PLANOVALGUS FOOT MANAGEMENT IN CHILDREN WITH CEREBRAL PALSY USING SUBTALAR ARTHROEREISIS.

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ABSTRACT

Purpose: The goal of this study was to see how effective subtalar arthroereisis with a specific screw was in correcting ambulatory children with cerebral palsy's flexible mild pes planovalgus deformity.

Method: Forty two children (18 girls and 24 boys) with average age 10 years (range, 5 to 15 years) with 80 feet with pes planovalgus (PPV) deformity were included in this study. Pre and postoperative radiological assessment of lateral Talocalcaneal angle (Lat. TCA), and heel alignment angles (HAA) had been done for all feet. Also, the presence of pain was assessed before and after the surgery by visual analogue scale (VAS). All cases were managed by arthroereisis of the subtalar joint using a special screw.

Result: There was a statistically significant decrease of LAT TCA (P<0.001), heel alignment angle (P<0.001) and visual analogue pain scale (<0.001) when compared to the preoperative values.

Conclusion: The results of the present study showed that it is an effective procedure, it has advantages over the other procedures such as shorter operative time, less complications, less postoperative period of immobilization, easier steps and preserving the chance for further surgery if failed.

KEY WORDS: Pes planovalgus, Arthroereisis

1. INTRODUCTION

A complicated three-dimensional malalignment (hindfoot valgus, midfoot planus, and forefoot abduction) is known as planovalgus deformity(1). Planovalgus deformity occurs in up to 42% of spastic diplegia patients and up to 68 percent of spastic quadriplegia patients. It generally manifests itself bilaterally(2). The major deforming forces that drive the foot into valgus are spastic and overactive peroneal muscles in certain children. Peroneal muscles that are spastic and hyperactive are most often observed in nonambulatory quadriplegic children, although they can also be seen in ambulatory children. In ambulatory children, an anomalous force environment is a serious problem. Spasticity, a condition in which the knee and ankle do not act as shock absorbers, causes this increased stress. In addition, because of the lack of motor control, the muscles in the foot are unable to function as secondary shock absorbers. The bones, joints, and connective tissue must absorb these tremendous pressures on a regular basis. The system collapses towards a direction where there are more stable osseous constraints as a result of these forces. Furthermore, gastrocnemius and soleus contractures increase the stress on the subtalar joint, which has a tendency to collapse. Torsional misalignments, particularly external tibial torsion, contribute a moment to the planovalgus, pushing it further into a severe deformity. The bone in children's foot is mainly cartilage, and the higher pressures distort the cartilaginous bones. The intrinsic structural stability of these irregularly formed bones with a substantial component of cartilage is reduced.

Planovalgus foot deformity has been linked to hereditary and racial factors, and these genetic factors are likely to have a role in the development of planovalgus deformity in children with CP as well. In addition, as the planovalgus deformity begins, the ligamentous tissues, such as the plantar fascia, are under greater strain. More stress is exerted when the deformity collapses, and the plantar fascia extends out, allowing for even more collapse. Despite the fact that there are a variety of factors for the onset of planovalgus, the deformity develops over a lengthy period of time, which is crucial for treatment planning and interpretation. As the planovalgus pathologic deformity progresses, the
foot moves into valgus, external rotation, and dorsiflexion in relation to the talus. As the deformity develops, the talus head becomes exposed medially and inferiorly. As dorsiflexion of the foot increases, the posterior condyle of the posterior facet subluxates out of the talus plateau, permitting posterior movement of the calcaneus on the talus and greater external rotation and dorsiflexion of the foot. In this process, there is a lot of variation in the relative degree and particular direction of motion. Some feet are mainly valgus, whereas others are more dorsiflexed and externally rotated. In a CP kid, PPV is generally asymptomatic. Atypical shoe wear, as well as pain from calluses and blisters in the talar head area, are common complaints. Hallux valgus develops over time as a result of the everted foot posture, which can be uncomfortable. Gait abnormalities resulting from lever arm dysfunction may develop over time. Treatment of planovalgus deformity is controversial. Even valgus foot orthotic assistance may not be required as long as the foot remains pain-free. Surgical therapy may be considered when all other options have been explored.

The surgery's goal is to create a corrected foot that allows for proper shoe use, bracing, standing, and pain alleviation, as well as to restore the lever arm to allow for proper push off. Several surgeries and techniques using a combination of soft tissue and bone surgery have been reported, including calcaneal lengthening, subtalar joint fusion, and triple arthrodesis. Arthroereisis was described for the first time by Lelievre in 1970. Vogler established the current biomechanical categorization system in 1987, categorising three types of implants: 1) To shift the subtalar joint axis and restrict the calcaneus’ internal rotation, an axis-altering prosthesis with a stem (vertically inserted in the sinus tarsi floor directly anterior to the posterior subtalar surface) and a superior head in contact with the lateral process of the talus is used, 2) Impact-blocking devices, similar to the first but with the head positioned somewhat farther anterior to impact on the talar lateral process, preventing anterior gliding and hence internal rotation., 3) Self-locking implants inserted along the sinus tarsi’s main axis to support the talar neck while avoiding contact between the talar lateral process and the sinus tarsi floor, limiting talar adduction and plantarflexion.

II. METHODS

A research was conducted on 42 ambulating children (16 were Gross Motor Function Classification System (GMFCS)I, 10 were GMFCS, and 16 were GMFCS) with bilateral spastic CP (18 girls and 24 boys) with an average age of 10 years between August 2019 and December 2020. (range, 5 to 15 years). All cases presented by symptomatic CP spastic flexible pes planovalgus were managed by arthroereisis of the subtalar joint using a special screw. we obtained informed written consent from their parents. In addition to arthroereisis, 10 limbs had accompanying Achilles tendon lengthening; either alone (4 patients with 8 limbs) or accompanied by medial hamstring release and supracondylar extension osteotomy (two out of the 10 limbs). Also, 10 limbs had accompanying patellar tendon plication. In addition, 24 limbs had accompanying soft tissue release around the hip, knee or both. SCEO was done in 12 limbs. Simultaneous surgeries designed to improve the entire gait pattern. Mean follow-up duration was 10 months, with shortest being 7 months and longest 17 months. The effectiveness of subtalar arthroereisis was assessed both radiologically (power of correction of the LAT TCA) and Clinically (Improvement of the HAA and VAS) via comparing the feet before and after the procedure.

Surgical technique:

All patients underwent surgery under general anaesthesis with endotracheal intubation. Perioperative antibiotic prophylactic doses were routinely used. All patients were positioned supine on a radiolucent operating table and image intensifier was tested ensuring ease of taking intraoperative radiographs. Tourniquet wasn’t used being non-bloody procedure. Sterilization and draping were performed as ordinary

A 2-cm skin incision was made on the lateral side of the hindfoot, focused on the sinus tarsi, just anterior and plantar to the tip of the lateral malleolus. (Fig. 1).
The contents of the sinus tarsi were debrided to remove the fatty tissue with many nerve terminals. A guiding pin was placed perpendicular to the calcaneus longitudinal axis from lateral to medial across the sinus tarsi. Intraoperative imaging with the c-arm was used to verify the location of the guide wire (Fig. 2).

The trial sizer was inserted into the guiding pin and moved from lateral to medial until the tip abutted the sinus tarsi’s medial border. The subtalar joint's range of motion was measured, and if correction was found to be insufficient, the remaining sizers were placed progressively until the necessary amount of subtalar joint mobility was attained. When the subtalar joint was limited to 2 degrees of eversion with the ankle at neutral, the correct size was found. The sizer was taken away. With a screwdriver over the pin, the slotted implant was advanced into the sinus tarsi until the leading edge was one to two threads beneath the lateral cortex of the overlying talar neck. An intraoperative radiography examination verified the implant's proper placement into the sinus tarsi. The trailing end of the calcaneus was roughly 5 to 8 mm away from the lateral wall. (Fig. 3).
Fig. 3: An intraoperative radiography examination verified the implant's proper placement into the sinus tarsi.

The subtalar joint's range of motion and alignment were reevaluated. To examine the location of the implant and the correction of the flatfoot deformity, simulated weightbearing anteroposterior and lateral images of the foot were acquired.

The guiding pin was withdrawn after physical and radiological confirmation that the implant was adequately placed, and the incision was closed in a layered way. Following wound closure, a bilateral walkable cast was applied (below knee in the event of arthroereisis alone or when associated by Achilles or peroneal lengthening, and above knee in the case of additional hamstring lengthening), with the emphasis on sculpting the cast to maintain heel varus/valgus alignment, plantigrade foot, and a well-supported medial arch. The casts were removed two weeks after surgery, and the wounds were examined. Immediately after surgery attention was paid to the following points: General condition of the patient after recovery from anaesthesia, Neurovascular condition of both lower limbs, Administration of analgesics and antibiotics on routine basis regarding types, doses, and forms and Close observation for the occurrence of operative or early postoperative complications.

The patient was discharged 24 hours after surgery with instructing the parents to the following points: Medications to be administered, Standing and walking as early as the patient can withstand (usually 4 to 5 days postoperatively).

The patient's first visit to the outpatient clinic was 2 weeks after surgery where casts were removed, wounds were checked, and postoperative radiographs were done ensuring proper positioning of screws.

Another visit to the outpatient clinic was paid 2 weeks later having standing lateral radiographs and photos for assessment of Lat. TCA and heel alignment angle.

There was no intention to remove screws unless there are complications requiring that removal.

Final assessment of Lat. TCA and heel alignment angle was performed at latest follow up visit comparing pre- and postoperative mean angle size and the mean angle improvement (in degrees). Also, the presence of pain was re-assessed by visual analogue score, in addition to the child's abilities which was re-evaluated by using FMS.

Statistical methods:
The data was coded and entered using SPSS version 26 statistical software for the social sciences (IBM Corp., Armonk, NY, USA). The mean, standard deviation, median, minimum, and maximum were used to represent quantitative data, while frequency (count) and relative frequency (percent) were used to summarise categorical data. To conduct comparisons between quantitative variables, the non-parametric Mann-Whitney test was utilised.

To compare serial measurements within each participant, the non-parametric Wilcoxon signed rank test was used (10). Correlations between quantitative variables were calculated using the Spearman correlation coefficient (11). A P-value of less than 0.05 was considered statistically significant.

RESULTS:
There was a statistically significant decrease of LAT TCA, HAA and VAS postoperatively when compared to the preoperative values (Table 1).
Table 1: Comparison between pre & post LAT TCA, HAA and VAS. *: Significant.

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Median</th>
<th>Minimum</th>
<th>Maximum</th>
<th>P value</th>
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<td>LTC angle pre</td>
<td>52.15</td>
<td>4.26</td>
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<td>40.00</td>
<td>65.00</td>
<td>&lt; 0.001*</td>
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<tr>
<td>LTC angle post</td>
<td>29.05</td>
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<td>18.00</td>
<td>38.00</td>
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<tr>
<td>HAA pre</td>
<td>20.80</td>
<td>3.66</td>
<td>20.00</td>
<td>14.00</td>
<td>30.00</td>
<td>&lt; 0.001*</td>
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<tr>
<td>HAA post</td>
<td>5.50</td>
<td>3.39</td>
<td>4.50</td>
<td>1.00</td>
<td>11.00</td>
<td>&lt; 0.001*</td>
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<tr>
<td>VAS Pre</td>
<td>7.00</td>
<td>1.11</td>
<td>7.00</td>
<td>6.00</td>
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<td>2.00</td>
<td>2.00</td>
<td>3.00</td>
<td>&lt; 0.001*</td>
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We had 8 limbs with complications related to the procedure; two feet with malpositioned screw (yet the foot was fully corrected) and another two with sinus tarsi pain that required removal of the screw. The maintenance of that correction at the patients’ latest follow up have drawn our attention to the stimulatory effect of the screw as hypothesized by Roth et al (12), but we think that, this requires more investigations to be proven. Also, two patients developed crouch gait bilaterally after tendo-achilles lengthening was done in addition to arthroereisis but the condition improved by wearing ground reaction ankle foot orthosis.

DISCUSSION:

There is no true consensus regarding the best way of treatment with a wide range of options starting from simple orthotics, up to the complex triple arthrodesis. The only thing that is agreed upon is that if planovalgus deformity is asymptomatic then no treatment is required. Our study was concerned about those patients with "moderate", flexible planovalgus deformity, who are symptomatic and have failed conservative measures, to whom the literature provides 2 main options; the Grice extra-articular arthrodesis (13,14) and lateral column lengthening as proposed by Evans (15) and popularized by Mosca (16). Despite Grice's claim that "the operational method is fairly easy," many surgeons have not found this to be the case, and numerous modifications have been created to address the difficulties that can emerge both during and after the procedure (17).

Complications of the Grice procedure include graft resorption, failure of the graft to unite, over-correction into varus and under-correction of valgus deformity (18,19). In 2 retrospective studies reviewing the long term results of patients who had undergone extra-articular arthrodesis for valgus deformities that were secondary to poliomyelitis, CP, myelodysplasia and other neuromuscular diseases, as well as congenital abnormalities (62 procedures in one and 149 procedures in the other), unsatisfactory results up to 61% and 46% were found respectively. Complications of the procedure included graft resorption, failure of the graft to unite, over-correction into varus and under-correction of valgus deformity (18,19).

Evans (15) invented the operation in 1975 as a treatment for bothersome idiopathic flatfeet in children and adolescents, however he cautioned that it is not suitable for children with spasticity because to the high rate of overcorrection. In 1995, Mosca (16) reported 20 cases of severe bothersome valgus deformities in babies who received calcaneal lengthening, six of whom had CP (8 feet). Clinical results were favourable in seven of the eight feet treated (87.5%).

The benefit of this technique is that the subtalar joint's mobility is retained, despite a substantial reduction in range of motion, especially when compared to a normal foot (3).

This technique works best on feet that are pliable and minimally misshapen. The operation has no maximum age limit; however, it is not indicated for severe deformity with fixed valgus or excessive joint hypermobility, as seen in some hypotonic youngsters. The calcaneal lengthening osteotomy is only for children who have reasonable ambulatory skills, which are characterised as full-time community ambulators with an assistive device (3).

This osteotomy is most effective in ambulators who do not use walking assistance, and it is not recommended for nonambulatory quadriplegic planovalgus deformities. The fact that this procedure works overtime is due to the fact that youngsters have some innate motor control, which is why it appears to function best in feet with enough motor control to allow them to be community ambulators (3).

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Poor results of Evans method are generally due to recurrence of planovalgus, or overcorrection into varus\(^{20-22}\). Other complications include graft dislodgment and dorsal subluxation of the calcaneocuboid joint\(^{22}\).

Recurrent deformity is the most common consequence following lateral column lengthening, and if the deformity becomes severe enough to need surgery, it should be corrected with a subtalar fusion. After a single failure, repeated lateral column expansion has little benefit. \(^{(3)}\)

Taking into consideration all that non-consensus about the indications of calcaneal lengthening, the way of postoperative follow up and its efficacy in treating planovalgus deformity in CP patients. And also; regarding that it is a relatively demanding surgery with both surgical and donor sites morbidity, the prolonged postoperative overall morbidity, the high poor results rates and the dramatic effect of its failure with the need of subtalar fusion, all of that had made calcaneal lengthening, like extra-articular arthrodesis, seem not to offer the best solution to our patients.

In CP patients, arthroereisis appears to address dysplasia in the talar plateau of the posterior facet of the subtalar joint by provoking a physical block of the calcaneus, preventing its posterior partial dislocation and breakdown into dorsiflexion relative to the talus, and re-establishing anatomic relationships of the hindfoot \(^{(3,23)}\). As a result, we were motivated to proceed with our study, which was designed to evaluate the efficacy of subtalar arthroereisis utilising a specific screw placed into the sinus tarsi for the treatment of flexible mild planovalgus deformity in children with cerebral palsy. The average age of our patients at the time of surgery was ten years in our research (range, 5-15 years). All 80 limbs of our patients showed improvement in their Lat. TCA, which varied from 18 to 38 degrees postoperatively with a mean of 29.05 degrees (SD 3.28), compared to 52.15 degrees (range 40-65 degrees) preoperatively, which was statistically significant with a p value <0.001.

### III. CONCLUSION:

Our study shows it is an effective procedure, it has advantages over the other procedures such as shorter operative time, less complications, less postoperative period of immobilization, easier steps and preserving the chance for further surgery if failed. In future research, it is suggested that the sample size be increased, the follow-up time be extended, and a study be allocated to link the footprint analysis with the radiological and clinical evaluation.

### REFERENCES


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