HALLUX VALGUS AND 1ST METATARSAL HEAD MORPHOLOGY – A SOUTH AFRICAN STUDY

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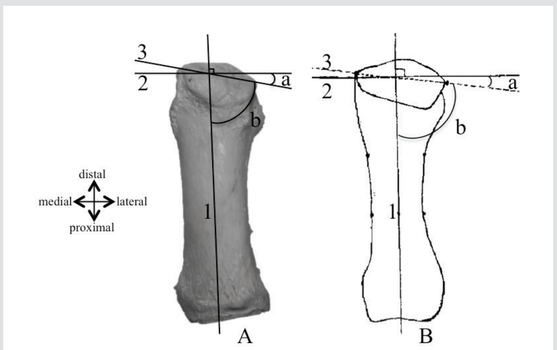
INTRODUCTION

Hallux valgus (HV) arises from a myriad of contributing factors and features an excessive lateral deviation of the 1st metatarsal distal articular surface. HV is assessed by measuring Distal Metatarsal Articular Angle (DMAA) on a plain film radiograph. The distal metatarsal articular angle (DMAA) is one of the radiographic angles used to assess the extent and the severity of the Hallux Valgus (HV) deformity [1–5]. It is defined as the relationship between the functional distal articular surface of the first metatarsal head, and the long axis of the metatarsal shaft [6–8] (Figure 1). The normal range is considered to be less than 8° [3,8,9] or 10° [6] of lateral deviation.

The aim of this study was to determine if there was a correlation between the size of the DMAA and the erosion of the intersesamoidal crista (Figure 2) on the first metatarsal bone, using a technique applied to skeletal material. We used a novel, experimental technique, emulating the position of the axial sesamoid radiograph in order to assess the erosion of the intersesamoidal crista. Figure 3 indicates the calculation of the height of the intersesamoidal crest. This study also investigated relationships between the DMAA, the intersesamoidal crista and other potentially associated features and variables, namely: metatarsal head shape (Figure 4), first intermetatarsal basal facet (Figure 5), side, age, sex and population group.



adapted from Vittetoe *et al.* (1994)

FIGURE 1: Distal Metatarsal Articular Angle (DMAA) measured on the 1st metatarsal indicated by angle "a"

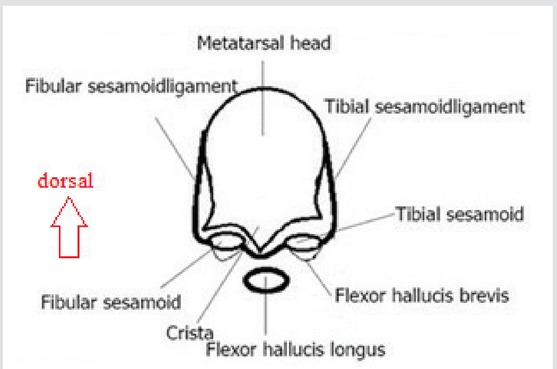


FIGURE 2: The location of the Intersesamoidal Crest/Crista (ISC)

MATERIALS AND METHODS

The DMAA and size of the ISC (via a novel technique) were measured and other features were studied on both 1st metatarsals of 120 adult human skeletons (See Table 1). Correlations between the size of the DMAA and HV as well as erosion of the ISC were evaluated. Correlation tests, T-tests and ANOVA were used to determine relationships between the variables.

DMAA measurements were taken from photographs of the first metatarsal positioned on artists' clay with the dorsal surface parallel to the camera lens. This was kept at a constant distance (20cm), with an F-stop of 18, for each specimen. On each digital image, reference points were plotted according to the American Orthopedic Foot & Ankle Society (AOFAS) criteria (2002). The reference lines were plotted within MS PowerPoint. The proximal lateral angle was measured with ImageJ's measuring tool and the DMAA was calculated according to the formula:

DMAA (a) = 90° - angle b
An angle of less than 8° was considered normal (See Figure 1).

To measure the intersesamoidal crista, each specimen was stabilized with artist's clay on a small, flat block of wood, with its dorsal surface against the block, so that the perpendicular reference line on the block served as an extension of the line from the intersesamoidal crista to the dorsal of the central head [16] as seen in Figure 3. The central and medial heights were recorded using a standard digital caliper (0.01mm). The ratio for the height was then calculated using the formula

{Crista height ratio= (x/y) x 100}
(100 = complete erosion; 110 – 120 = normal range; 111 = average)

Ethical approval was granted by the University of Johannesburg's, Faculty of Health Science, Research Ethics Committee (REC-01-166-2015). Permission to access the University of the Witwatersrand's Raymond A Dart Collection, and the Evolutionary Science Institute, was granted by Brendon Billings and Bernhard Zipfel, respectfully.

TABLE 1: Sample of modern human utilized in this study

Group Population			Age Group				Total
			18-30 years	31-45 years	46-60 years	Over 60 years	
Zulu	Sex	Male	10	10	8	14	42
		Female	8	16	10	8	42
	Total		18	26	18	22	84
Sotho	Sex	Male	16	12	8	10	46
		Female	8	6	18	10	42
	Total		24	18	26	20	88
European	Sex	Male	4	10	12	10	36
		Female	6	6	12	8	32
	Total		10	16	24	18	68
Total	Sex	Male	30	32	28	34	124
		Female	22	28	40	26	116
	Total		52	60	68	60	240

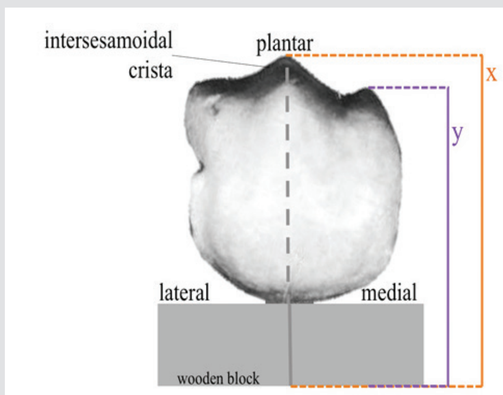
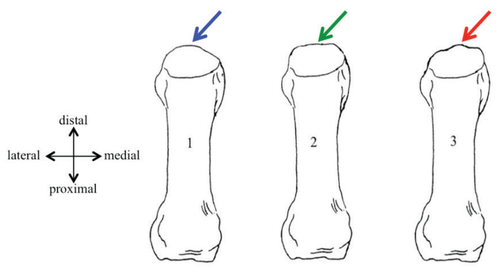
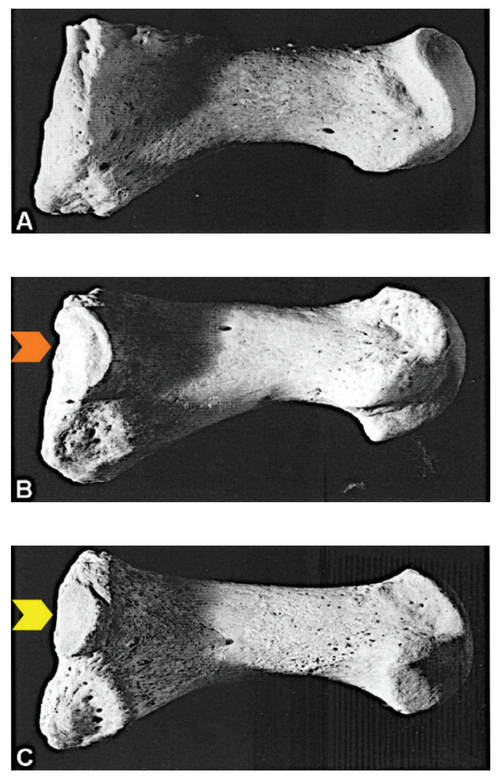


FIGURE 3: Measurement of the height of the intersesamoidal crest



adapted from LaPorta *et al.* (1994)

FIGURE 4: Shape of the metatarsal head (1 = Round; 2 = Square; 3 = Square with a central ridge)



adapted from Le Minor and Winter (2003)

FIGURE 5: Intermetatarsal Facet Presence and structure (A = Absent; B = Poorly defined; C = Well defined)

RESULTS

- As hallux valgus progresses, the medial sesamoid encroaches upon the intersesamoidal crista, as the distal first metatarsal drifts medially;
- Excessive lateral deviation of the first metatarsal distal articular surface is widely considered an important feature of HV deformity;
- The first intermetatarsal facet is present in about one third of the general human population, and is believed to be characteristic of modern humans, as it is not present in any non-human primates;
- There is no significant correlation between the lateral deviation of the distal metatarsal articular surface (distal metatarsal articular angle) and the erosion or height of the intersesamoidal crista; and
- There is no significant association between the crista erosion and age.

TABLE 2: Descriptive Statistics of DMAA and Crista ratio

	N	Range	Min	Max	Mean	Std. Dev	Variance
DMAA	240	34.44	-7.28	27.16	8.4355	5.50654	30.322
Crista Ratio	240	37.44	95.67	133.12	111.4041	5.96293	35.557

TABLE 3: Prevalence (as a percentage) of the non-metric features observed on the 1st metatarsal

Crista Appearance		Metatarsal Head Shape		Intermetatarsal Facet					
				Presence		Location		Relation	
Complete Erosion	7.5	**Round**	40.8	**Absent**	29.2	**Dorsal Third**	1.2	**Connected to**	88.6
Partial Erosion	25	**Square**	3.8	**Poorly Defined**	55.4	**Middle Third**	98.8	**Separate From**	11.4
No Erosion	67.5	**Square + central ridge**	55.4	**Well Defined**	15.4				

TABLE 4: Morphology of Metatarsal Head Shape compared to other studies (as percentages)

Metatarsal Head Shape	Current Study	Zipfel (2004)	Roukis *et al* (2005)	ElSaid *et al* (2006)
	n = 240	n = 214	n = 166	n = 478
Round	40.8	70.65	56.0	75.0
Square	3.8	12.00	39.0	0.0
Square + central ridge	55.4	17.28	5.0	25.0

TABLE 5: Intermetatarsal prevalence as compared to other studies (as percentages)

Intermetatarsal Facet Presence	Current Study	Singh (1960)	Le Minor (2003)	Zipfel (2004)	ElSaid *et al* (2006)	Hyer *et al* (2005)
	n = 240	n = 100	n = 412	n = 214	n = 478	n = 77
Absent	29.2	39		11		
Poorly Defined	55.4	40	-	69	-	-
Well Defined	15.4	21	31	20	25	29

DISCUSSION AND CONCLUSION

There is an expectation that the more laterally deviated the distal articular surface of the first metatarsal head, the more eroded the intersesamoidal crista would be. However, this study found that there is no significant correlation between the DMAA and the erosion of the crista. This may be due to the great variation that has been shown to exist in both variables. However, both of these variables are still valuable to assess the extent and severity of hallux valgus deformity as both are associated with the deformity. Furthermore, there are no significant relationships between these two variables and the shape of the metatarsal head, nor with the first intermetatarsal facet. Either or both of these variables, however, need to be considered when contemplating surgical correction of HV, as they may both potentially play a role in the pathology and/or recurrence of the deformity.

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