Plantar pressure parameters for the functional description of residual clubfoot deformity

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Introduction
The treatment of congenital idiopathic clubfoot is still a controversial issue. The discussion about the advantages of conservative or operative procedures has not yet been solved and there is no general agreement about the optimum age for initial treatment. Furthermore, several surgical approaches have been described in the literature. Therefore, the purpose of the present investigation was to evaluate the dynamic plantar loading of previously treated clubfeet and to compare clinical and functional results after surgical treatment using plantar pressure measurements during barefoot walking.

Material & Methods
41 children with unilateral clubfoot (27 male, 14 female age 8.3±2.7 years, range 3-13 years) treated surgically with a dorsal (n=25) or dorsomedial (n=16) release were investigated. For clinical and radiographic evaluation, the scores according to McNicol (1) and McKay (2) were determined. Pedobarographic measurements were performed with a capacitive pressure distribution platform (EMED ST4, Novel Inc. Munich) during barefoot walking at self-selected speed. 5 trials were collected for each foot. The pressure patterns were subdivided in ten selected areas: medial and lateral heel, medial and lateral midfoot, medial, central and lateral forefoot, hallux, 2nd toe, lateral toes. Loading patterns were averaged and the parameters loading area, peak pressure, total force, contact time, impulse in were analyzed with a commercial software (Novel Navigator).

Results
Subjective satisfaction was excellent or good in 34 patients, fair in 7 patients. The average Macnicol score was good (102±17 points, range 55 to 120), the McKay score was fair (140±28 points, range 75 to 180). Passive range of motion was significantly reduced in plantar-/dorsiflexion (65° vs. 40°, p<0.0001) and in eversion /inversion (43° vs. 31°, p=0.0002). Significantly less heel rises indicated a reduced calf muscle strength (18 vs.13, p=0.0009). Differences in plantar loading characteristics were seen in the whole foot as well as in selected areas (Figs. 1 & 2):

Fig. 1: Summary of the significant differences of foot loading characteristics of the clubfeet in comparison with the contralateral feet.
For the **whole foot** a significantly lower maximum force (p=0.0003) and impulse (p<0.0001) were found under the clubfoot as compared to the contralateral foot.

The **medial heel** was significantly unloaded with a lower force (p<0.0001), peak pressure (p=0.04) and force-time integral (p=0.01) as well as a smaller contact area (p=0.01).

The load appeared to be transferred to the lateral mid foot which revealed a significantly higher force (p=0.0013), peak pressure (p=0.0002), force-time integral (p=0.0008), a larger contact area (p=0.0053), and longer contact time (p=0.0011).

Also in the forefoot a load shift from medial to lateral could be observed. The **lateral forefoot** demonstrated a significantly higher force (p=0.141) and peak pressure (p=0.0241) as well as a larger contact area (p=0.0197).

In the **central forefoot** the force (p=0.0003) and force-time integral (<0.0001), the contact area (p=0.0002), and the contact time (p=0.0011) were significantly reduced.

Furthermore, the **medial forefoot** showed a significantly reduced force (p<0.0001), peak pressure (p<0.0001), area (p<0.0001), force-time integral (p<0.0001) and shorter contact time (p<0.0001).

Finally, the **hallux** revealed a significantly lower force (p=0.0109), peak pressure (p=0.0162), and a reduced contact area (p=0.0131).

The differences can best be described and summarized when using indices of mediolateral loading show the most pronounced differences. The index that is based on the force-time integral medial and lateral to the long axis of the foot (a straight line connecting the center of the heel and the second toe) correlated significantly with the clinical scores (Fig. 3) indicating a more pronounced lateral loading with worse clinical outcome.

![Fig. 2: Example of a single patient with a residual clubfoot (right).](image)

**Fig. 2:** Example of a single patient with a residual clubfoot (right).

**Fig. 3:** Regression diagrams between the mediolateral loading factor (lateral force-time integral divided by medial force-time integral) and the two clinical scores.
Discussion
The present results show that dorsal or dorsomedial correction of the clubfoot results in good alignment of the forefoot and hind foot. Nevertheless, the pedobarographic measurements indicate persisting differences predominantly in the loading characteristics of the midfoot and forefoot. The correlation between pedobarographic and clinical results indicate that foot pressure measurements are a valuable tool in the analysis of residual clubfoot deformity. In the future, we want to use the pedobarographic parameters for longitudinal evaluation of clubfeet and to support the clinical decision process for potential surgical interventions.

References