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Title: Morphology of the Naviculocuneiform Joints: A Cadaveric 3D Surface-Mapping Study

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ABSTRACT

Background

The naviculocuneiform (NC) joint complex plays a central role in medial column stability, midfoot load transfer, and maintenance of the medial longitudinal arch. Morphologic variation or degeneration at the NC joint may contribute to pathologies such as adult-acquired flatfoot deformity (AAFD), progressive collapsing foot deformity (PCFD), midfoot arthritis, cavus deformity, and various midfoot coalitions and traumatic injuries [1-8, 9-12, 16, 25]. Despite its clinical importance, there is a relative scarcity of high-resolution morphometric data describing NC joint articular surfaces, particularly at the level of the cartilage and its relationship to underlying bone dimensions.

Objective

To characterize the 3D morphology of the NC joint cartilage surfaces and evaluate correlations between cuneiform bone geometry and articular surface area using advanced surface-mapping techniques.

Methods

Twenty-four fresh-frozen cadaveric feet without evidence of midfoot deformity, significant traumatic or degenerative changes, or prior foot and ankle surgery were dissected to isolate the navicular and the medial, intermediate, and lateral cuneiform bones. The Artec Space Spider 3D scanner was used to generate high-resolution surface maps of articular cartilage surfaces. Segmentation and surface reconstruction were performed in Mimics and GeoMagic Studio 10. Morphometric variables included articular surface area and longitudinal axis length of each cuneiform. Descriptive

statistics and Pearson correlations between longitudinal axis length and articular surface area were calculated in SAS (v9.4) with statistical significance set at $p < 0.05$.

Results

The mean NC articular surface area measured $232.72 \pm 42.72 \text{ mm}^2$ on the navicular and $225.58 \pm 39.58 \text{ mm}^2$ on the medial cuneiform. The longitudinal axis length of the medial cuneiform averaged $25.21 \pm 2.66 \text{ mm}$. Significant positive correlations were identified between cuneiform bone length and NC articular surface area across all three cuneiforms. A 1-mm increase in cuneiform bone length corresponded to articular-area increases of 7.19 mm^2 (medial), 15.32 mm^2 (intermediate), and 13.41 mm^2 (lateral) with $p < 0.05$. High-resolution mapping also revealed distinct intra-cuneiform articular facets between medial-intermediate and intermediate-lateral cuneiforms.

Conclusion

This study provides a detailed, high-resolution 3D morphometric description of NC joint cartilage surfaces. The strong correlations identified between cuneiform geometry and articular morphology highlight that NC morphology follows predictable geometric patterns with potential clinical relevance. These findings may improve understanding of midfoot biomechanics, guide surgical planning, and inform evaluations of medial column pathology.