Application of Center of Rotation of Angulation (CORA) Principles to the Sagittal Plane of the First Ray

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Statement of Purpose and Literature Review

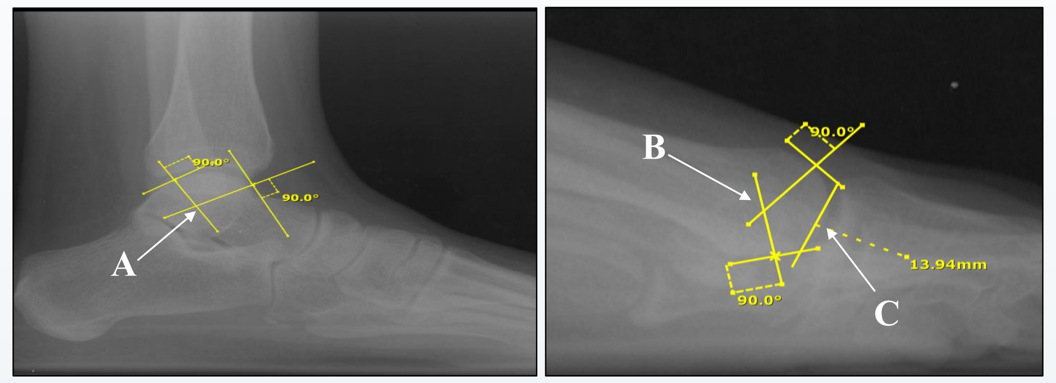
Several contemporary investigators have recently attempted to apply center of rotation of angulation (CORA) principles to forefoot surgery [1-2]. The concept of CORA has traditionally been described in terms of the mechanical and anatomical axes of the long bones of the lower extremity, specifically in the frontal and sagittal planes [3-4]. The foot-specific studies have focused on the transverse plane of the hallux abductovalgus (HAV) deformity [1,2]. Although this is consistent with previously published literature which primarily focuses on HAV in the transverse plane, it likely does not take into account the established triplanar nature of the deformity [5-6]. We are unaware of any investigation which has specifically looked into the mechanical or anatomical axes of the sagittal plane of the first ray, for example.

Therefore the objectives of this original investigation were to 1) attempt to define the mechanical axis of the first ray in the sagittal plane and 2) examine the relationship of the first ray sagittal plane mechanical axis in rectus foot types, feet with HAV deformity, and feet with hallux limitus/rigidus (HL/HR) deformity.

Methodology

Following IRB approval, weight-bearing lateral radiographic projections of 5 rectus feet, 5 feet scheduled to undergo a cheilectomy, and 5 feet scheduled to undergo a HAV reconstruction were evaluated. A rectus foot was defined as one without a history of foot/ankle surgery or trauma, and observed normal ranges of the calcaneal inclination angle, talar declination angle, first intermetatarsal angle, Meary's angle and the first metatarsal inclination angle.

Using principles outlined by Paley et al, first the center point for the talar body (Point A, Figure 1), the first metatarsal head, (Point B, Figure 2) and the hallux proximal phalanx base (Point C, Figure 2) were identified [3,4,7,8]. Points A and B were connected and named Line AB. Points A and C were connected and named Line AC. Line AC was considered the mechanical axis of the medial column (Figure 3). Any resultant angular deviation between Line AB and Line AC was measured and considered the angle of mechanical axis deviation. Any deviation between Lines AB and AC was also physicially measured at the level of the hallux proximal phalanx (Figure 3).



Figures 1 and 2: The centers of the talar body (Point A), first metatarsal head (Point B) and base of the hallux proximal phalanx (Point C) were first identified from lateral radiographic projections.

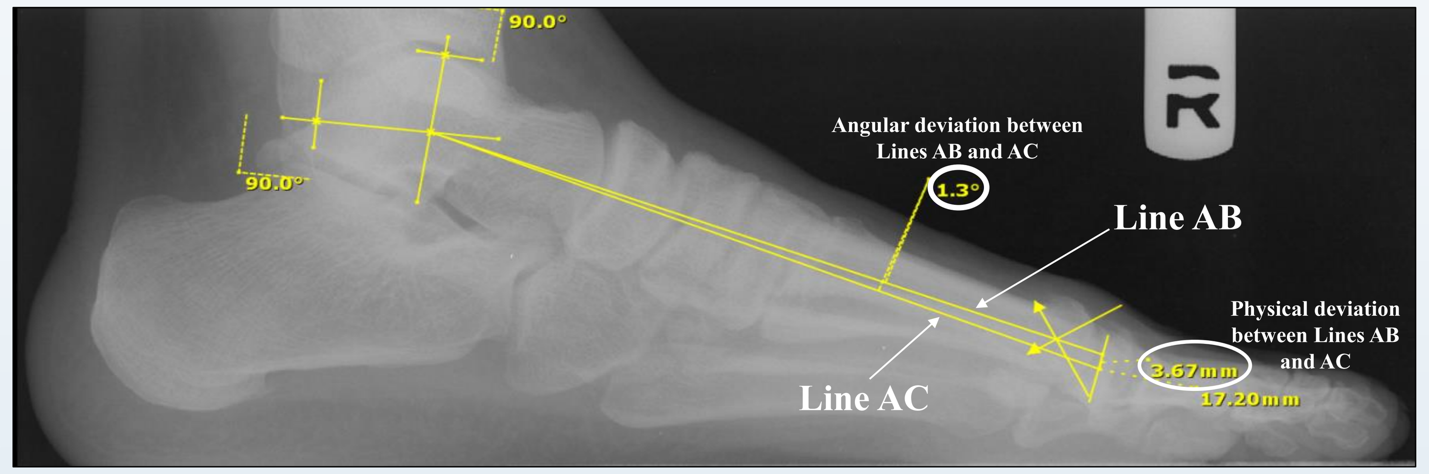


Figure 3: Line AB was subsequently created connecting the center of the talar body and first metatarsal head, and Line AC connecting the center of talar body and the center of the base of the hallux proximal phalanx. Line AC was considered the mechanical axis of the medial column. The primary outcomes of this investigation were the angular deviation and the physical deviation of Lines AB and AC in groups of rectus feet, feet with HAV and feet with HL/HR.

Discussion

As with any scientific investigation, critical readers are encouraged to review the study design and results and reach their own conclusions, while the following represents our conclusions based on the specific results. As scientists, we also never consider data to be definitive, but do think that these results are worthy of attention and future investigation.

-First, this investigation describes a means to quantify sagittal plane deformity of the foot based on CORA principles of the mechanical axes. We chose to utilize the center of the talar body, center of the first metatarsal head, and the center of the base of the hallux proximal phalanx for this analysis. Our finding of near equivalence of Lines AB and AC in rectus feet lends some support to the use of these landmarks.

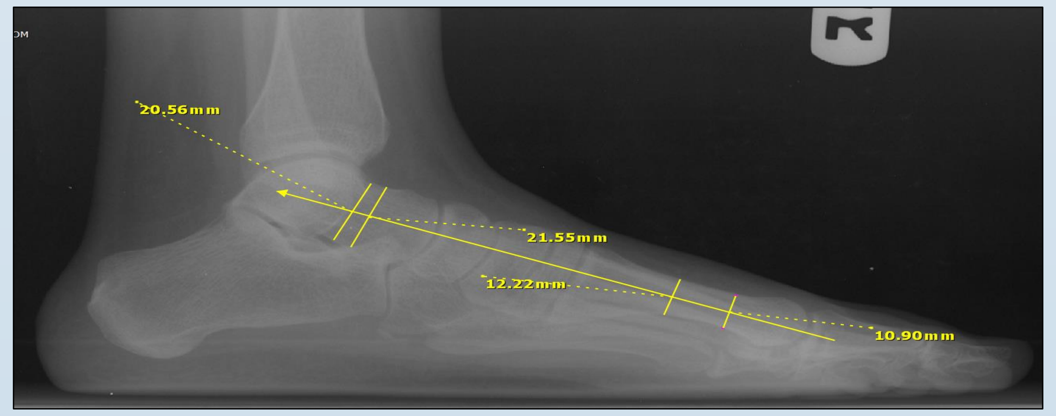
-Second, we were able to quantify angular and physical deviation measurements from normal in feet presenting with HL/HR and HAV deformities. This might represent an objective way to pre-operatively plan for structural deformity correction of the first ray.

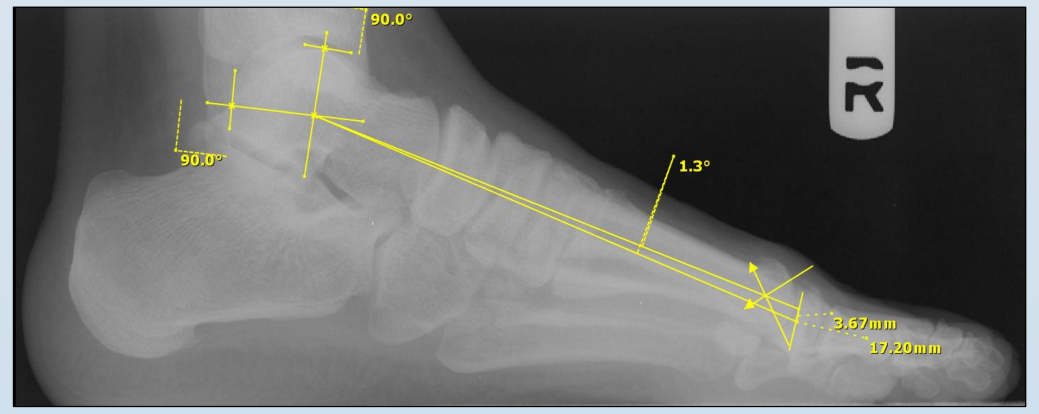
In conclusion, we hope that the results of this investigation add to the body of knowledge and lead to future investigations into the progression, evaluation and treatment of the medial column deformities.

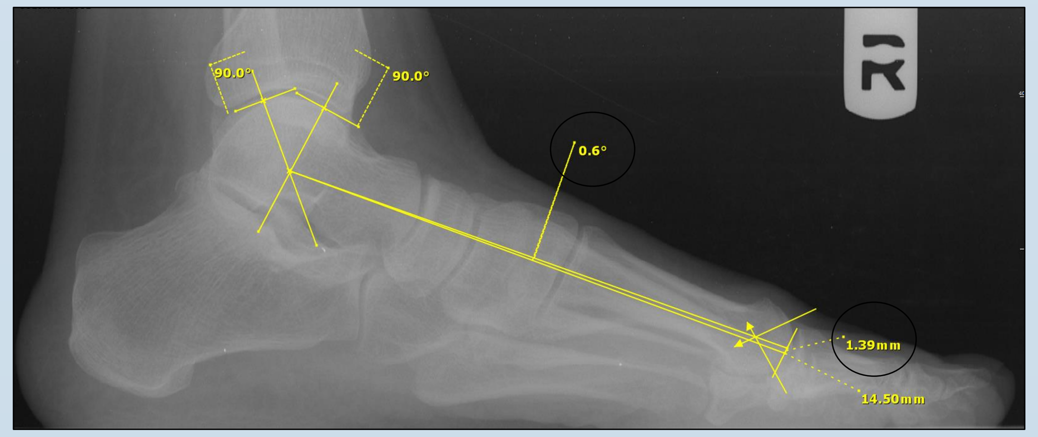
Results

	Rectus (n=5)	HAV (n=5)	HL/HR (n=5)
Angular deviation between Lines AB and AC	**0.0 degrees**	**0.2 degrees**	**1.4 degrees**
Physical deviation between Lines AB and AC	**0.0mm**	**0.66mm**	**3.69mm**

We observed that Lines AB and AC were essentially identical in rectus feet, whereas angular and physical deviation occurred between Lines AB and AC in both the HAV and HL/HR deformities. HL/HR deformities were noted to have a greater degree of sagittal plane deviation with respect to the angular deviation and physical deviation than HAV deformities.







Figures 4-6: These figures show demonstrative examples of measurement of rectus feet (above left), feet with HL/HR (above right), and feet with HAV (below right). Note that in the rectus feet the two lines are essentially identical and essentially equivalent to measurement of Meary's angle. In feet with both HL/HR and HAV, Line AB was always found to be superior to the mechanical axis of the medial column (Line AC).

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