

Taylor Barg<sup>1</sup>, Mingjie Zhu, DAOM, MPH<sup>2</sup>, Jingdian Huang<sup>1</sup>, Conor Wallace<sup>1</sup>, Charles Nolte<sup>1</sup>, Michael Nocek<sup>1</sup>, Alasdair Younger<sup>1</sup>, Caley Orr<sup>1</sup>, Mark S Myerson, MD<sup>2,3</sup>, Shuyuan Li, MD, PhD<sup>2,3</sup>

1. University of Colorado School of Medicine, Denver, CO, USA  
2. Department of Orthopaedic Surgery, University of Colorado School of Medicine, Denver, CO, USA  
3. Steps2Walk, Inc, Denver, CO, USA

## BACKGROUND

The naviculocuneiform (NC) joint is a crucial component of the midfoot complex, playing integral roles in weightbearing, shock absorption, and contributing to the overall stability and flexibility of the foot arch. Dysfunction or pathology affecting these joints can lead to significant impairments in foot mechanics, resulting in conditions such as pes planus or pes cavus and various inflammatory or degenerative disorders. This study utilized 3D surface mapping to evaluate the morphometrics of the cartilage surfaces within the NC joint.

## OBJECTIVE

This study utilized 3D surface mapping to evaluate the morphometrics of the cartilage surfaces within the NC joint.

## METHODS

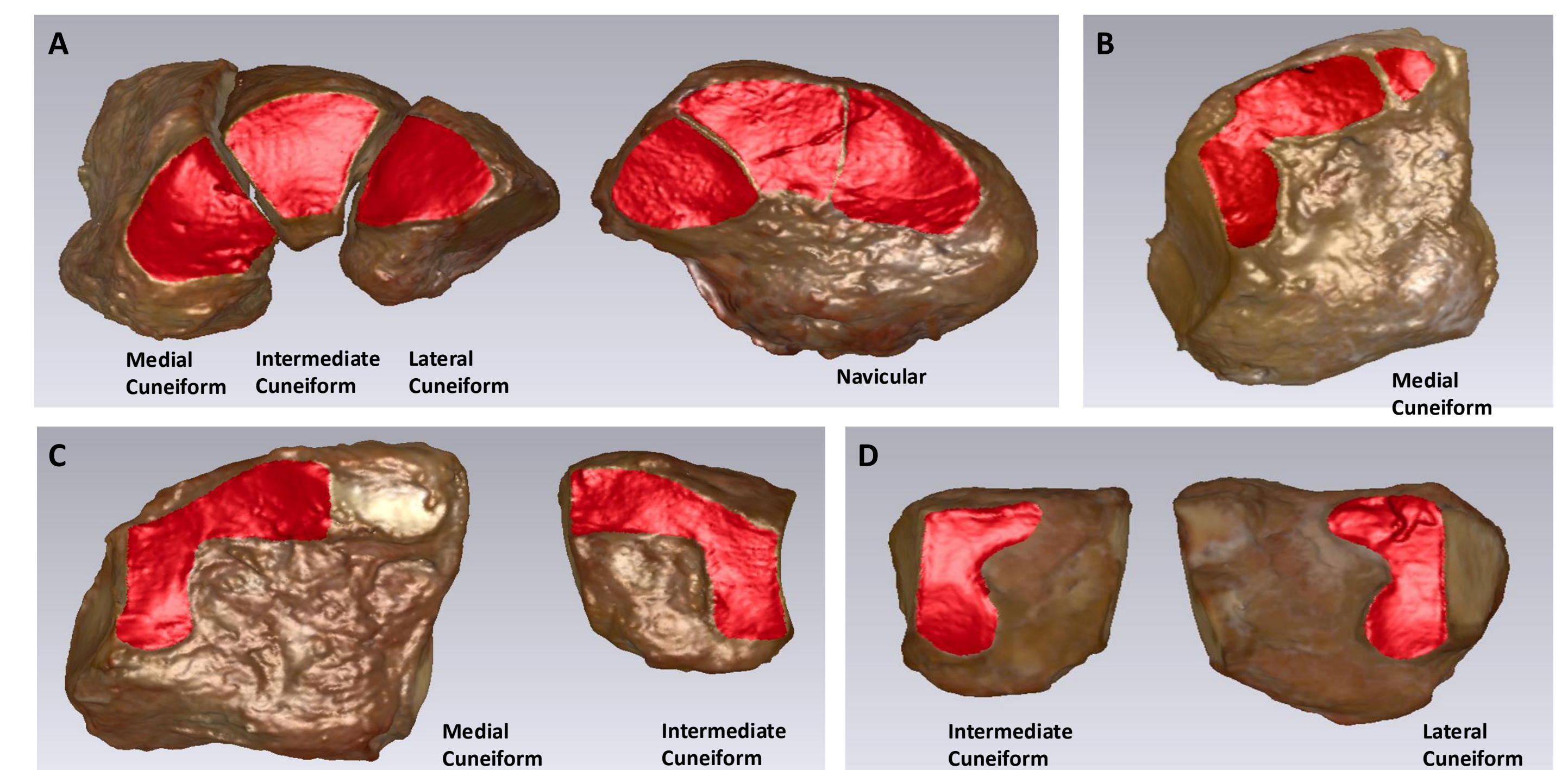
24 fresh frozen cadaveric feet were included, each devoid of trauma, surgery, or deformities. The navicular and 3 cuneiform bones were exposed. By employing the Artec Spider 3D Scanner, meticulous surface mapping of the articular surfaces and the bones was undertaken. Subsequent digital analysis was conducted using GeoMagic Studio 10 (Figure 1). Descriptive and correlation analyses were performed using SAS software. Correlation coefficient was analyzed. Statistical significance level was set to  $P < .05$ .

Corresponding author:

## RESULTS

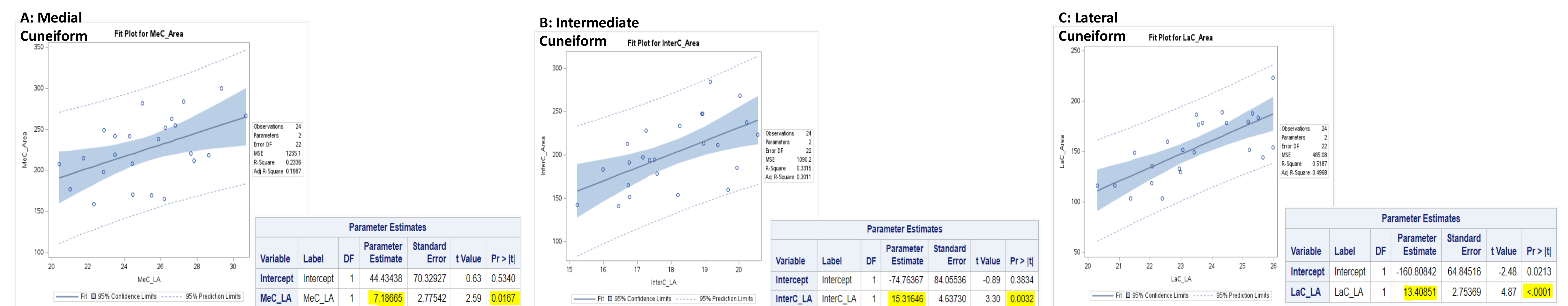
Means and SDs of the articular surface and the bone length were summarized for the NC joint, along with the related intraarticular joints (Table 1). The average articular area of the NC joint was  $232.72 (\pm 42.72)$  mm<sup>2</sup> on the navicular,  $225.58 (\pm 39.58)$  mm<sup>2</sup> on the medial cuneiform, with the longitudinal axis length measured  $25.21 (\pm 2.66)$  mm for the medial cuneiform. Statistically significant correlations between the articular-area and the longitudinal axis length of the bone were found on all three cuneiforms. 1 mm bone length increase was correlated with 7.19 mm<sup>2</sup> articular-area increase on medial cuneiform, 15.32 mm<sup>2</sup> on the intermediate cuneiform, and 13.41mm<sup>2</sup> on the lateral cuneiform ( $P < 0.05$ ) (Figure 2).

Joint	Joint Facet	Cartilaginous Surface	Cartilaginous Articulation Area (mm <sup>2</sup> )		Longitudinal Axis Length (mm)	
			Mean	SD	Mean	SD
NC Joint	Navicular - Medial Cuneiform	Navicular	232.72	42.72	NA	NA
		Medial Cuneiform	225.58	39.58	25.21	2.66
	Navicular - Intermediate Cuneiform	Navicular	193.42	44.36	NA	NA
		Intermediate Cuneiform	201.97	39.49	18.07	1.48
	Navicular - Lateral Cuneiform	Navicular	146.91	27.92	NA	NA
		Lateral Cuneiform	154.18	31.05	23.49	1.67
Intraarticular Joints	Medial Cuneiform - Intermediate Cuneiform	Medial Cuneiform	175.51	37.79	Data same as above	
		Intermediate Cuneiform	163.84	37.31		
	Intermediate Cuneiform - Lateral Cuneiform	Intermediate Cuneiform	106.47	25.35		
		Lateral Cuneiform	105.79	27.19		



**Figure 1.** 3D remodeled naviculocuneiform joint and intraarticular joints using the surface mapping technique. A) NC joint, each facet was distinguished. B) The lateral side of medial cuneiform was shown, indicating the joint between 1) medial cuneiform and intermediate cuneiform, and the one between 2) medial cuneiform and 2<sup>nd</sup> MT were two separated cartilaginous surfaces. C) Intraarticular joint between medial and intermediate cuneiforms. D) Intraarticular joint between lateral and intermediate cuneiforms.

**Table 1.** Morphological data of the NC and intraarticular joints measured using surface mapping.  
\*: Longitudinal Axis Length was defined as the distance between the anterior and posterior articular surfaces on the cuneiform (center of NC joint surface to center of TMT joint surface).



**Figure 2.** Based on correlation analysis, There were statistically significant correlations between the articular-area and the longitudinal axis length of the bone on all three cuneiforms. 1 mm bone length increase was correlated with 7.19 mm<sup>2</sup> articular-area increase on medial cuneiform, 15.32 mm<sup>2</sup> articular-area increase on intermediate cuneiform, and 13.41mm<sup>2</sup> articular-area increase on lateral cuneiform ( $P < 0.05$ ).

## CONCLUSIONS

This study provides valuable insight into the morphological characteristics of the NC joint using advanced 3D surface mapping techniques. The observed variations in cartilage morphology and joint architecture underscore the complexity and individuality of these joints within the midfoot complex. These findings contribute to our understanding of the biomechanics and function of the NC joint, which are crucial for maintaining foot stability and facilitating locomotion. Future research directions may involve investigating the relationship between joint morphology and biomechanical function.