The use of radiographic images of the foot in forensic evaluation

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FORENSIC PODIATRY: ROLE AND SCOPE OF PRACTICE

INTERNATIONAL ASSOCIATION FOR IDENTIFICATION

FORENSIC PODIATRY: ROLE AND SCOPE OF PRACTICE

(IN THE CONTEXT OF FORENSIC HUMAN IDENTIFICATION)

FORENSIC PODIATRY: ROLE AND SCOPE OF PRACTICE

Forensic podiatry currently has four sub-specialties covering analysis and identification involving:

Podiatry treatment records

Bare footprints

Footwear

Forensic Gait Analysis

What a forensic podiatrist may do:

- Examination of foot prints; bare or sock clad
- Examination of foot impressions
- Examination of footwear - particularly where there is a question of the predominant wearer or ownership of the footwear in questions
- Footprint profiling
- Mass disaster applications

Podiatrist's clinical records

- Clinical records could be used in the identification of deceased persons.
- Clinical records can be of particular use when the lower limb has been separated from the body, or when other methods of identification are compromised.
- Clinical records can supplement other means of identification

The records made by podiatrists contain the following information:

- Personal information (name, address, contact details)
- General and foot specific medical history
- Foot/ lower extremity description, including foot-related pathologies
- Information concerning treatment carried by the podiatrist, including:
  1. Foot/ lower extremity treatment description
  2. Pedal surgery
  3. Relevant foot x-rays
  4. Preserved lab specimens

Has DNA made the need for medical records and radiographs obsolete?

The False Promise of DNA Testing

- DNA typing has long been held up as the exception to the rule—an infallible technique rooted in unassailable science.
- “Conclusive results in only one test!”
- The FBI created its codis database for storing DNA profiles of convicted criminals
- Obtaining usable DNA from the smallest of samples, like so-called touch DNA

http://www.theatlantic.com/magazine/archive/2016/06/a-reasonable-doubt/480747/

Problems with DNA

- Time
- Expense
- Analysis
- No Database for comparison

Radiographs of the foot

- Plain radiographs of the foot are a common form of examination when medical evaluation is indicated, providing useful information on bone morphology and angular relationships.
- Since they are commonly performed, their availability makes them potentially useful in assisting in the identification of an unknown individual from pedal osseous remains.

Exploring the relationship between radiographic and osteologic linear measurements of the human talus and calcaneus

Talus and calcaneus

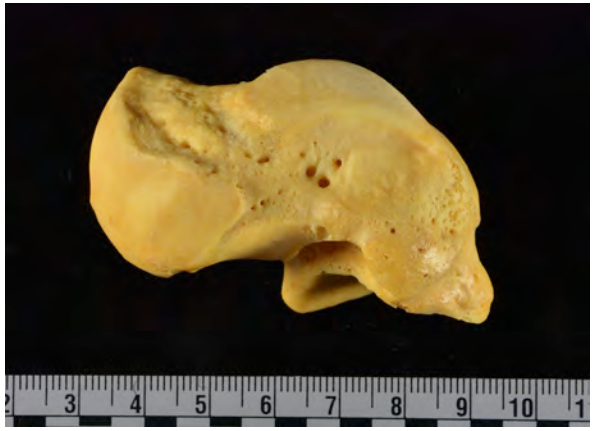
- The talus and calcaneus can be useful skeletal elements in forensic investigation. They are the largest bones of the foot, relatively sturdy, able to withstand high compressive forces, and are often protected in shoe gear.

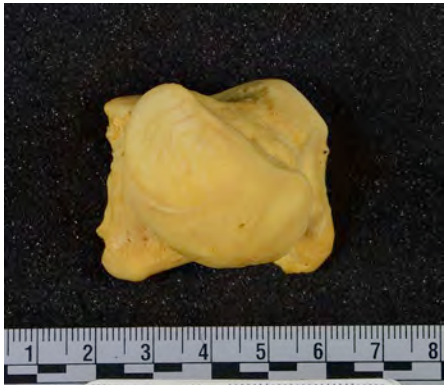
- As elements of the skeleton that may endure, the calcaneus and talus can potentially be important bones in assisting in the creation of a biological profile and thus identification.

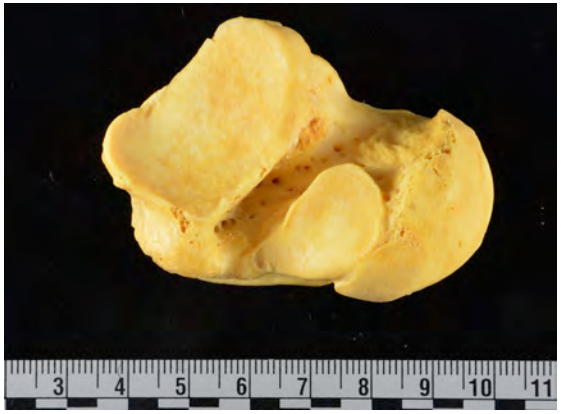
- This lecture will present the results of a study, using the talus and calcaneus, demonstrating the correlation of measurements taken from radiographic images with that from the actual bone. The objective of this lecture is to demonstrate how radiographs can be used in the forensic evaluation of pedal remains of unknown individuals.

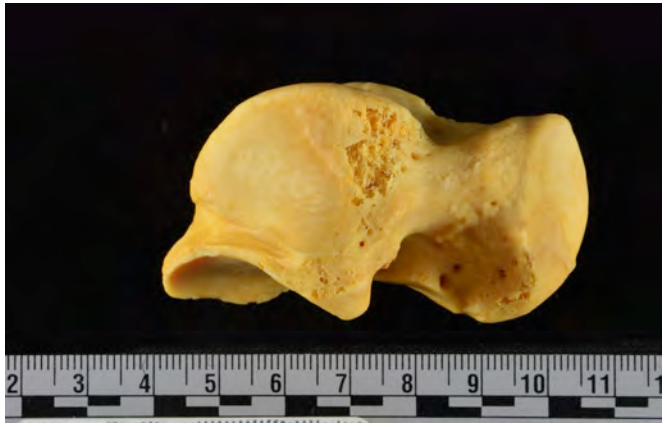
Biological Profile (Sex, Age, Stature, Ancestry), Anomalies and Pathologies all assist with identification

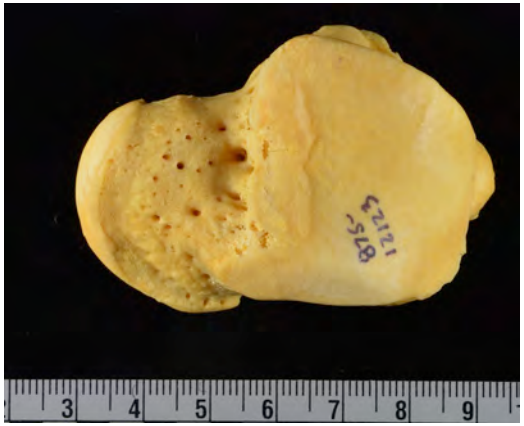
Talus



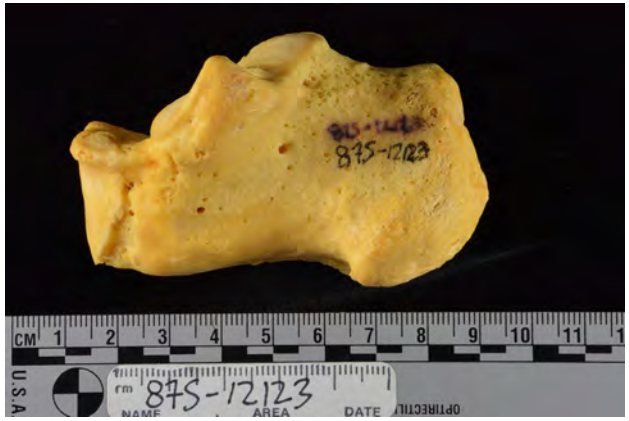


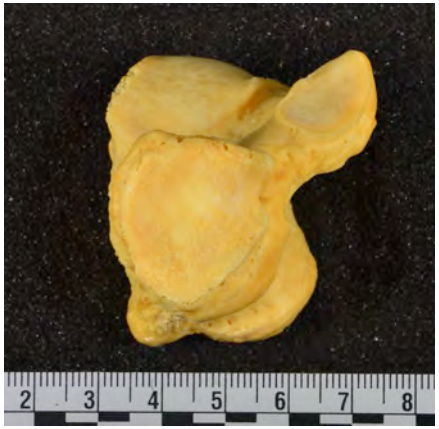


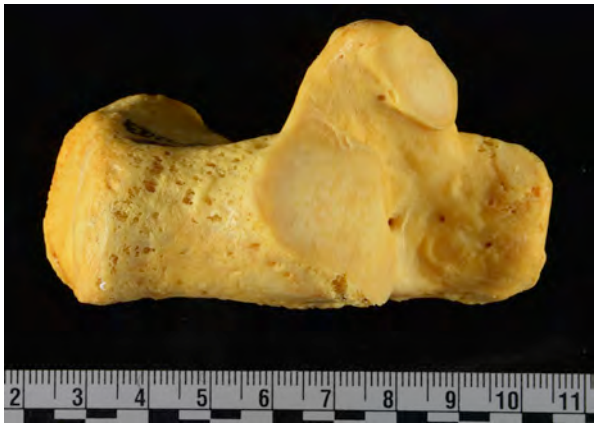


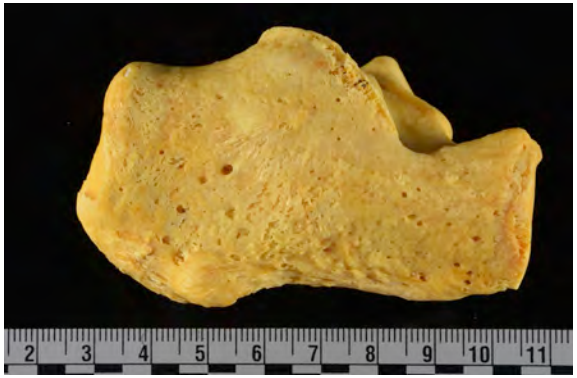


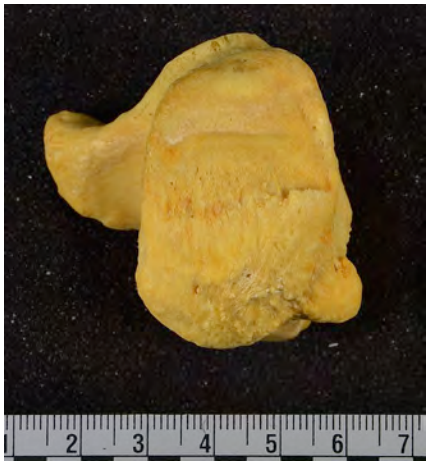
Calcaneus

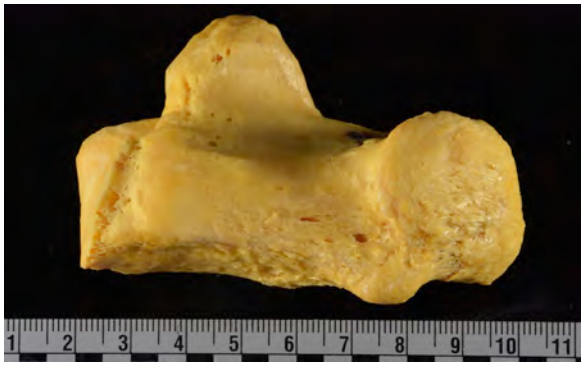










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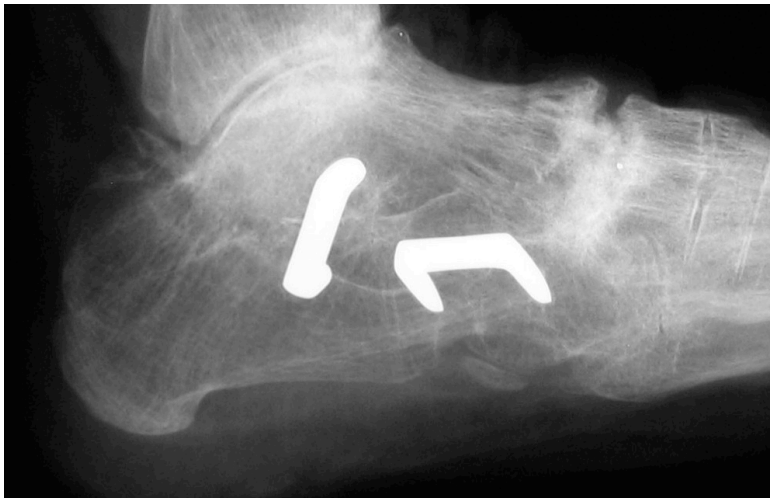


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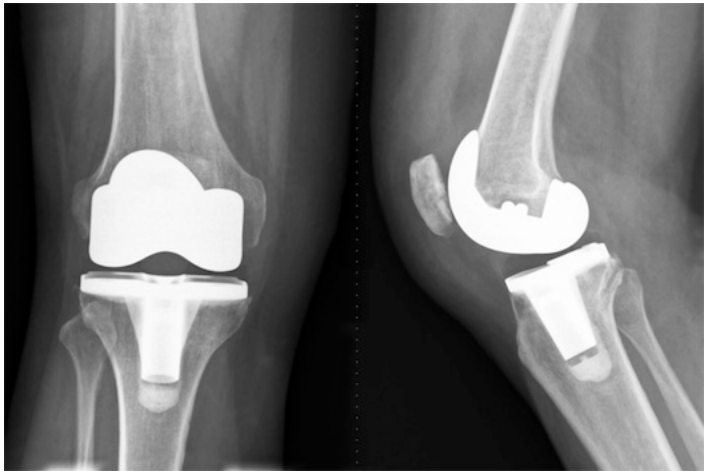
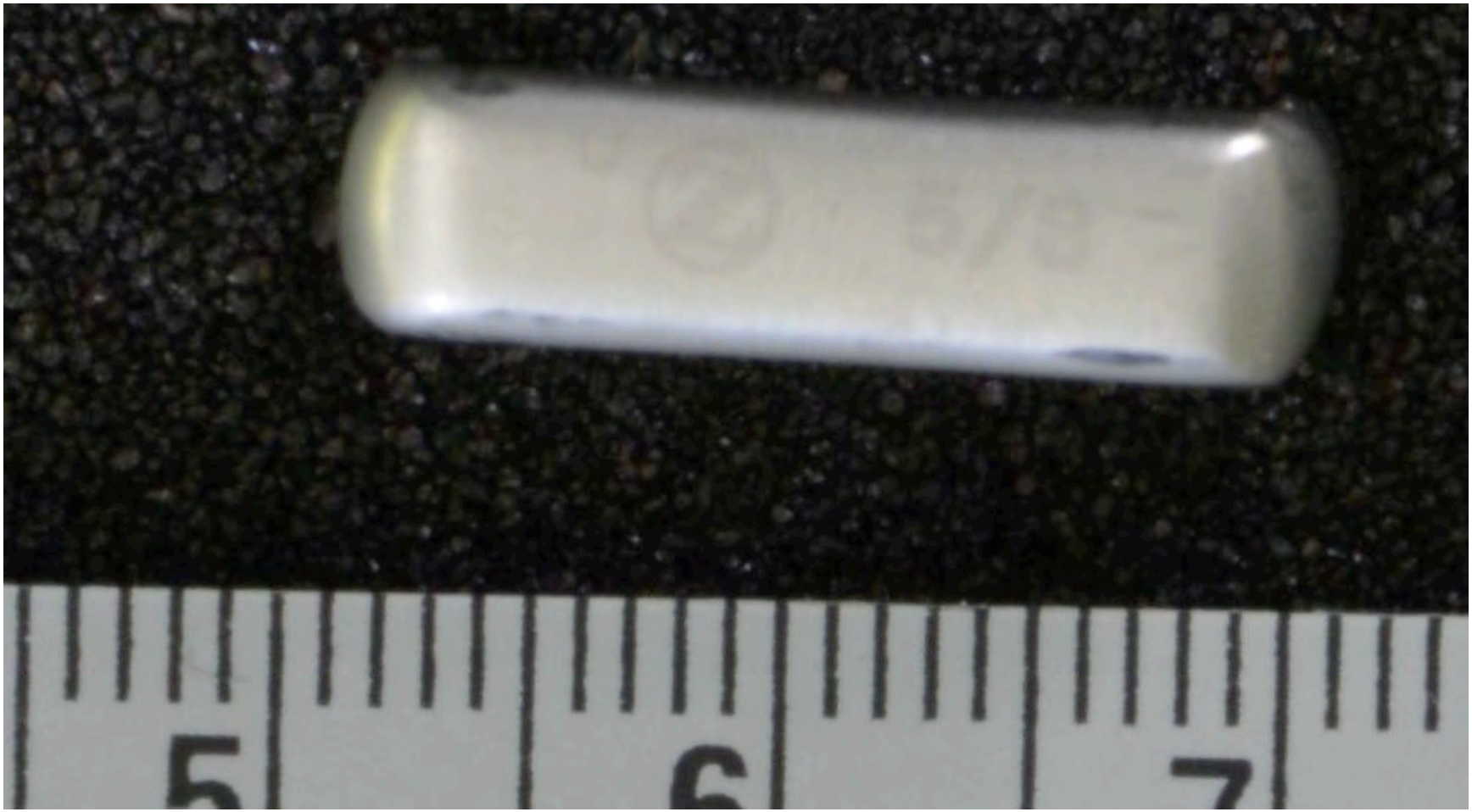
Positive Identification



Safe Medical Device Act of 1990 (FDA)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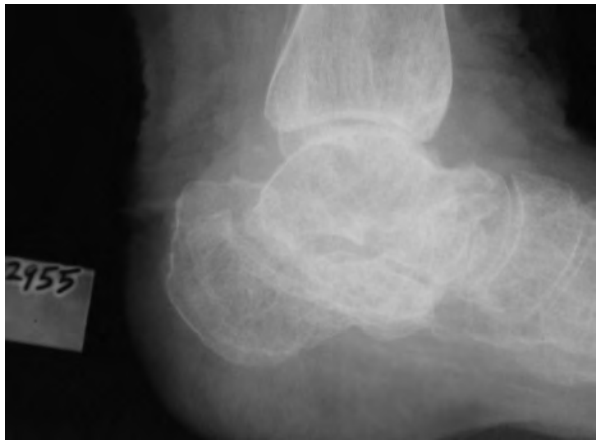
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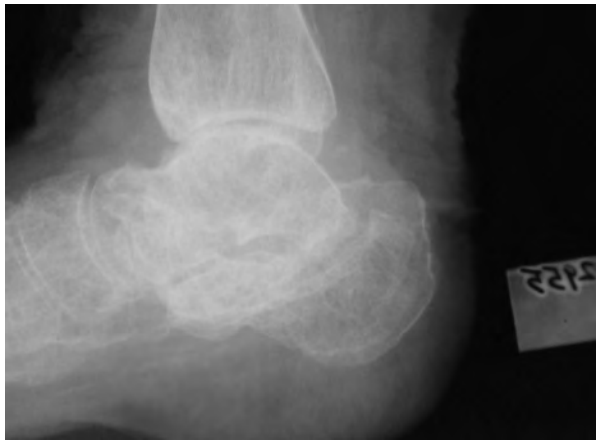


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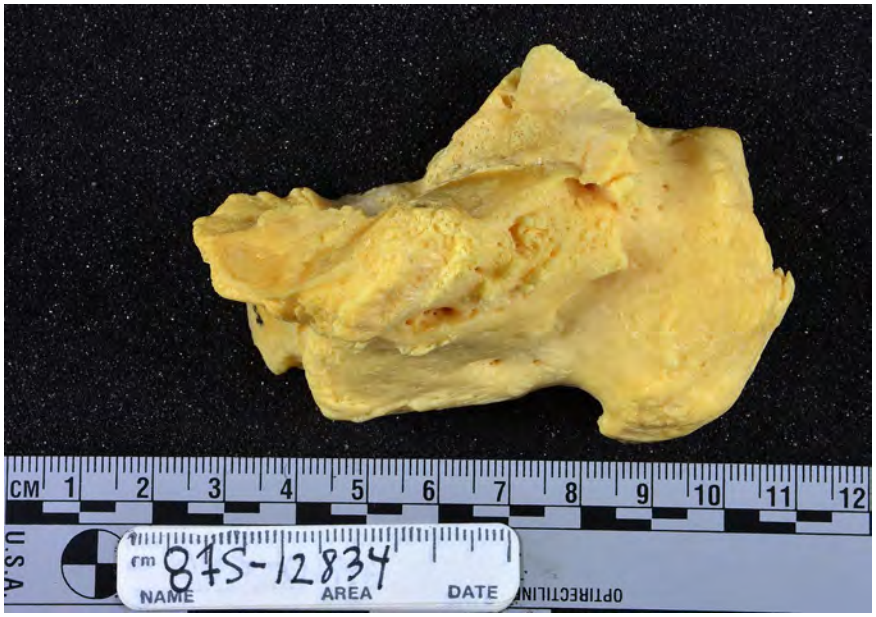
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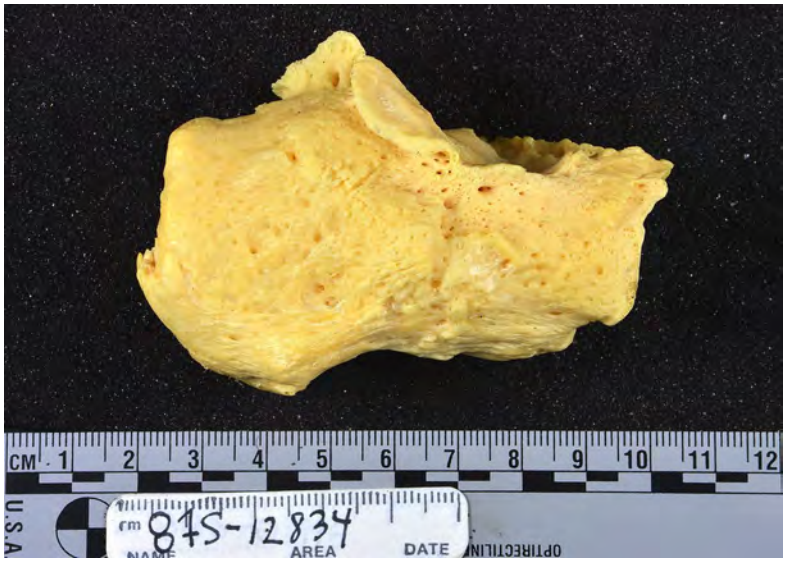
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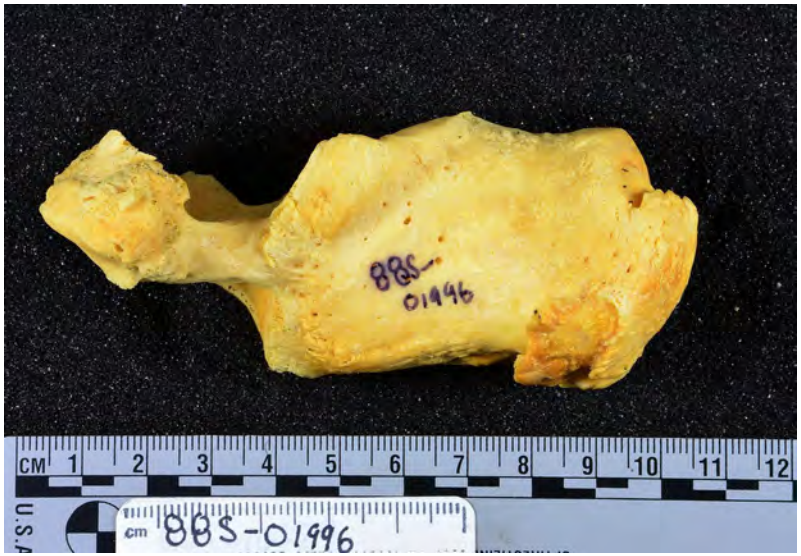
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Analyzing radiographs qualitatively and quantitatively

Qualitative vs. Quantitative Analysis

Daubert Standard for scientific methodology:

1. **Empirical testing: the theory or technique must be testable.**
2. Subjected to peer review and publication.
3. Known or potential error rate.
4. The existence and maintenance of standards and controls concerning its operation.
5. Degree to which the theory and technique is generally accepted by a relevant scientific community.

Exploring the relationship between radiographic and osteologic linear measurements of the human talus and calcaneus

Materials and Methods

- The specimens for this study were collected from lower extremity amputations with the written approval of the hospital's institutional review board on human studies.
- Each amputated lower limb was sectioned above the ankle, x-rayed in standardized (non-weight bearing) views, and skeletonized.
- A total of 54 feet (32 males, 19 females, and 3 where sex was not recorded) were collected.
- The talus and calcaneus were examined.

Materials and Methods

Materials and Methods

- Selected measurements were taken of the talus and calcaneus of each foot
- Corresponding points were determined on the radiographs and measurements performed on the distance between these points
- The radiographic measurements were compared to the measurements taken on the actual bone to determine the accuracy of the radiographic measurements

Radiographs

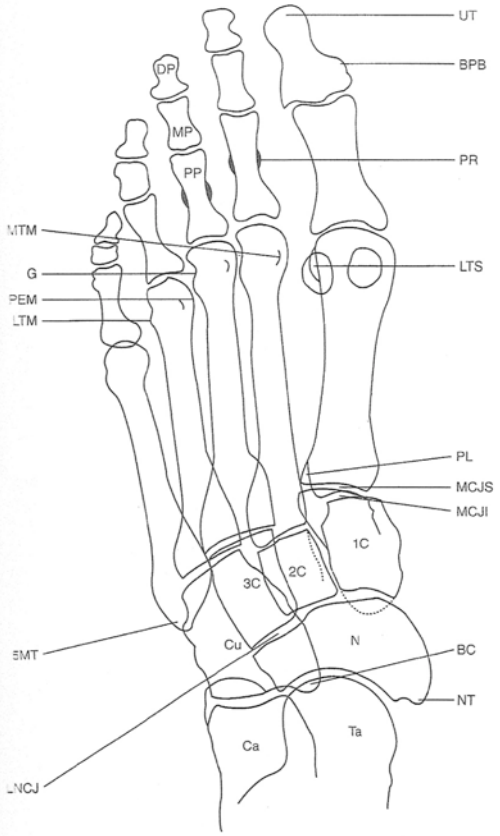
- AP and lateral radiographic views were used in this study since they provide the most accurate linear measurements (Christman, 2014).
- Land marks on the radiographs corresponding to those on the bone were identified.
- Using a reference scale, each radiograph was calibrated, and measurements performed, using the ImageJ (NIH) software program (http://imagej.nih.gov/ij/).

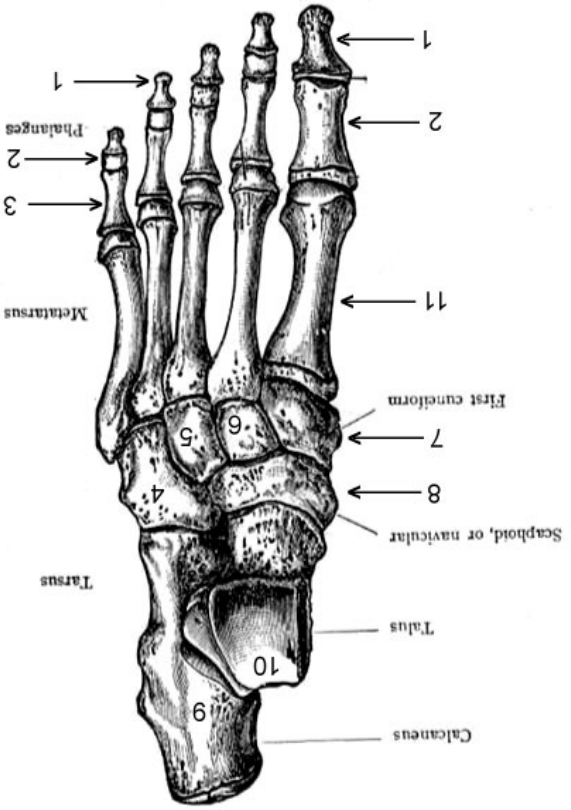
Factors which may interfere with taking accurate measurements from radiographs

- Distortion caused by distance from x-ray receptor
- Distortion caused by the angulation of bone in relationship to x-ray receptor and x-ray beam
- Inconsistencies in following uniform radiograph taking technique
- Difficulty in choosing radiographic measuring points with those identified for the bone

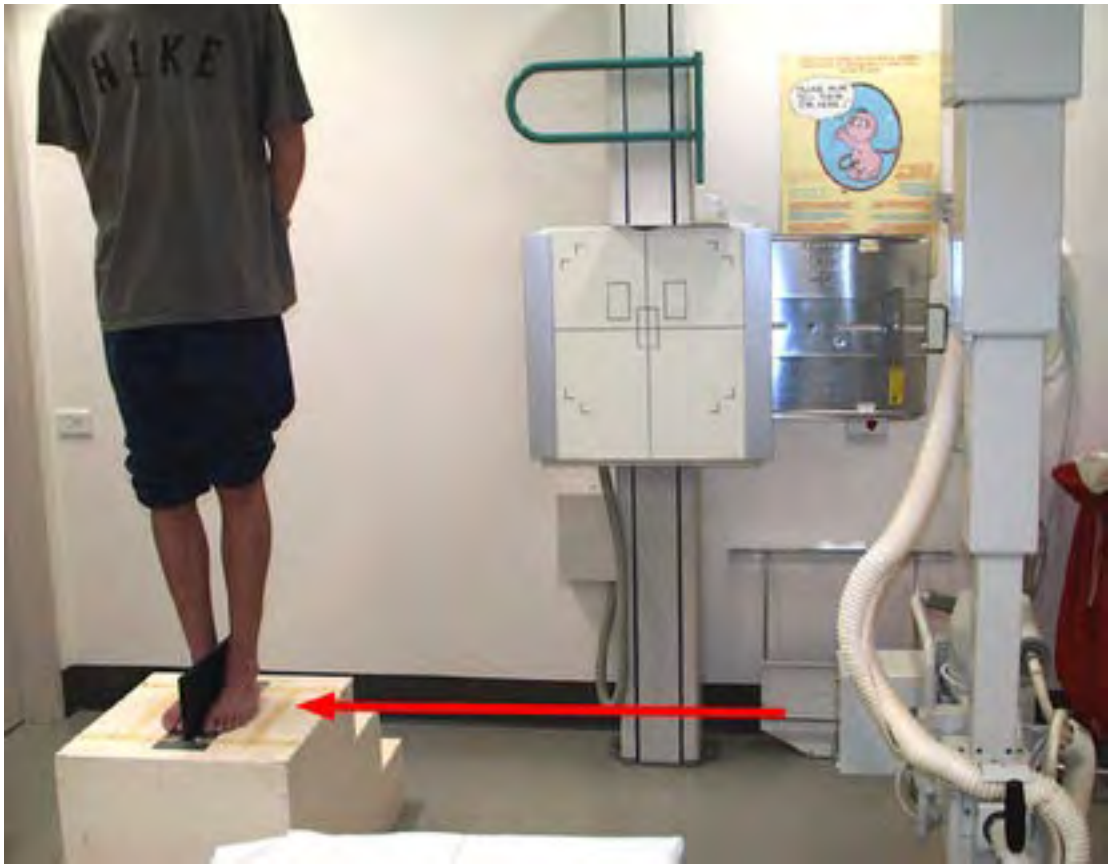
Weight Bearing Dorsoplantar (DP) view

Anterior-Posterior (DP) view

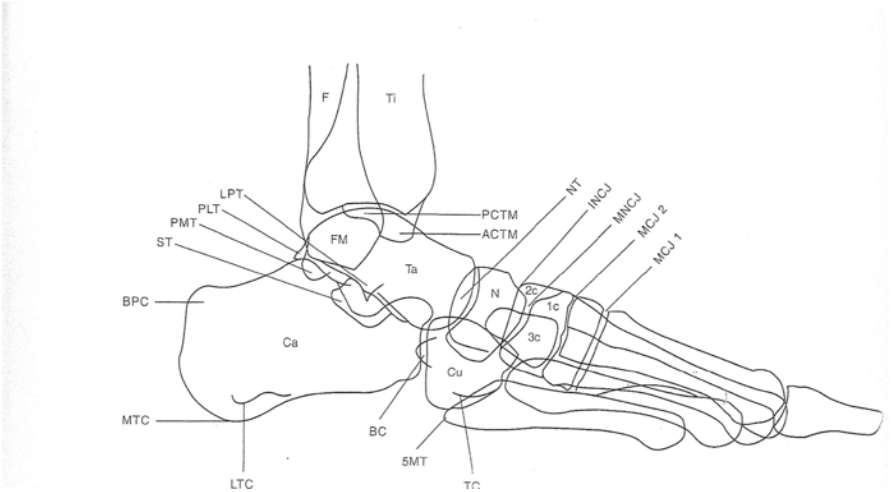


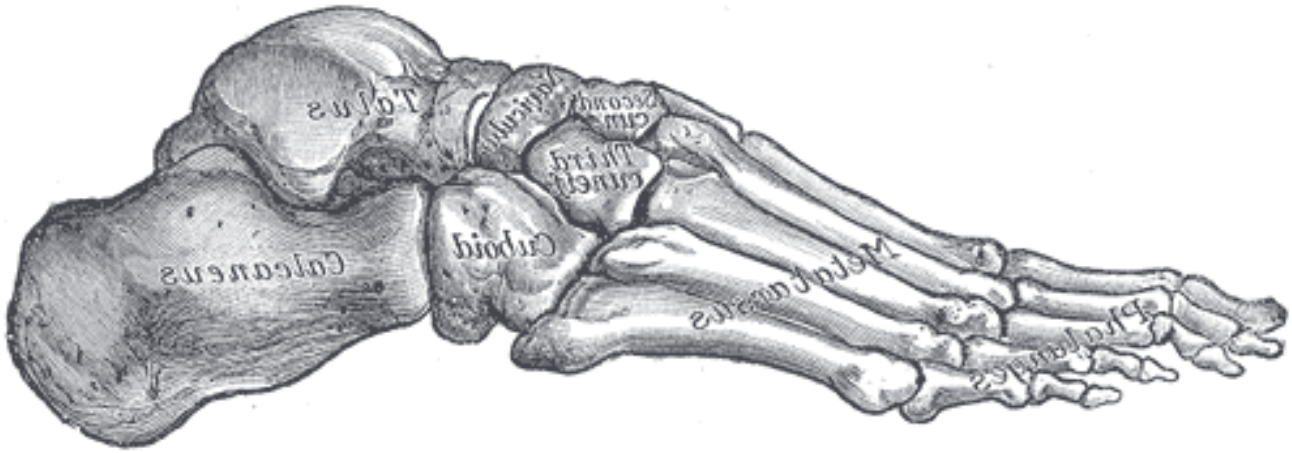


Lateral Weightbearing View



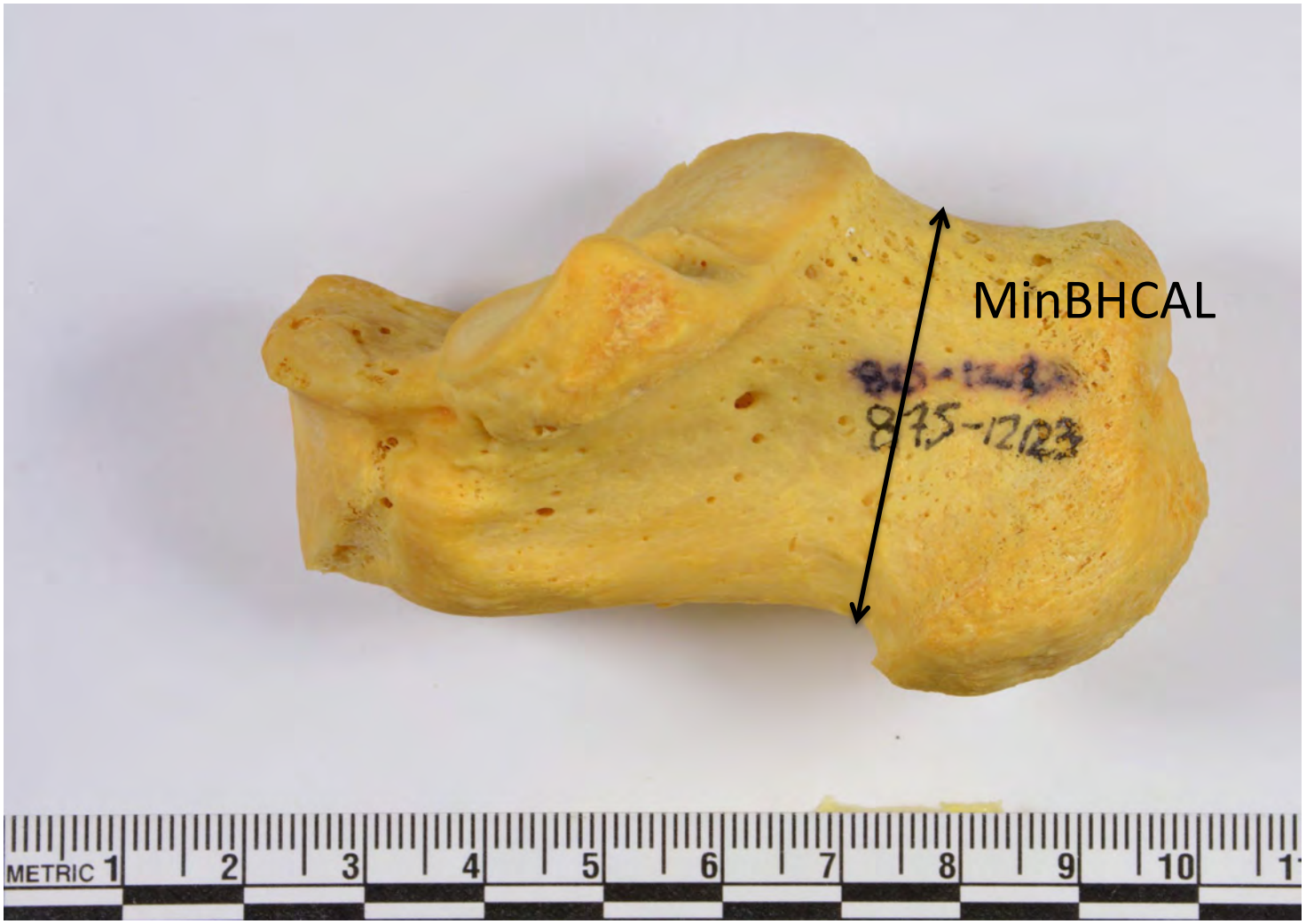
Lateral view



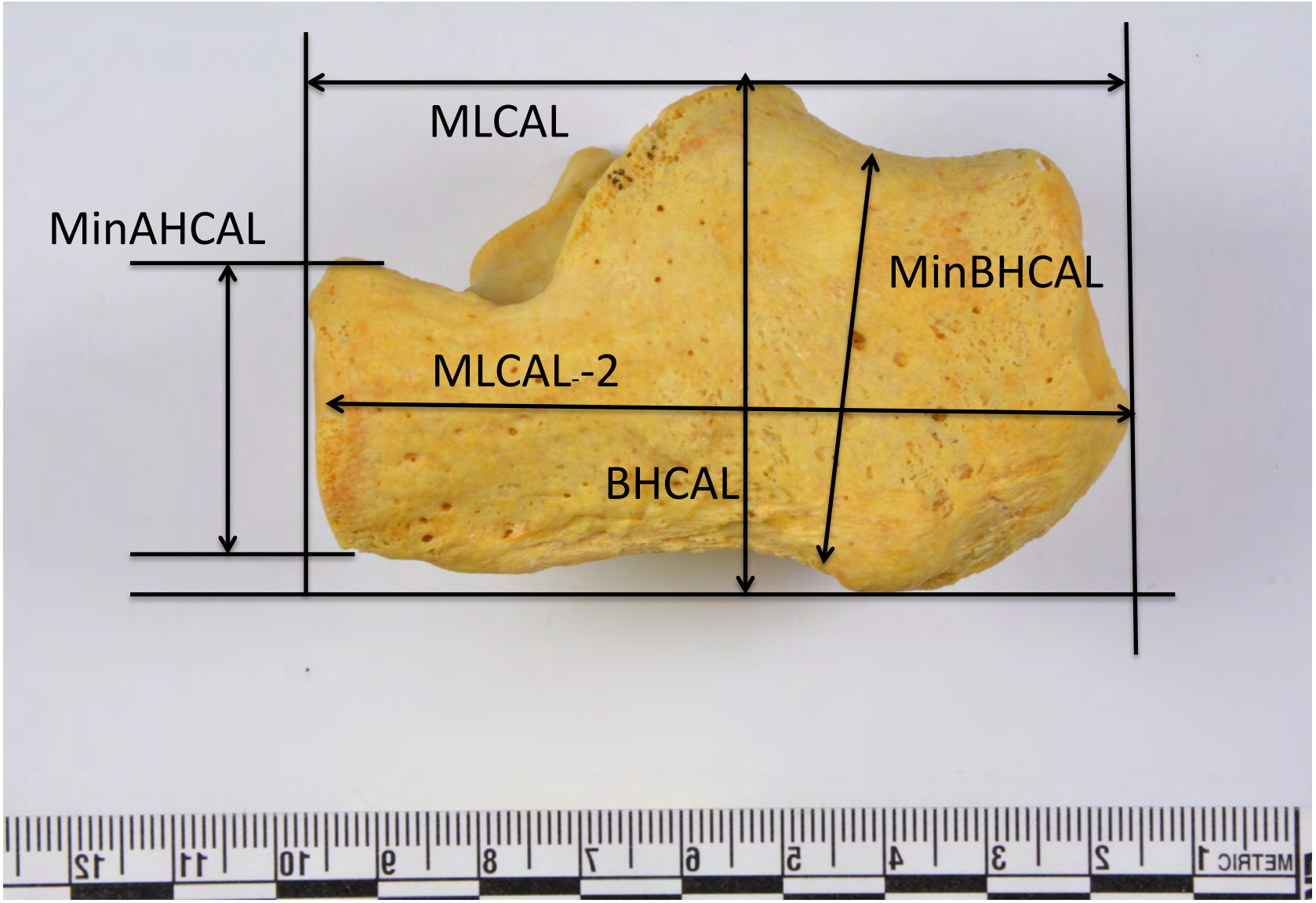


Materials and Methods: Measuring points

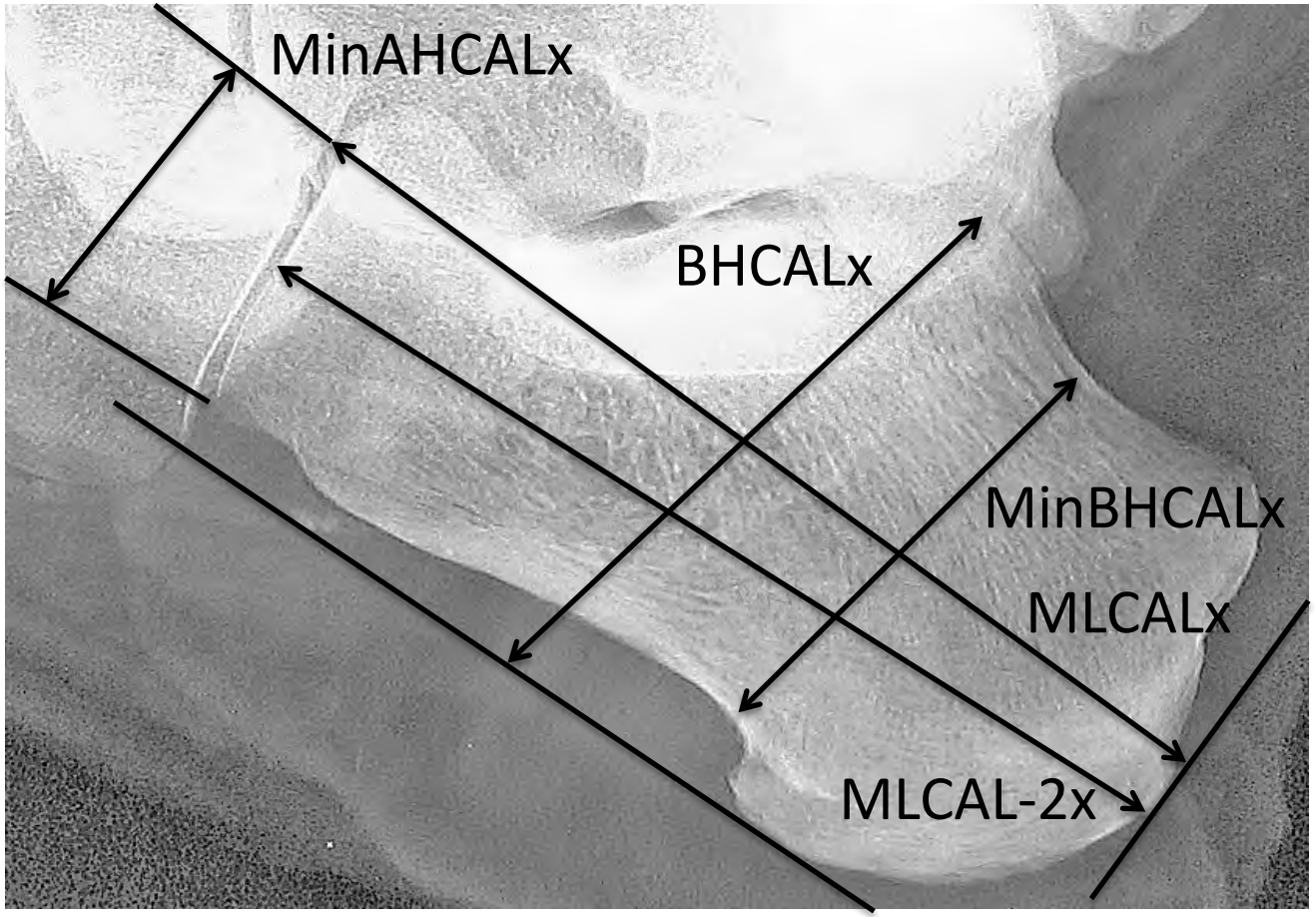
Medial view of calcaneus



Lateral view of calcaneus (flipped horizontally)



Lateral view



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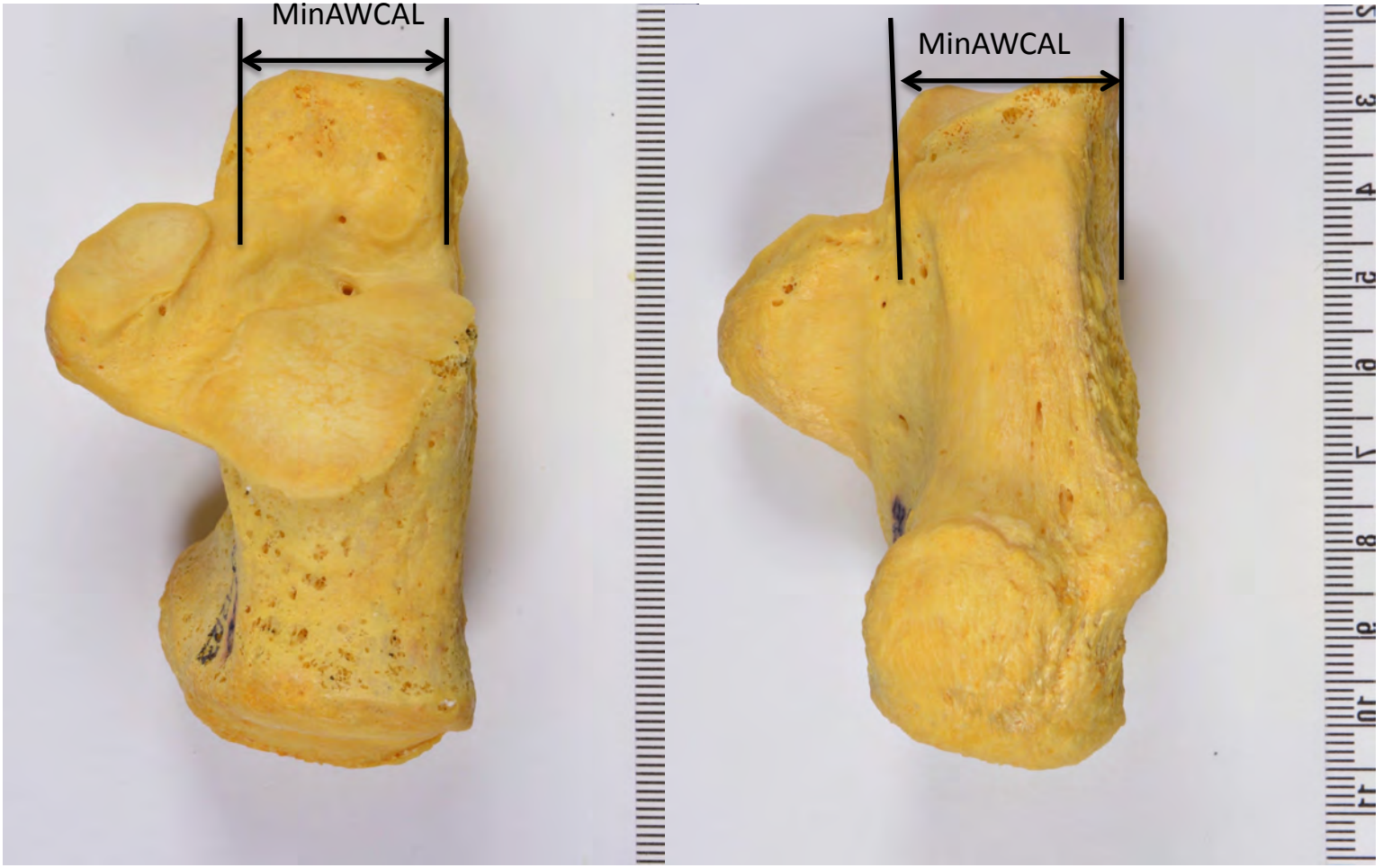

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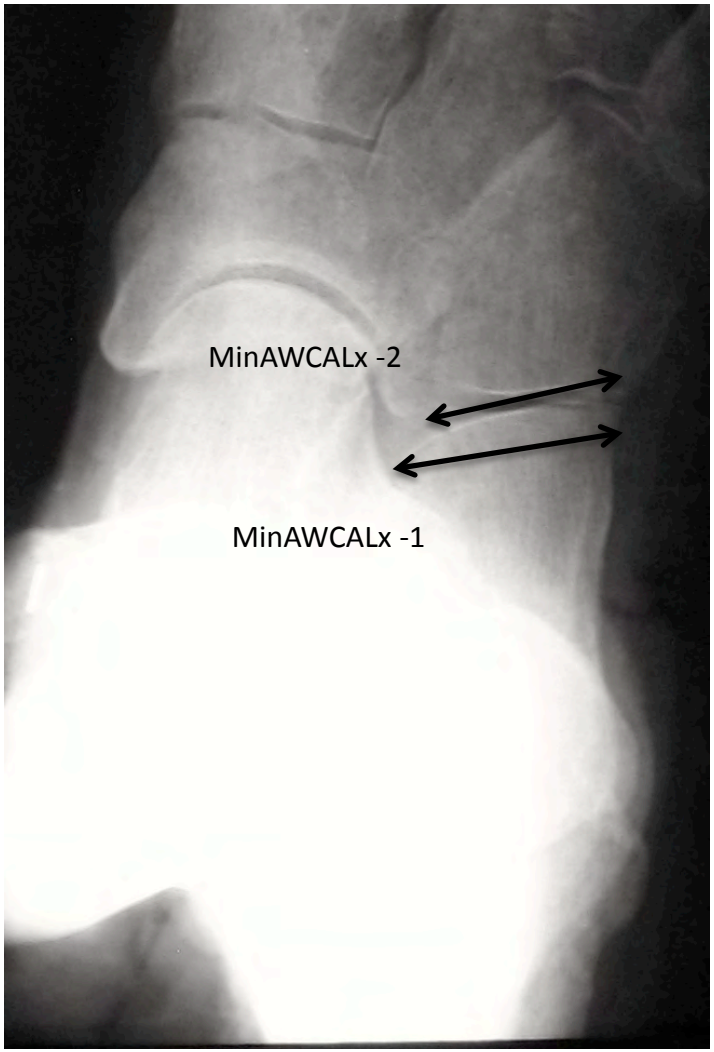
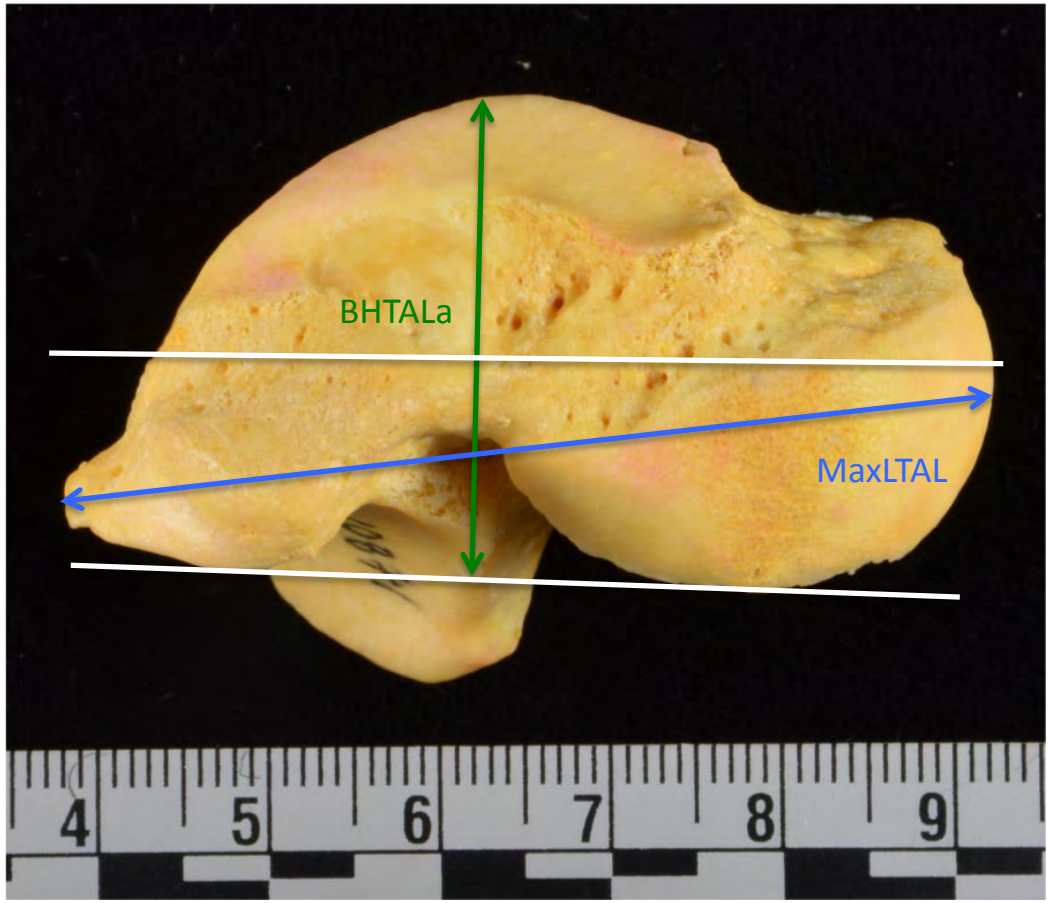
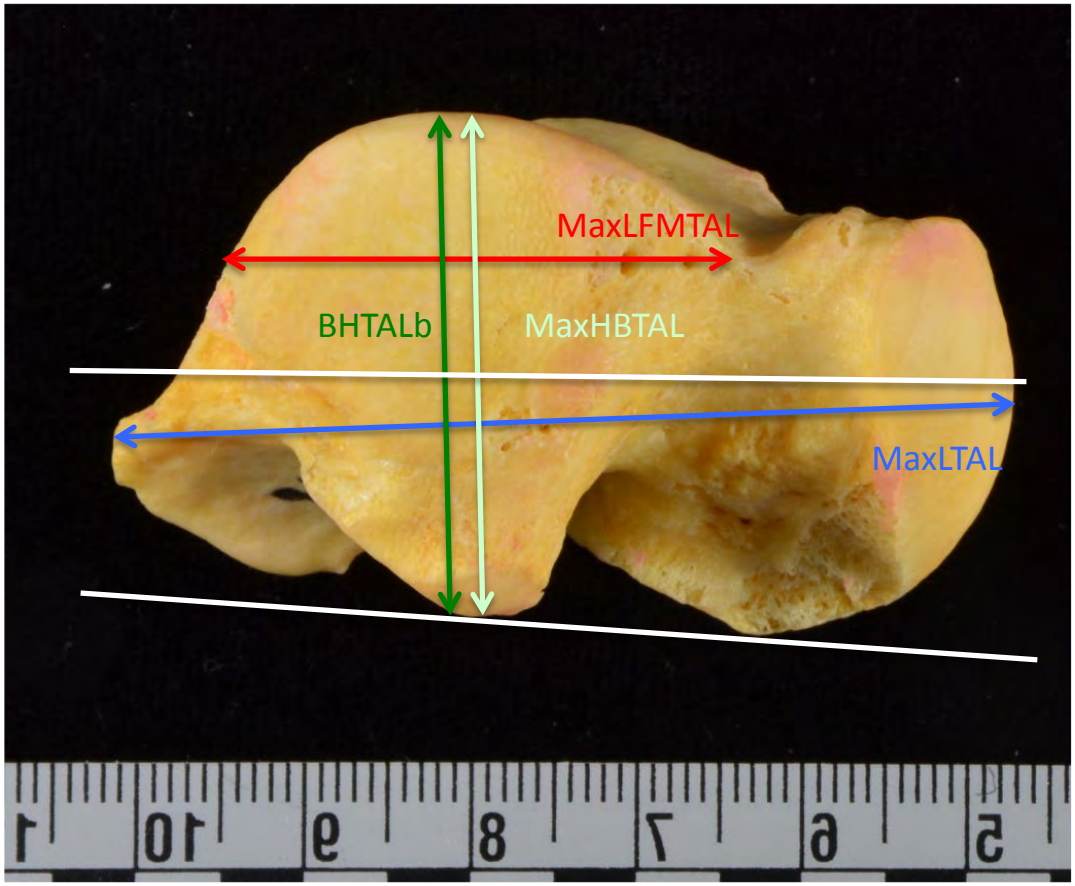


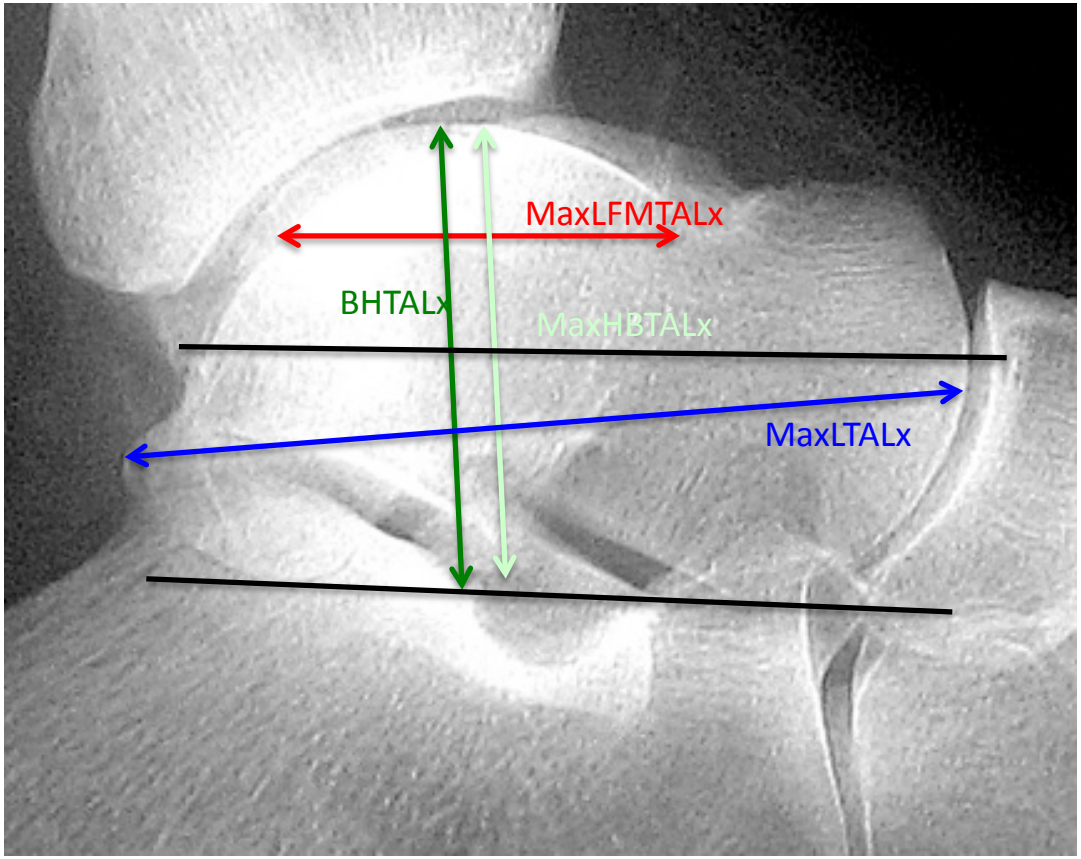
Medial view of the left talus.



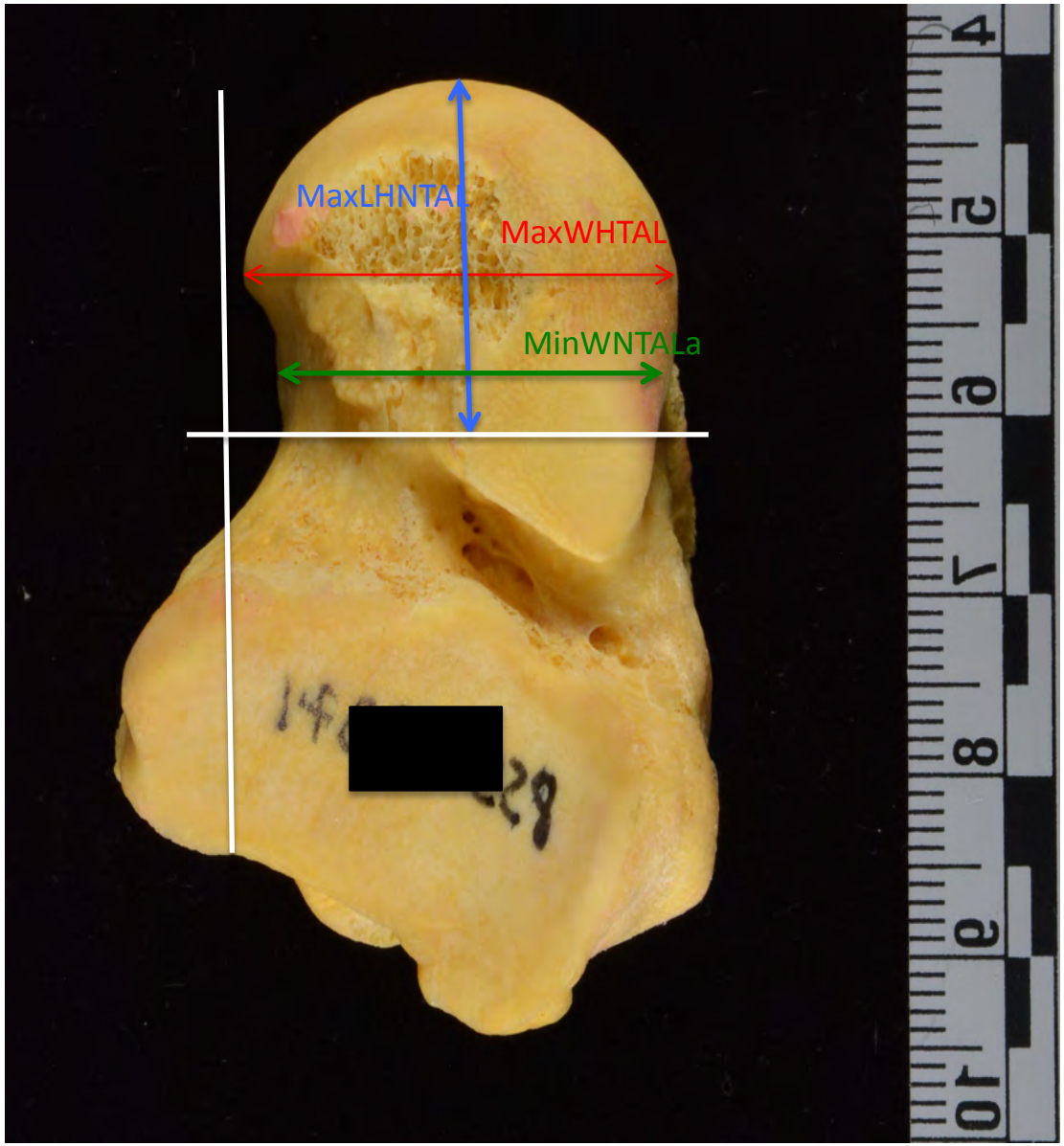
Lateral view of the left talus (flipped horizontally).



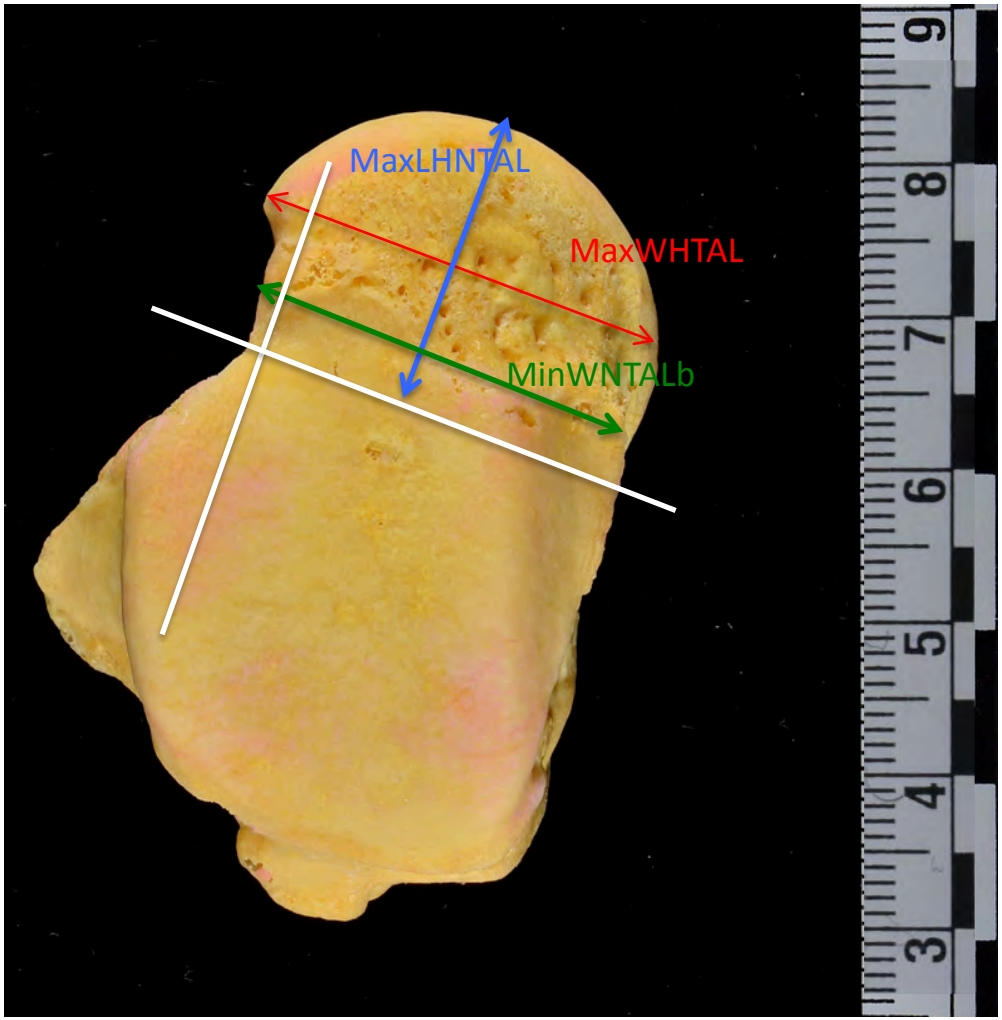
Lateral radiograph of the talus.



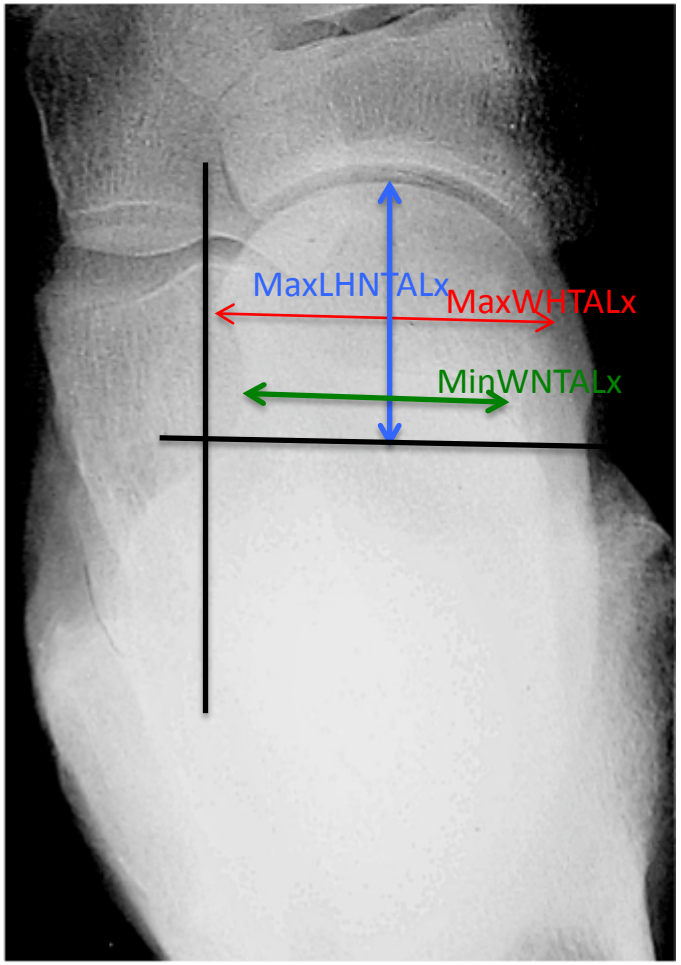
Plantar view of the left talus (flipped horizontally).



Dorsal view of the left talus.



AP radiograph of the talus.



Materials and Methods

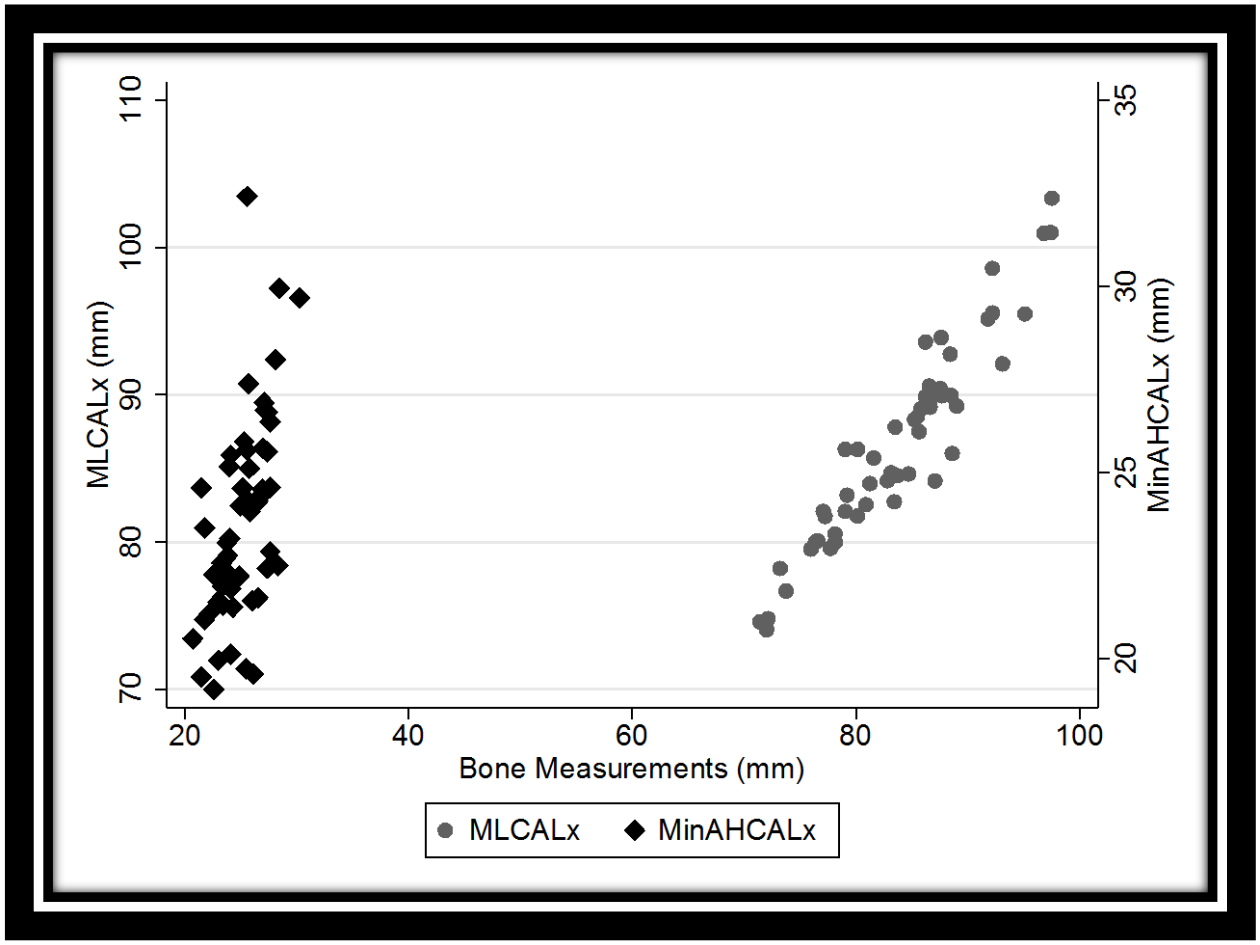
- Descriptive statistics were performed on the measurements taken from the actual bones and the radiographs. Student *t*-test comparing actual bone and radiographic measurements were performed to identify the presence of significant differences in measurement dimensions between bone and radiograph.
- The degree to which measurements were correlated was established using ordinary least squares regression and confirmed with reduced major axis analysis.
- Statistical significance was established using an alpha of 95%.

Results

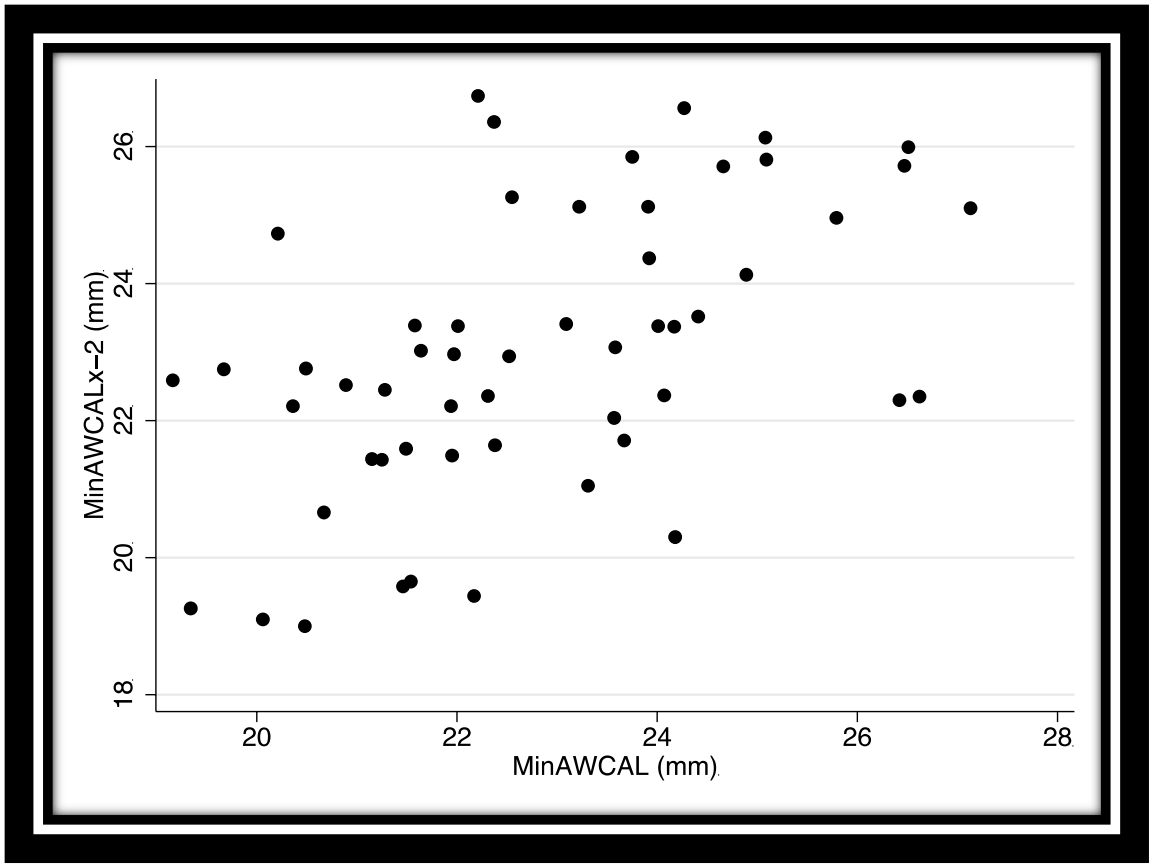
Measurements and Descriptive Statistics of Calcaneus Bone and Radiographic Measurements

			Bone			Radiographic					*t*-test	Correlation
Description	**Variable**	**N**	**Mean**	**SEM**	**SD**	**Mean**	**SEM**	**SD**	**t**	**df**	**p**	**r^2**
Maximum Length	MLCAL	54	83.87	0.893	6.56	86.75	0.915	6.72	-9.965	53	<0.001	0.90
Maximum Length	MLCAL-2	54	82.15	0.917	6.74	83.32	0.918	6.74	-4.113	53	<0.001	0.90
Body Height	BHCAL	54	49.75	0.587	4.31	50.50	0.773	5.68	-1.784	53	0.08	0.71
Minimum Body Height	MinBHCAL	54	39.24	0.497	3.65	38.98	0.520	3.82	1.119	53	0.26	0.80
Minimum Anterior Height	MinAHCAL	54	25.07	0.289	2.12	23.08	0.301	2.21	-0.044	53	0.96	0.52
(Minimum Anterior Width)	MinAWCAL-1	54	22.83	0.272	2.00	23.04	0.302	2.22	-0.691	53	0.25	0.21
Minimum Anterior Width*	MinAWCAL-2	54	22.83	0.272	2.00	23.01	0.285	2.09	-0.642	53	0.52	0.26

Calcaneus correlation



Calcaneus correlation



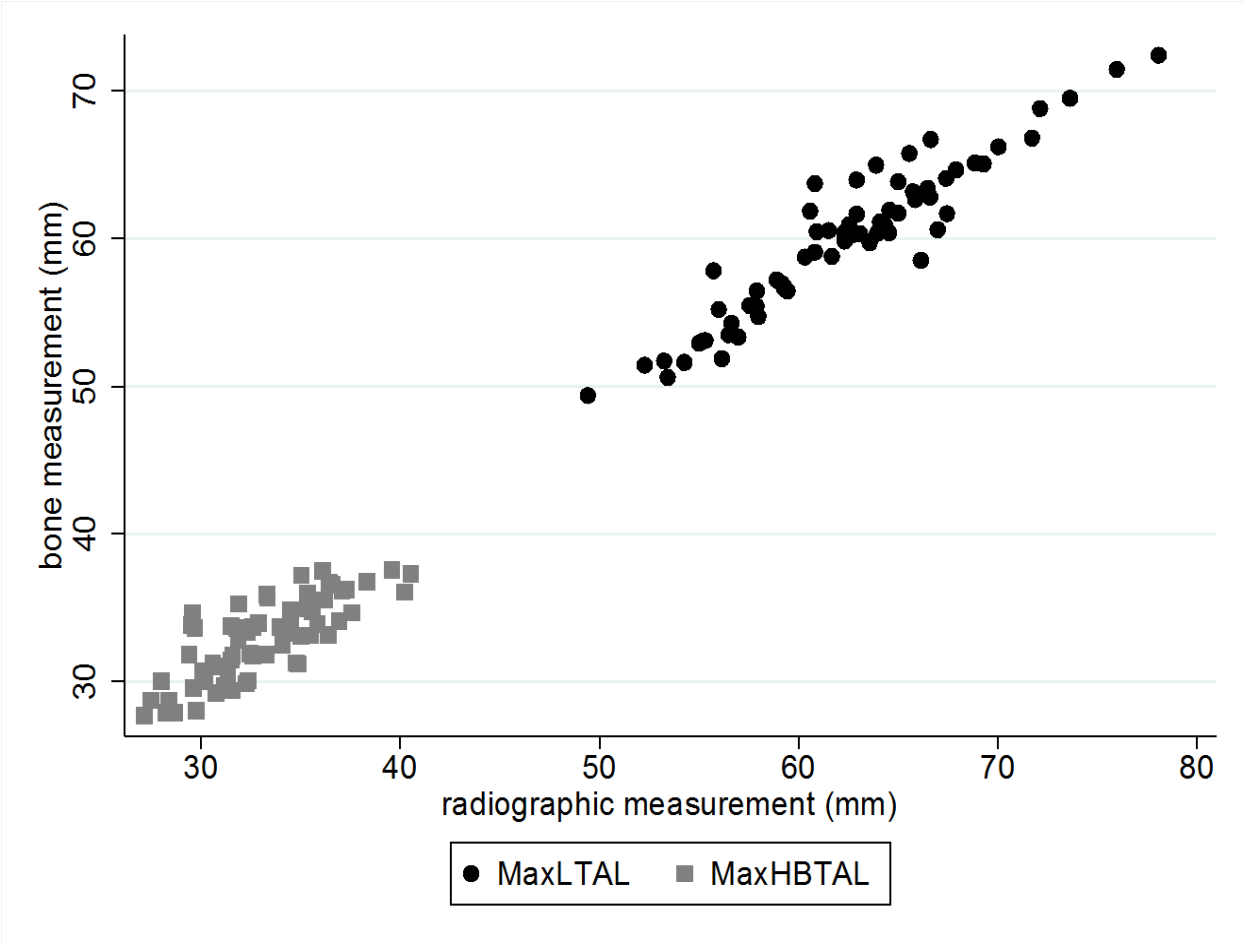
Calcaneus Results

As demonstrated, while length and height measurements are different ($p \geq 0.05$), most correlated ($r^2 > 0.70$, all $p < 0.001$). The anterior process width measures are more challenging to obtain from radiographs.

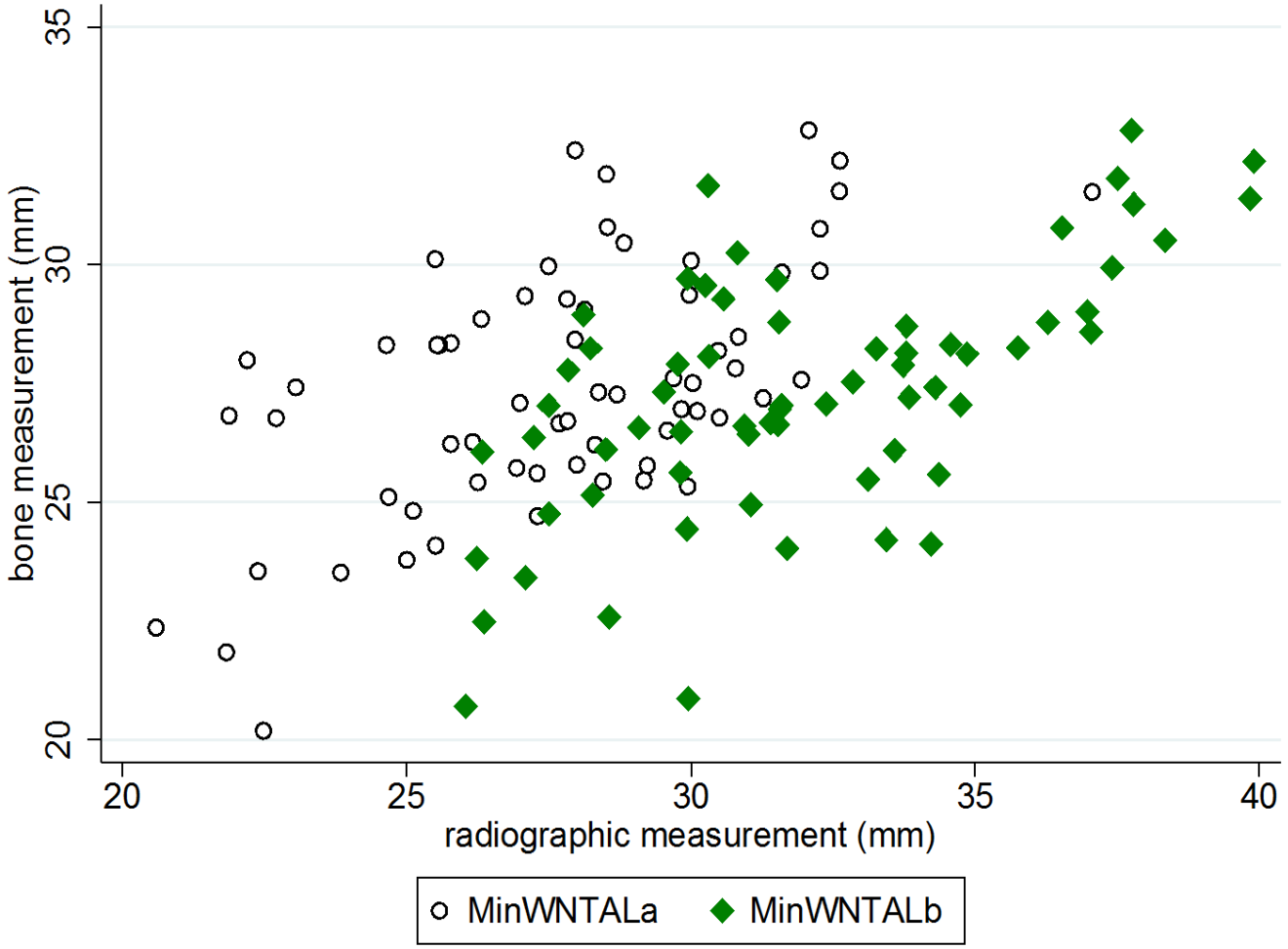
Measurements and Descriptive Statistics of Talus Bone and Radiographic Measurements

			Bone			Radiographic (x)					*t*-test	
Description	**Variable**	**N**	**Mean**	**SEM**	**SD**	**Mean**	**SEM**	**SD**	**t**	**df**	**p**	**r^2**
Maximum Length	MaxLTAL	54	60.10	0.713	5.24	62.45	0.803	5.90	-8.5328	53	<0.001	0.88
Maximum Body Height	MaxHBTAL	54	32.91	0.370	2.72	33.16	0.449	3.30	-0.8879	53	0.377	0.62
Body Height*	BHTALa	54	33.05	0.404	2.97	33.81	0.444	3.26	-4.3034	53	<0.001	0.84
Body Height*	BHTALb	54	33.53	0.434	3.19	33.81	0.444	3.26	-1.3143	53	0.194	0.78
Maximum Length Fibular Malleolar Facet	MaxLFMTAL	54	32.40	0.391	2.87	32.83	0.384	2.82	-1.7214	53	0.091	0.61
Maximum Width Talar Head	MaxWHTAL	54	31.60	0.397	2.92	31.92	0.477	3.51	-0.6961	53	0.489	0.20
Minimal Width Talar neck*	MinWNTALa	54	27.43	0.352	2.56	27.75	0.449	3.30	-0.8753	53	0.385	0.36
Minimal Width Talar neck*	MinWNTALb	54	27.32	0.369	2.72	27.75	0.449	3.30	-1.2679	53	0.210	0.45
Maximum Length Talar Head and Neck	MaxLHNTAL	54	25.22	0.415	3.05	24.54	0.464	3.41	2.4258	53	0.019	0.63

Talus correlation



Talus correlation



Talus Results

As demonstrated, while length (MaxLTAL) and one of the height measurements (BHTALa) are significantly different ($p \leq 0.05$), the differences between most of the radiographic and bone measurements of the other variables are not. Most measurements between radiograph and bone are correlated. The relationships in the transverse plane are weak, while those in the sagittal plane are stronger.

Conclusions

Conclusions

In spite of all the potential factors that can interfere with the accuracy of measurements taken from radiographs and corresponding bone, the results of this study demonstrate that, for most variables, selected measurements taken from radiographs accurately represent corresponding measurements taken from bone.

Conclusions (continued)

Measurements that are taken from radiographic views provide useful information:

- in assisting in the identification of an unknown individual by comparing measurements taken from the radiographs with those of the bone of the unknown individual (along with qualitative features).
- in adding to the data base of measurements that can be used in the development of a biological profile.

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Questions?

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