The Morphology the Navicular Bone and its Talonavicular Articular Surface: A Comparison Between Congenital Flatfeet and Normal Controls

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Background

A combination of the geometry and functions of the tarsal bones, ligaments, plantar aponeurosis, and muscle-tendon complexes contribute to the complicated structure of medial longitudinal arch. However, the exact role of each component in both health and pathological conditions is still debated. It was hypothesized in this study that there might be morphological abnormalities in the bone and joint surfaces of the navicular bone, the keystone of the medial longitudinal arch, in healthy controls and patients with symptomatic congenital flatfoot deformities.

Methods

Weightbearing CT scans of 8 controls and 8 symptomatic congenital flatfeet were used for 3D segmentation of the navicular bones using Mimics. Then, the morphology of the bone was compared between the two groups using the methods described in Figures 1 and 2. The bone articular surface of the talonavicular joint was mapped and separated from the rest of the navicular and studied for detailed metrics (longitudinal axis length, width, depth) using GeoMagic Studio 10. Each articular surface was oriented to a rectangular shape to measure the length and width. The depth was calculated by Pythagorean theorem, using the measurements of the distance from the edge to the apex and the longest edge-to-edge distance of the surface.

Results

There was no statistically significant difference between the congenital flatfoot group and the controls in both morphology of the navicular bone and metrics of the bone articular surface (the talonavicular articulation). (Figure 1, Table 1)

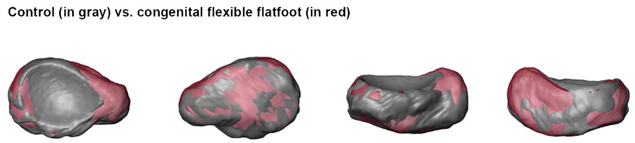

Figure 1. 3D remodeled navicular bones using WBCT scans
The 3D surface superimposition of means between the control and congenital flexible flatfoot. Shapes of naviculars are shown in proximal, distal, plantar, and dorsal views from left to right.

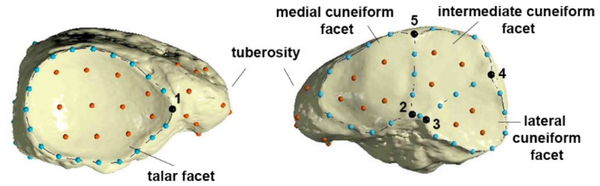

Figure 2. Anatomical position of the navicular (orange) in the medial column of the foot
The placement of the landmarks and semi landmarks configuration: Five fixed landmarks (black), 46 curved semi-landmarks (light blue) describing the corresponding articular surface counters, and 34 surface semi-landmarks (orange) on the articular surfaces and navicular tuberosity.

Congenital flatfoot	Navicular Surface Area	Length	Width	Depth
CF 1	537.10	23.92	21.66	7.55
CF 2	531.93	24.44	22.33	9.14
CF 3	400.10	23.97	17.53	8.43
CF 4	484.95	27.84	19.44	6.31
CF 5	425.42	26.79	17.46	7.73
CF 6	614.06	29.15	23.41	9.42
CF 7	458.60	27.13	19.17	5.61
CF 8	467.58	26.85	19.76	5.40
Mean	489.97	26.26	20.10	7.45
Standard deviation	68.80	1.94	2.18	1.54
Controls				
Control 1	472.12	27.50	18.28	5.62
Control 2	576.97	27.31	22.10	4.50
Control 3	579.07	27.49	21.65	7.90
Control 4	523.14	26.31	21.02	8.01
Control 5	433.49	24.32	17.93	6.28
Control 6	329.63	23.19	15.65	6.52
Control 8	358.35	22.77	17.37	4.11
Control	409.36	24.46	18.26	4.35
Mean	460.27	25.42	19.03	5.91
Standard deviation	94.56	1.97	2.29	1.54

Table 1. Morphometrics of the bone articular surface in the congenital flatfoot (CF) and control groups. Areas in $mm^2$and other measurements in mm.
There was no statistically significant difference in any measurements between the two groups

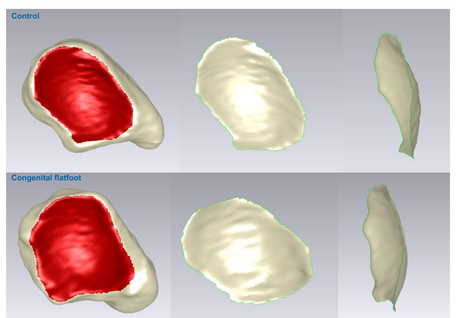

Figure 3. 3D remodeled navicular bone articular surfaces using WBCT scans

Conclusions

In this pilot study with a small sample size, there was no significant difference observed in morphology of the navicular bone and its talonavicular articular surface between the congenital flatfoot group and the controls.

Implications

Further study with a larger sample size and more detailed information of the articulation contours using a different software are under investigation by our research group.

Disclosures

The authors have nothing to disclose.