et al* [16].**

Outcome:

Regarding Union, **Child *et al*. [13].** One (4.17%) was observed to have symptomatic nonunion and one (4.17%) had asymptomatic nonunion. **Frost *et al.* [9]** recorded two (8.7%) with nonunion, where one of them refused another surgery, and the other did a bone graft, and the full union was achieved. According to **Ohly *et al.* [20]**, there was no nonunion in the study; in this study, all patients achieved full union, but in one case, 5% had valgus malunion with a recurrence of flatfoot deformity.

Regarding wound complications, **Child *et al.* [15]** recorded wound infection with dehiscence in six (25%) patients, where four of them had their infection resolved with the use of systemic antibiotics and local wound care, whereas the other two required surgical debridement. All six of these patients went on to full healing. **Doğan *et al.* [17]** recorded superficial wound infections in two (6.7%) feet, which improved with antibiotic therapy and wound care, and one (3.3%) had deep cutaneous & subcutaneous infection and skin necrosis, which was treated by antibiotic therapy, debridement, and skin graft. **Frost *et al.* [9]** recorded two (8.7%) superficial wound complications treated by wound care and antibiotic therapy. **Javier Masquijo *et al.* [10]** recorded one (7.7%) superficial infection treated with oral antibiotics with complete resolution.

Quinn *et al.* [16] observed one (3.7%) superficial infection, which improved with oral antibiotics. **Ohly *et al*. [20]** reported only one wound complication in the study, which included 30 patients who had triple arthrodesis using only lateral incision. They also mentioned the beneficial use of the single lateral approach to reduce wound complications.

In our study, three feet (15%) had superficial wound infection on the lateral wound, which improved with daily dressing and antibiotic therapy. With close follow-up, no wound dehiscence occurred.

Regarding hardware complications, **Horton and Olney[18]** recorded one (7.14%) tibiotalar impingement symptom that required the removal of the talocalcaneal screw. **Child *et al.*[15]** Nine (37.5%) were observed with painful hardware treated by removal. **Frost *et al.* [9]** recorded four (17.4%) hardware-related complications necessitating the removal of the hardware. **Javier Masquijo *et al.* [10]** recorded one (7.7%) case with a prominent screw that required removal. In this study, there were no hardware complications.

Child *et al.* [15] observed ankle pain in one (4.17%) and prolonged postoperative pain in one (4.17%). **Frost *et al.* [9]** recorded two (8.7%) with sural neuroma, where one of them improved but did not resolve completely with desensitization and oral medicine, leaving the patient with residual pain, whereas the other patient was treated by surgical exploration and neuroma excision. In this study, there was no pain till the last follow-up. **Child *et al.* [15]** recorded chronic edema in five (20.83%) patients. **Frost *et al.* [9]** recorded one (4.3%) with a supinated forefoot requiring additional surgery, two (8.7%) with symptomatic bony prominence requiring additional surgery, and one (4.3%) developed Achilles tendonitis who responded to nonoperative measures. In this study, there were two (10%) patients who showed postcast ankle stiffness. Both improved after physiotherapy.

Strengths aspects of the current study which might augment its internal validity include; Retrospective cohort study design, matched patient groups, strict implementation of inclusion and exclusion criteria to avoid bias of including different pathological conditions, i.e. in the current study, no cases of associated pathological conditions and similar technical steps were employed in all cases.

The limitations of the present study include the small sample size. Follow-up duration was relatively short-term. The motion part in the AOFAS score was bypassed in this study due to loss of hindfoot motion postoperatively secondary to fusion. This made the comparison inaccurate with the same score in the studies concerned with resection without fusion, as the hind-foot motion was evaluated as being preserved postoperatively. All cases were complicated with advanced symptoms and altered biomechanics, forcing only the option of arthrodesis to restore normal alignment and function of the foot.

CONCLUSION:

Surgical treatment of symptomatic cases suffering from tarsal coalition provides good clinical and functional outcomes; Triple arthrodesis was found to be an excellent surgical option in the treatment of complicated cases of tarsal coalition with altered hindfoot biomechanics and heel valgus causing clinical improvement regarding pain relief (according to VAS score), functional improvement (according to AOFAS score) and also improvement of radiological parameters AP T1stMTA, AP TNCA, lateral T1stMTA and lateral CPA.

Recommendations

Large samples will be used in future studies to get more accurate results regarding the statistical score. Prolongation of the follow-up period to assess the late outcomes and complications. A specific modification in the AOFAS score for triple arthrodesis should be created to avoid bias in the statistical findings in comparing different studies. Screening for Tarsal Coalition in children complaining of ankle pain or recurrent sprains for early diagnosis of the case before the occurrence of arthritis and heel valgus makes it possible to intervene using less drastic solutions.

Conflict of interest: None

Financial Disclosure: None

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Table S1: Comparison between the pre & postoperative Talo-navicular coverage angle (n = 20)

TN coverage	Pre-operative	Post-operative	t	P
Min. – Max.	12.0 –22.0	3.0 –11.0	29.160*	<0.001*
Mean ± SD.	17.25 ±3.01	7.35 ±2.35		
Median (IQR)	17.50 (15.0 –20.0)	7.50 (5.0 –10.0)		
Mean correction	9.90 ±1.52			

t: Paired t-test p: p-value for comparing between pre and post-operative
*: Statistically significant at $p \leq 0.05$
IQR: Inter quartile range SD: Standard deviation

Table S2: Distribution of the studied feet according to union time (n=20)

Union time (weeks)	No.	%
<8	9	45.0
≥8	11	55.0
Min. – Max.	5.0 –10.0	
Mean ± SD.	7.25 ±1.48	
Median (IQR)	8.0 (6.0 –8.0)	

IQR: Inter quartile range SD: Standard deviation

Table S3: Distribution of the studied feet according to complications (n = 20)

Complications	No.	%
No	14	70.0
Yes	**6**	**30.0**
Ankle stiffness	2	10.0
Valgus mal-alignment	1	5.0
Superficial infection	3	15.0

Figure S1: Pre-operative flatfoot & hindfoot valgus. X-ray of lt foot, 1. AP 2. oblique 3. Lateral view

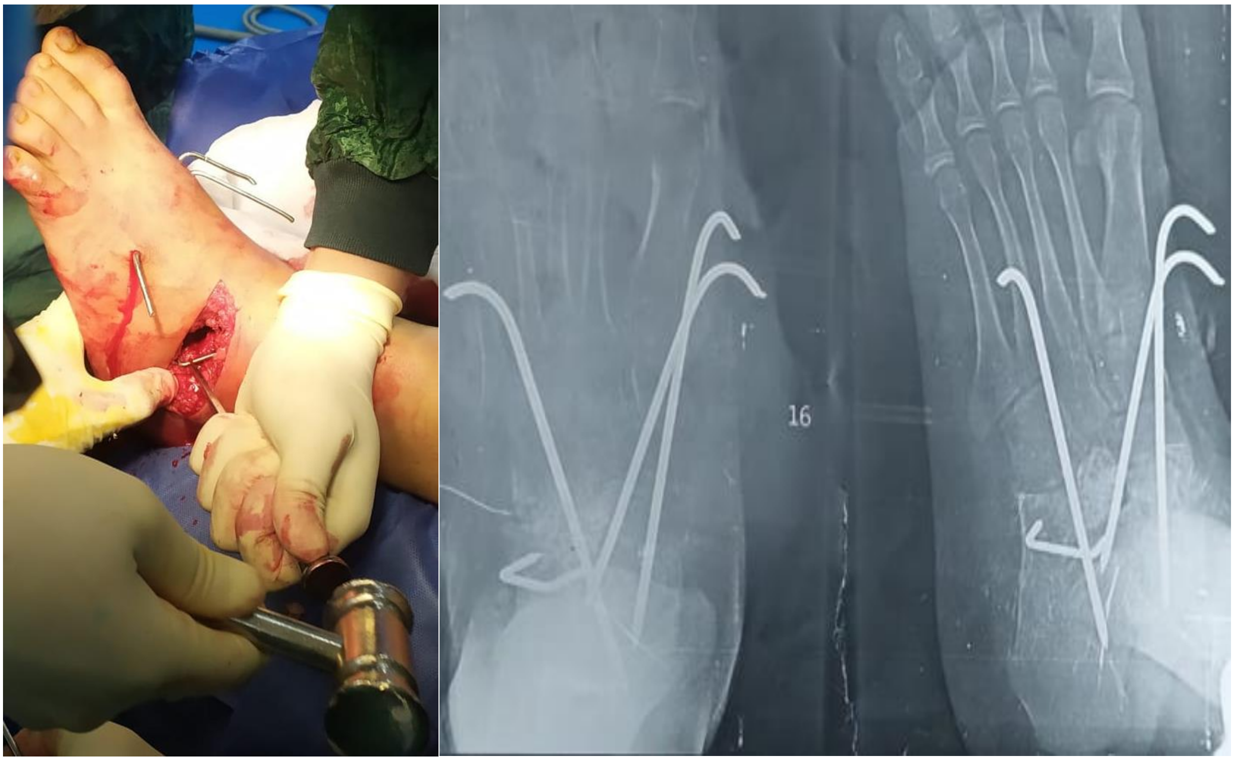

Figure S2: Intraoperative fixation using k. Wires and staples postoperative X-ray.

Figure S3: final follow-up foot X-ray, final follow-up ankle X-ray, wound in a final follow-up visit

Citation

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