Improvement Pattern of Talo-first Metatarsal Angle in Congenital Pes Planus Due to Conservative Rehabilitative Measures

Saumen Kumar De¹, Debangshu Bhakat², Rajesh Pramanik³, Manomohan Biswas⁴, Sunil Kumar Basu⁵

ABSTRACT

Introduction: Pes planus is one of the commonest foot deformities during childhood. By measuring the talo-first metatarsal (TFM) angle radiologically, the condition can be classified as mild, moderate, and severe. This study is our humble attempt to put some light to assess the role of nonsurgical treatment approaches in cases of congenital pes planus with respect to the measurement of improvement in TFM angle.

Materials and methods: This prospective randomized open label control trial was conducted in the Department of Physical Medicine and Rehabilitation, Sambhu Nath Pandit Hospital, Lala Lajpat Rai Sarani, Kolkata, India, between December 2009 and November 2011, after obtaining clearance from the Institutional Ethical Committee clearance. Proper consent was taken from the legal guardian of the patient. Confirmed cases of congenital pes planus (flat foot) between 6 years and 18 years were included according to the inclusion and exclusion criteria and were being randomly subdivided into two groups. One group (group I) of patients received exercise (Ex) therapy, shoe modification (SM), and acetaminophen (paracetamol) SOS; and the other group of patients (group II) received Ex therapy, SM, electrical stimulation in the form of faradic foot bath (FFB), and acetaminophen (paracetamol) SOS; and after initial visit, these patients were followed up on 6th, 12th, 24th week, every time with respect to measurement of improvement in TFM angle.

Results: Statistically significant improvement (with p-value less than 0.05) was observed in group I, and similar type of observation was also found while analyzing the improvement in TFM angle among group II patients. But unfortunately, the comparative analysis by Student’s unpaired t test of the numerical variables of group I and II failed to show any statistically significant improvement pattern of TFM angle due to FFB itself.

Conclusion: The TFM angle radiologically is a good assessment scale for measuring the outcome of conservative management in case congenital pes planus (flat foot).

Keywords: Congenital pes planus (flat foot), Faradic foot bath, Talo-first metatarsal angle.

Indian Journal of Physical Medicine & Rehabilitation (2019): 10.5005/jp-journals-10066-0038

INTRODUCTION

Pes planus is one of the foot deformities common during childhood. Physiatrists are coming across more and more patients with pes planus, particularly of congenital etiology. This is due to the increased awareness of the parents, schoolteachers, and family members. Many theories have been advanced over the years about the cause of physiologic pes planus, and most centered around abnormal bone configuration, muscle imbalance, or ligamentous laxity. Jack¹ reviewed the anatomical types of flat foot and pointed out that in normal weight-bearing foot, an axis through the talus, the middle of the navicular, the medial cuneiform, and the metatarsals, showed a straight line on lateral radiographs taken with the patient standing. Per Adam’s outline of orthopedics, when the deformity persists into adult life it becomes a permanent structural defect, the tarsal bones being so shaped that when articulated they tend to form a straight line rather than an arch.² Per a study published in Clin Podiatr Med Surg, most developmental flat feet are present at birth. James V Ganley was a proponent of the philosophy that the talus was blamed for causing a flat foot deformity; however, Ganley felt that the talus was relatively innocent in the cause of this condition and the remainder of the bones of the foot were the true villains in the pathogenesis of the valgus foot.³ According to literature, lots of radiological angles are available for assessing pes planus such as talar axis-first metatarsal base angle (TAMBA), calcaneal axis-first metatarsal base angle (CAMBA), calcaneal-fifth metatarsal angle (arch angle), medial arch angle (MAA), calcaneal pitch (CP) angle, talus angle (TA), and talar-first metatarsal angle (TFM).⁴,⁵

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Source of support: Nil
Conflict of interest: None

By measuring the TFM angle radiologically, the condition can be classified as mild, moderate, and severe. In the mild case, the TFM angle is between 0° and 15°; in the moderate case, the TFM angle is more than 15°–30°; and in the severe case, the TFM angle is more than 30°. The normal TFM angle is 0°.⁶ Radiological assessment for categorization of flat foot as mild, moderate, and severe and further
follow-up are being done by measuring the TFM angle. Standing antero-posterior (AP), lateral, and 45° medial oblique radiographs should be obtained when there is varying degrees loss of longitudinal arch is suspected. According to Turek’s Orthopaedics Principles and Application, 6th Edition, in the normal standing AP radiograph, the talocalcaneal angle should be between 15° and 35°. Diversion of AP talocalcaneal angle to greater than 35° is an evidence of heel valgus. The midtalar line passing medial to the first metatarsal with the navicular displaced laterally is an evidence of forefoot abduction. In the standing lateral radiograph, the normal lateral talocalcaneal angle is between 25° and 50°. The talus first metatarsal angle should be about 0°. In the lateral view, the exact location of the loss of longitudinal arch can be determined. This sag may occur at the talonavicular joint, first naviculocuneiform joint, and first metatarsocuneiform joint, or a combination thereof. The normal range of the talus first metatarsal angle is −10° (varus) to +30° (valgus) equaling ±2 standard deviation (SD). The relationship of the forefoot to the hindfoot demonstrates an increasingly abnormal positive value of the talus first metatarsal angle. Because the talus is positioned vertically, the talohorizontal and tibiotalar angles approach 90° and 180°, respectively.

This study is our humble attempt to put some light to assess the role of nonsurgical treatment approaches available such as EX, SMs, electrical stimulations of intrinsic foot muscles in cases of congenital pes planus, with respect to measurement of improvement in TFM angle.

**Materials and Methods**

**Study Design**
A prospective randomized open label control trial.

**Place of Study**
The study was conducted in the Department of Physical Medicine and Rehabilitation, Sambhu Nath Pandit Hospital, Lala Lajpat Rai Sarani, Kolkata, India.

**Study Population**
Subjects of this study were selected from the patients attending the outpatient department, Department of Physical Medicine and Rehabilitation, Sambhu Nath Pandit Hospital, Kolkata, India.

**Study Period**
December 2009 to November 2011.

**Study Duration**
The study duration was 24 months.

**Sample Size**
The sample size of the study was 60.

**Inclusion Criteria**

**Patient Selection**
Confirmed cases of congenital pes planus (flat foot).

**Age-Group**
The study patients belonged to an age-group of between 6 years and 18 years.

**Exclusion Criteria**
The participant exclusion criteria are (1) acquired flat foot, (2) consent not given by the legal guardian, (3) flat foot as a part of syndrome complex, (4) flat foot complicated with infection or recent fracture, and (5) otherwise contraindicated for treatment option applied (e.g., flat foot associated with sensory changes).

**Study Group**
After getting Institutional Ethical Committee clearance, all the patients attending the outpatient Department of Physical Medicine and Rehabilitation, Sambhu Nath Pandit Hospital fulfilling the above-mentioned inclusion and exclusion criteria were being randomly subdivided into two groups. Randomization was done by computer-generated random number list. Software used for randomization is Win Pepi, version 10.

**Group: I (n = 30)**
These patients received Ex therapy, SM, and acetaminophen (paracetamol) SOS.

**Group: II (n = 30)**
Patients in group II received Ex therapy, SM, electrical stimulation in the form of FFB, and acetaminophen (paracetamol) SOS.

**Exercise Protocol**
Both the groups were given a set of four exercise to strengthen intrinsic foot muscles, tibialis anterior, and peronei muscles. The patients are to do the exercise for a duration of 10 minutes each twice a day.

**Shoe Modification**
All the patients were given medial heel wedge of 3/16 inch size (tapering to 0 laterally) placed between the outer and the inner sole for the mild cases. In the moderate cases, the patients were given medial heel wedge and medial arch support. Severe and heavier patients were given the Thomas heel in addition to the medial heel wedge and medial arch support.

**Electrical Stimulation**
All the patients of group II were being treated with electrical stimulation (FFB) in addition to Ex and SM/orthosis. They had 21 sitting, with one sitting per day.

**Follow-up Plan**
Initial visit or visit 1 (V₁), visit 2 (V₂) on 6th week, visit 3 (V₃) on 12th week, and visit 4 (V₄) on 24th week. At the initial visit and the subsequent visits, the TFM angles were measured and documented.

**Initial Visit (V₁)**
Thorough clinical examination including biochemical and radiological assessment was done on the very first visit and all the information were documented. After the initial assessment, the patients were being treated with different types of conservative modes according to the above randomization. All patients were advised some basic management which includes patient education regarding rest, using best type and shape of shoe (well-fitting shoes), correct method of standing and walking, using a pair of running shoes for the runners, control of body weight per body mass index (BMI), attempt to remove any provoking painful activity, and attempt to improve the posture of the foot. Aerobic conditionings were also advised. Advises were also given for improving the quality of life and the general well-being. The patients were followed up on the subsequent visits (i.e., 6th week, 12th week, and 24th week), and specific improvement patterns.
Assessment Parameters
At the initial visit, a demographic profile including age, sex distribution, and BMI were documented. The radiological assessment was also done by assessing the TFM angle for every patient in every visit.

Data Collection
Data were collected by taking detailed history of patients’ ailment, thorough clinical examination, radiological investigation of foot–ankle complex measuring the TFM angle on initial visit, and subsequent follow-up also. Parameter, namely, radiological improvement was considered for this study.

Data Analysis
All the data collected during this study period were analyzed by using statistical software Statistica version 6 [Tulsa, Oklahoma: StatSoft Inc., 2001] and GraphPad Prism version 4 [San Diego, California: GraphPad Software Inc., 2005] (Fig. 1).

Results and Analysis
Data collected in our study were analyzed using appropriate statistical tests and results were obtained. Statistical charts and diagrams represent statistical data (Fig. 2).

Software used
- GraphPad Prism version 4 [San Diego, California: GraphPad Software Inc., 2005]

Sample size, that is, the total number of patients included in our study is 60 (Fig. 3).
In each group, the number of patients is 30 (n = 30).

Age Distribution
From the Table 1 and Figure 4, it is noted that the mean age of group I is 11.27, median 11, and range is 6–18, with an SD of 4.03; and in case of group II mean age is 11.93, median 12, and range 6–18, with an SD of 3.19.
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**Sex Distribution**

As the Table 2 and Figure 5 show, the incidence is more or less similar in males and females of both the groups. The incidence among male is 53.33% in group I and 43.33% in group II; and the incidence among females is 46.67% in group I and 56.67% in group II.

**Table 2: Sex distribution: comparison of categorical variables between group I and group II**

<table>
<thead>
<tr>
<th>Group</th>
<th>Variables</th>
<th>Male</th>
<th>Female</th>
<th>Row totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group I</td>
<td>No.</td>
<td>16</td>
<td>14</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>Row%</td>
<td>53.33%</td>
<td>46.67%</td>
<td></td>
</tr>
<tr>
<td>Group II</td>
<td>No.</td>
<td>13</td>
<td>17</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>Row%</td>
<td>43.33%</td>
<td>56.67%</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>29</td>
<td>31</td>
<td>60</td>
</tr>
</tbody>
</table>

**Body Mass Index Distribution**

From the Table 3 and Figure 6, it can be observed that the mean BMI of group I is 17.77 with an SD of 2.19; and in case of group II, it is 17.99 with an SD of 1.75.

**Radiological Score (TFM Angle)**

From the Tables 4 to 6 and Figures 7 and 8, it is clear that Tukey’s multiple comparison test shows statistically significant improvement with p value less than 0.05 during the comparison of first and fourth visits, second and fourth visits, and third and fourth visits but fails to show improvement between second and third visits. Similar findings were also found while analyzing the improvement in TFM angle among group II patients.

Unfortunately, the comparative analysis by student’s unpaired t test of the numerical variables of groups I and II failed to show any statistically significant improvement pattern of TFM angle due to FFB itself.

**Discussion**

In the current medical practice, pes planus has becoming a real rehabilitation challenge in our society. Pes planus is relatively a more common condition, with an incidence of 23% among the public per Nelson Textbook of Pediatrics. According to the Cochrane review published in the European Journal of PMR, the prevalence rate varies a lot including even in 45% of pre-schoolchildren and 15% of older children. Chen et al. showed that the prevalence of flat foot in a child of 5–13 years was 28%, with a decreasing trend in age. An Indian study done by Sachithanandam et al. reported that the incidence of pes planus was 3.24% among those children who started wearing shoes before the age of 6 years. Rose stated that the critical age of development of plantar arch is 6 years. In our study, the mean age of presentation is 11.27 with an SD of 4.025 in group I and 11.93 with an SD of 3.19 in group II. We excluded patients less than 6 years of age due to difficulties with the use of modalities, education, assessment, and nondevelopment of arch till 6 years.

According to Chen et al., boys had a significantly higher frequency for flat foot compared to girls (35% in boys and 20% in girls). In our study, girls and boys were almost equally affected with this particular clinical problem (male:female = 8:7 in case of group I and 13:7 in case of group II).

Lots of literature described that different factors influenced the development of the foot arch and the factors contributing to the deviation. One important information per the literature is that an abnormally high percentage of children are overweight.
Although our study showed that the mean BMI of the affected children are approximately 18 in both the groups.

According to literature, many radiological angles are available for assessing pes planus such as TAMBA, CAMBA, calcaneal-fifth metatarsal angle (arch angle), MAA, CP angle, TA, and talar-first metatarsal angle (TFM). Per Lo et al., the TFM angle had the highest specificity for assessment of pes planus (90.3%), which is also supported by Younger et al.

The relationship of the forefoot to the hindfoot demonstrates an increasingly abnormal positive value of the talus first metatarsal angle. A reducible talonavicular joint is observed in oblique talus. Hamanishi published a new measurement system based on the review of 69 cases of congenital vertical talus. Hamanishi also introduced the measurements of TAMBA and CAMBA. Both TAMBA of about 60° and CAMBA of about 20° represent the transition from oblique talus to congenital vertical talus, which is a cause of congenital pes planus. Hamanishi described the following two radiographic angles: TAMBA and CAMBA. The changing point from a flexible oblique talus to rigid congenital vertical talus (CVT) is TAMBA of approximately 60° and CAMBA of 20°.

In our study, the conservative management by SM and Ex in group I, along with those having modalities such as FFB in group II patients, showed some inconsistent improvement in TFM angle in different time frame of treatment duration as in group I (without FFB); Tukey’s multiple comparison test showed statistically significant improvement with p value less than 0.05 during the comparison of first and fourth visits, second and fourth visits, and third and fourth visits but failed to show improvement between second and third visits.

Similar type of observation was also found while analyzing the improvement in the TFM angle in group II patients. Unfortunately, the comparative analysis by Student’s unpaired t test of the numerical variables of groups I and II failed to show

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**Table 4:** Comparison of numerical variables between groups I and II—Student’s independent samples (unpaired) t test

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean Gr. I</th>
<th>Mean Gr. II</th>
<th>t value</th>
<th>df</th>
<th>p</th>
<th>Valid n Gr. I</th>
<th>Valid n Gr. II</th>
<th>SD Gr. I</th>
<th>SD Gr. II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>11.27</td>
<td>11.93</td>
<td>-0.71</td>
<td>58</td>
<td>0.48</td>
<td>30</td>
<td>30</td>
<td>4.03</td>
<td>3.19</td>
</tr>
<tr>
<td>BMI</td>
<td>17.77</td>
<td>17.99</td>
<td>-0.42</td>
<td>58</td>
<td>0.67</td>
<td>30</td>
<td>30</td>
<td>2.19</td>
<td>1.75</td>
</tr>
<tr>
<td>TFMAnV</td>
<td>26.20</td>
<td>25.83</td>
<td>0.22</td>
<td>58</td>
<td>0.83</td>
<td>30</td>
<td>30</td>
<td>7.41</td>
<td>5.66</td>
</tr>
<tr>
<td>TFMAnV</td>
<td>26.20</td>
<td>25.83</td>
<td>0.22</td>
<td>58</td>
<td>0.83</td>
<td>30</td>
<td>30</td>
<td>7.41</td>
<td>5.66</td>
</tr>
<tr>
<td>TFMAnV</td>
<td>26.47</td>
<td>25.87</td>
<td>0.35</td>
<td>58</td>
<td>0.73</td>
<td>30</td>
<td>30</td>
<td>7.64</td>
<td>5.67</td>
</tr>
<tr>
<td>TFMAnV</td>
<td>26.87</td>
<td>26.47</td>
<td>0.22</td>
<td>58</td>
<td>0.82</td>
<td>30</td>
<td>30</td>
<td>7.93</td>
<td>5.78</td>
</tr>
</tbody>
</table>

**Table 5:** Group I: p value <0.001, number of groups = 4, F statistic = 13.953

<table>
<thead>
<tr>
<th>Tukey’s multiple comparison test</th>
<th>Mean diff.</th>
<th>q</th>
<th>p value</th>
<th>95% CL of diff.</th>
</tr>
</thead>
<tbody>
<tr>
<td>TFMAnV1 vs TFMAnV2</td>
<td>0.00</td>
<td>0.00</td>
<td>p &gt; 0.05</td>
<td>-0.31 to 0.31</td>
</tr>
<tr>
<td>TFMAnV1 vs TFMAnV3</td>
<td>-0.27</td>
<td>3.16</td>
<td>p &gt; 0.05</td>
<td>-0.58 to 0.05</td>
</tr>
<tr>
<td>TFMAnV1 vs TFMAnV4</td>
<td>-0.67</td>
<td>7.90</td>
<td>p &lt; 0.001</td>
<td>-0.98 to -0.35</td>
</tr>
<tr>
<td>TFMAnV2 vs TFMAnV3</td>
<td>-0.27</td>
<td>3.16</td>
<td>p &gt; 0.05</td>
<td>-0.58 to 0.05</td>
</tr>
<tr>
<td>TFMAnV2 vs TFMAnV4</td>
<td>-0.67</td>
<td>7.90</td>
<td>p &lt; 0.001</td>
<td>-0.98 to -0.35</td>
</tr>
<tr>
<td>TFMAnV3 vs TFMAnV4</td>
<td>-0.40</td>
<td>4.74</td>
<td>p &lt; 0.01</td>
<td>-0.71 to -0.09</td>
</tr>
</tbody>
</table>

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Fig. 6: Bar diagram showing body mass index distribution
any statistically significant improvement pattern of the TFM angle due to FFB itself.

**Drop Out**

We missed four patients (two from each group), as they did not turn up for follow-up visits.

**Limitations**

- Small number of sample population.
- Short duration of follow-up.
- Short duration of treatment with Ex, SM, and FFB is not sufficient enough to improve the radiological angle (TFM angle) of pes planus. Further study of long duration may be done to see the radiological improvement.

**Conclusion**

- Although there was symptomatic improvement with conservative management including FFB, the statistical analysis failed to show any radiological improvement in congenital pes planus.
- The conservative management showed some inconsistent improvement in the TFM angle in different time frame of treatment duration as Tukey’s multiple comparison test shows statistically significant improvement with \( p \) value less than 0.05 during the comparison of first and fourth visits, second and fourth visits, and third and fourth visits but failed to show improvement between second and third visits in patients of both groups. Unfortunately, the comparative analysis by Student’s unpaired \( t \) test of the numerical variables of groups I and II failed to show any statistically significant improvement pattern of the TFM angle.
- The TFM angle measurement could give important radiological information for assessment and follow-up of patients with congenital pes planus.

<table>
<thead>
<tr>
<th>Tukey’s multiple comparison test</th>
<th>Mean diff.</th>
<th>( q )</th>
<th>( p ) value</th>
<th>95% CL of diff.</th>
</tr>
</thead>
<tbody>
<tr>
<td>TFMAnV1 vs TFMAnV2</td>
<td>0.00</td>
<td>0.00</td>
<td>( p &gt; 0.05 )</td>
<td>-0.20 to 0.20</td>
</tr>
<tr>
<td>TFMAnV1 vs TFMAnV3</td>
<td>-0.03</td>
<td>0.63</td>
<td>( p &gt; 0.05 )</td>
<td>-0.23 to 0.16</td>
</tr>
<tr>
<td>TFMAnV1 vs TFMAnV4</td>
<td>-0.63</td>
<td>12.03</td>
<td>( p &lt; 0.001 )</td>
<td>-0.83 to -0.44</td>
</tr>
<tr>
<td>TFMAnV2 vs TFMAnV3</td>
<td>-0.03</td>
<td>0.63</td>
<td>( p &gt; 0.05 )</td>
<td>-0.23 to 0.16</td>
</tr>
<tr>
<td>TFMAnV2 vs TFMAnV4</td>
<td>-0.63</td>
<td>12.00</td>
<td>( p &lt; 0.001 )</td>
<td>-0.83 to -0.44</td>
</tr>
<tr>
<td>TFMAnV3 vs TFMAnV4</td>
<td>-0.60</td>
<td>11.37</td>
<td>( p &lt; 0.001 )</td>
<td>-0.80 to -0.40</td>
</tr>
</tbody>
</table>
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REFERENCES