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Research Article

Correlation of the 6 Anthropometric Parameters to the AP Scanogram of the Tibia in Determining the Ideal Tibial Intramedullary Nail Length

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Abstract

Background: Accurate preoperative nail estimation has the potential to reduce intra-operative errors, operative time and radiation exposure.

Objectives: The study aims to determine the accuracy and correlation of the 6 anthropometric parameters to the ideal tibial IM nail length based on the AP scanogram of the tibia.

Methodology: Six anthropometric parameters were measured in 15 males and 15 females: knee joint line to the ankle joint line distance (KAD), knee joint line to the medial malleolus distance (KMD), tibial tuberosity to the ankle joint line distance (TAD), tibial tuberosity to the medial malleolus distance (TMD), olecranon tip to the head of the 5th metacarpal distance (OMD), body height (BH). The ideal tibial IM nail length was determined using the AP scanogram of the ipsilateral tibia measured as 10 mm from the proximal tibial articular surface and 10 mm from the distal tibial articular surface of the AP scanogram film of the tibia using the metal radiographic ruler as measuring tool. A regression equation was applied to BH measurements.

Results: Accuracy of BH regression equations recommended by other authors were calculated in the study. It was found out that the six anthropometric parameters have poor accuracy: KAD 27% (CI 32.59 - 34.24), OMD 13% (CI 31. 36 - 32.84) and KMD 7% (CI 33.79 - 35.31). The predicted nail length using BH regression (CI 29.26 - 30.41), TAD (CI 29.79 - 31.07) and TMD (CI 30.94 - 32.19) are not accurate with 0% accuracy.

Conclusion: KMD, KAD and OMD when taken altogether, are useful for estimating the range of tibial IM nail lengths. There was a strong correlation between the 6 anthropometric parameters and the ideal tibial IM nail length with KMD (r = .892, p = .000) having the highest correlation.

Keywords: Tibia Nail Length; Anthropometric Measurements

Introduction

The tibia is the most frequently fractured long bone, the tibial diaphysis being the most common site. Intramedullary (IM) nailing is considered the treatment of choice for most type I, type II, and type IIIA open and closed tibial shaft fractures and is especially useful for segmental and bilateral tibial shaft fractures [1]. An international survey showed that orthopaedic surgeons preferred IM nail fixation for 96% of closed fractures and lower grade open fractures of the tibia. This practice trend is reinforced by multiple prospective randomized trials and a systematic review of literature that supports the outcome of IM nail fixation over closed treatment of tibial shaft fractures [2]. Preoperative planning for IM nailing of the tibial shaft includes obtaining the correct IM nail length for the tibia. A short IM nail will result in malreduction, loss of reduction and inadequate working length, leading to failure of the construct. A long IM nail will distract the fracture site, impinge on the knee or violate the tibiotalar joint. Thus, proper nail length is imperative for satisfactory patient outcomes.

There are various methods of determining the IM nail length of the tibia in literature. Preoperative assessment of the IM nail length includes anthropometric and radiologic methods. Preoperative anthropometric methods use anatomic landmarks: distance from the knee joint line to ankle joint line, distance from the knee joint line to medial malleolus, distance from the tibial tuberosity to ankle joint line, distance from the tibial tuberosity to medial malleolus, distance from the olecranon to fifth metacarpal head and body height. Preoperative radiologic methods include use of acrylic template overlays or full length scanogram of the contralateral tibia. The use of full length AP scanogram of the tibia in one literature has 100 percent accuracy in selecting the ideal tibial IM nail length.

Intraoperative assessment of the IM nail length includes 2 guidewire technique or use of radiographic ruler. Intraoperative IM nail length measurement is more precise compared to preoperative assessment, however, needs the availability of a full range of tibial IM nail lengths to choose from the ideal IM nail length, availability of intraoperative x-ray machine/c-arm and can result in increased operative time as well as increased radiation exposure. Thus, preoperative assessment of tibial IM nail length will obviate the shortcomings of intraoperative assessment alone and eliminate the complications of using too short or too long tibial IM nail.

Measurement of any of the 6 anthropometric parameters is simple, uncomplicated and an economical technique in ascertaining the tibial IM nail length preoperatively. This can be accomplished by any orthopedic surgeon or resident in all secondary and tertiary hospitals with ease. Moreover, there are only a few literature and prospective studies that discuss anthropometric parameters for assessment of the tibial IM nail length, with conclusions on its accuracy and applicability ranging from mixed to conflicting. To date, no local study exploring the interrelationship as well as the accuracy of these 6 anthropometric parameters is available.

Objectives of the Study

General

To determine the accuracy and correlation of the 6 anthropometric parameters to the ideal tibial IM nail length based on the AP scanogram of the tibia.

Specific

1. To obtain the measurements of the 6 anthropometric parameters and, the ideal IM nail length using the AP scanogram film of the tibia:
   - Knee joint line to the ankle joint line distance (KAD)
   - Knee joint line to the medial malleolus distance (KMD)
   - Tibial tuberosity to the ankle joint line distance (TAD)
   - Tibial tuberosity to the medial malleolus distance (TMD)
   - Olecranon tip to the head of the 5^{th} metacarpal distance (OMD)
   - Body height (BH).
2. To measure the ideal IM nail length using the AP scanogram of the tibia.
3. To determine the accuracy of the 6 anthropometric parameters to the ideal tibial IM nail length based on the AP scanogram of the tibia.
4. To determine the correlation of the 6 anthropometric parameters to the ideal tibial IM nail length based on the AP scanogram of the tibia.

Significance of the Study

The study will clarify the gap in knowledge on the predictive potential of the 6 anthropometric parameters in determining the ideal tibial IM nail length. It has the prospect to guide orthopaedic

surgeons and residents in choosing the ideal tibial IM nail length preoperatively. Preoperative assessment of tibial IM nail length will allow the surgeon with confidence to choose 1 or 2 tibial IM nails only when patients cannot afford to pay for the full range of tibial IM nail lengths usually provided by the hospital or third party implant providers. Also, this prevents the difficulty of reinserting the correct IM nail after a difficult closed or open reduction of the tibia, when one has initially inserted a too short or too long IM nail.

Definition of terms

KAD (Knee joint line to the ankle joint line): Distance from a point on the medial knee joint line 3 cm medial to the medial edge of patellar tendon to another point on the medial ankle joint line felt as a depression just medial to the tibialis anterior tendon at the medial corner of the ankle joint.

KMD (Knee joint line to the medial malleolus): Distance from a point on the medial knee joint line 3 cm medial to the medial edge of patellar tendon to the most prominent point on the medial malleolus.

TAD (Tibial tuberosity to the ankle joint line): Distance between the most prominent point on the tibial tuberosity and a point on the medial ankle joint line felt as a depression just medial to the tibialis anterior tendon at the medial corner of the ankle joint.

TMD (Tibial tuberosity to the medial malleolus): Distance is the length between the most prominent points on the tibial tuberosity and the medial malleolus.

OMD (Olecranon tip to the head of the 5th metacarpal): Distance from the olecranon tip to the head of the fifth metacarpal.

AP scanogram of the ipsilateral tibia: Standard radiography of the ipsilateral leg with the patient supine on the x-ray table and using a 35 x 43 cm standard sized cassette tape. The x-ray beam is centered over the midpoint of the tibial shaft with a patient-to-tube distance of 101 cm. A metal radiographic ruler and Kuntscher nail of known length (20cms) are taped to the cassette tape.

Ideal tibial intramedullary (IM) nail length is the distance from a point 10 mm from the proximal tibial articular surface and 10 mm from the distal tibial articular surface as measured on the AP scanogram film of the tibia.

Background of the Study

In a study of J.G. Galbraith., *et al*. they used 16 paired cadaveric tibia and compared the most commonly used radiologic, anthropometric and intra-operative techniques to determine the ideal IM nail length and concluded that radiologic methods such as the AP radiograph with known magnification and intra-operative radiographic ruler were able to predict IM nail length very accurately and suggested that these measurements be performed routinely. They found anatomical measurements to be inaccurate for predicting tibial IM nail length. The AP scanogram was found to be 100% accurate in selecting ideal nail length. However, they also found out in 19% of cases it led to a nail being too long. The intra-operative radiographic ruler was found to give a good indication of the ideal nail size, as did the guide wire technique, with only 6% resulting to an incorrect nail size. In general according to their study, anatomical measurements gave a poor indication of ideal tibial IM nail size compared with the other techniques (KAD 56%, OMD 56%, KMD 50%, TMD 38%, and BH 13%) [2].

According to a study by RP Colen., *et al*. which assessed four methods of tibial IM nail length determination using full-length scanograms, spotograms, acrylic template overlays, and TMD on 14 cadaveric tibia and concluded that TMD to be an easy, inexpensive, and accurate method of preoperative tibial IM nail length assessment [3].

In a retrospective study of 16 patients done by B Venkateswaran., *et al*. they measured the normal leg's length from knee joint line to ankle joint line, tibial tuberosity to medial malleolus, knee joint line to medial malleolus and olecranon to 5th metacarpal head distance and found out that KAD to be the most reliable and showed the best correlation with ideal tibial IM nail length [4].

A study done by Isaac., *et al*. which assessed the correlation between five anthropometric parameters and the distance from the tibial tuberosity to medial malleolus (TMD) in 100 volunteers, and found out that TAD, KAD and KMD can be used simultaneously to increase the accuracy of tibial IM nail length prediction. Furthermore, they indicated that adding 11 mm to TAD had highest accuracy (81%) and correlation (0.966) in predicting nails correctly. Subtracting 33 mm from KMD and 25 mm from KAD derived accurate sizes in 69% and 76% respectively. Adding 6 mm to OMD had a poor accuracy of 51%. Nail size prediction based upon body

height regression equation derived correct nail sizes in only 34% of the cases. Regression equation analysis by other authors based on OMD and BH distances yielded correct sizes in 11% and 5% of the cases respectively [5].

The studies provide mixed and even conflicting recommendations on the most accurate preoperative anthropometric measurement technique in determining the ideal tibial IM nail length.

Methodology

Study design

A cross-sectional study design was conducted.

Study population

The population of the study included 30 volunteers, 15 males and 15 females, with informed written consents, from the roster of employees of CLMMRH, Bacolod City, Negros Occidental and was conducted from July 1, 2018 to July 28, 2018.

Inclusion criteria

Any male or female volunteer age 18 years old and above, with no previous or recent history of upper and lower extremity trauma, with no congenital deformity of the upper and lower extremity and agreed to undergo an AP scanogram of the ipsilateral leg with a signed written consent was included in the study. The volunteers should have no history of trauma and congenital deformity to any extremity to eliminate any positive or negative confounder in the outcomes of the research.

Exclusion criteria

Any male or female volunteer age less than 18 years old, with a previous or recent history of unilateral or bilateral upper and lower extremity trauma, with a congenital deformity of the upper and lower extremity, and with no signed written consent for AP scanogram of the ipsilateral leg.

All pregnant or expectant women are excluded from the study because of diagnostic x-ray exposure, although according to the American College of Radiology, no single diagnostic x-ray has radiation dose significant enough to cause adverse effects in a developing embryo or fetus were not included in the study.

Ethical considerations

Informed written consent was carried out for each participant prior the conduct of the study. The participants were informed with regards to the procedure they will undergo in the acquisition of anthropometric and radiologic measurements. The investigator was accompanied by a female resident when examining a female subject and volunteers may use a lead shield during x-ray. The research involves interaction with a human sample, thus it is important to establish trust with the participants. This was achieved by ensuring anonymity and confidentiality to all participants during and after the course of the research. The authors also carefully explained the research process and how the data will be gathered and presented. The accepted cumulative dose of ionizing radiation during pregnancy is 5 rad. The estimated fetal dose in a single extremity diagnostic x-ray is 0.001 rad.

Procedural details and anthropometric measurements

Materials used for the study included a standard tape measure, a metal radiographic ruler and an object with known length (Kunstcher IM nail measuring 20 cm in length).

The 15 male and female volunteers underwent the following anthropometric measurements using a standard tape measure: knee joint line to ankle joint line distance (KAD), knee joint line to medial malleolus distance (KMD), tibial tuberosity to ankle joint line distance (TAD), tibial tuberosity to medial malleolus distance (TMD), olecranon to 5th metacarpal head distance (OMD) and body height (BH). The anatomical landmarks that will be used for measurement of each parameter were defined based upon previous studies in literature [4]. An orthopedic female resident was present and assisted during taking of the anthropometric measurements of the 15 female volunteers.

KAD was measured from a point on the medial knee joint line 3 cm medial to the medial edge of patellar tendon to another point on the medial ankle joint line felt as a depression just medial to the tibialis anterior tendon at the medial corner of the ankle joint. This measurement will be performed with the volunteer supine, knee flexed 90 degrees and ankle in neutral dorsiflexion with the leg in 20 degree external rotation.

KMD was measured from the medial knee joint line 3 cm medial to the medial edge of patellar tendon to the most prominent point on the medial malleolus.

TAD was determined by measuring the distance between the most prominent point on the tibial tuberosity and a point on the

medial ankle joint line felt as a depression just medial to the tibialis anterior tendon at the medial corner of the ankle joint, with the ankle in neutral dorsiflexion.

TMD was determined by measuring the length between the most prominent points on the tibial tuberosity and the medial malleolus.

OMD was measured from the olecranon tip to the head of the fifth metacarpal with the elbow and metacarpophalangeal joints flexed to 90 degrees and the wrist held in neutral.

BH was measured in the standing position using a standardized weighing scale with a height rod.

Radiologic measurements

The 15 male and 15 female volunteers also underwent antero-posterior (AP) scanogram of the ipsilateral leg. Antero-posterior (AP) scanograms of the ipsilateral leg was performed alongside a metal radiographic ruler and a Kuntscher nail of known length (20 cms). The patient laid down in supine position on the x-ray table with the leg on a 14 x 17 cm standard sized cassette tape. The patella is pointing towards the ceiling and a metal radiographic ruler and Kuntscher nail of known length (20 cms) were taped to the cassette tape. The beam was centered over the midpoint of the tibial shaft with a patient-to-tube distance of 101 cm. This technique was done to standardize the magnification of the AP scanogram and get the actual length of the volunteer's tibia.

Ideal tibial IM nail length

The ideal length of the tibial IM nail should rest 5 - 10 mm below the proximal tibial articular surface and 5 - 20 mm above the distal tibial articular surface. This study used the ideal tibial IM nail length as 10 mm from the proximal tibial articular surface and 10 mm from the distal tibial articular surface as measured on the AP scanogram film of the tibia using the metal radiographic ruler as measuring tool. The measurement recorded from the AP scanogram of the tibia would reflect the ideal tibial IM nail length.

Data analysis

Data was processed using Statistical Package for Social Sciences (SPSS) version 22. Demographic profile of the participants in terms of sex and age were presented using frequency and percent.

Measurement of the six (6) anthropometric parameters were expressed in centimeters (cm) and the mean and standard deviation were calculated. Nail size calculation applying the regression equations recommended by Fischmeister., *et al*. [2] (nail length = - 5.05729 + .222 x BH) was also used.

Accuracy of the IM nail size calculation based upon each anthropometric parameter measurement was evaluated as a percentage and the 95% confidence interval (CI) will be calculated. These will also be compared with the ideal IM nail length taken from the AP scanogram of the tibia measurement.

The correlation of the 6 anthropometric parameters to the ideal tibial IM nail length based on the AP scanogram of the tibia was calculated using Pearson's correlation.

Results

Sex	Frequency	Percent	Mean Age	Age SD
Female	15	50	31.93	9.51
Male	15	50	31.27	6.96
Total	30	100	31.60	8.20

Table 1: Demographic profile.

Table 1 indicates the demographic profile of the participants. Of the 30 volunteers (50% female and 50% male), the mean age of the female volunteers was 31.93 years old while the male volunteers have a mean age of 31.27.

The six anthropometric parameters were measured and expressed in centimeters (cm) as shown in table 2. The KAD of female volunteers had a minimum length of 30 cm and maximum length of 35 cm as compared to the KAD measurements of the male volunteers which had a minimum of 31 cm and maximum length of 41 cm. Mean length of KAD among female volunteers was 32.43 cm with standard deviation of 1.39 cm while male volunteers had a mean length of KAD of 34.40 cm with standard deviation of 1.48 cm.

KMD among females had a minimum of 31 cm and maximum length of 36 cm while males had a minimum length of 32 cm and maximum length of 40.50 cm. Mean length of KMD among females was 33.57 cm with a standard deviation of 1.35 cm compared to

Sex	Measurement	Minimum	Maximum	Mean	Standard deviation
Female	KAD	30.00	35.00	32.43	1.39
	KMD	31.00	36.00	33.57	1.35
	TAD	27.50	32.00	29.93	1.33
	TMD	28.50	33.00	31.10	1.37
	OMD	29.00	32.00	30.67	1.05
	BH	146.00	163.50	153.10	4.35
	AP Scanogram	31.00	36.50	32.50	1.48
Male	KAD	31.00	41.00	34.40	2.47
	KMD	32.00	40.50	35.53	2.19
	TAD	26.50	34.50	30.93	1.94
	TMD	27.50	35.00	32.03	1.86
	OMD	30.00	35.50	33.53	1.65
	BH	151.50	173.00	161.63	6.45
	AP Scanogram	30.00	37.50	34.23	2.02

Table 2: Anthropometric and ideal tibial IM nail length measurements.

the mean length among males of 35.53 cm with a standard deviation of 2.19 cm.

Females had a minimum length of 27.50 cm and maximum length of 32 cm as compared to males with a minimum of 26.50 cm and maximum length of 34.50 cm for TAD. TAD mean length for females was 29.93 cm with standard deviation of 1.33 cm and males had a mean length of 30.93 cm with standard deviation of 1.94 cm.

TMD for females had a minimum length of 28.50 cm and maximum length of 33 cm. On the other hand, males had a minimum TMD length of 27.50 cm and maximum TMD length of 35 cm. Mean lengths for females was 31.10 cm and for males 32.03 cm. Standard deviations of 1.37 cm and 1.86, for females and males respectively.

OMD for females had a minimum length of 29 cm and maximum length of 32 cm while males had a minimum length of 30 cm and maximum length of 35.50 cm. Mean lengths for females was 30.67 cm and 33.53 for males. Standard deviations were 1.05 cm and 1.65 cm, for females and males respectively.

BH for females had a minimum length of 146 cm and maximum length of 163.50 cm. For males, BH had a minimum length of 151.50 cm and maximum length of 173 cm. Mean BH was 153.10 cm with standard deviation of 4.35 cm for females. For males, a mean length of 161.61 cm with standard deviation of 6.45 cm for BH.

AP scanogram of the female volunteers had a minimum of 31 cm and maximum length of 36.50 while the male volunteers had a minimum of 30 cm and a maximum of 37.50 cm. Mean length for females was 32.50 cm with standard deviation of 1.48 cm. Mean length for males was 34.23 cm with standard deviation of 2.02 cm.

Nail size derived from each anthropometric parameter was compared with the ideal tibial IM nail length based from the AP scanogram of the tibia. The results were summarized in table 3. The AP scanogram of the tibia which was found to be 100% (CI 79 - 100) accurate in selecting ideal tibial IM nail length based on the study of Galbraith., *et al*.

KAD had 27% (32.59 - 34.24) accuracy with 40% of the measurements being too long.

OMD had 13% (31. 36 - 32.84) accuracy with 10% of the measurements being too long.

KMD had 7% (33.79 - 35.31) accuracy with 83% of the measurements being too long.

Patient	AP Scanogram	KAD	KMD	TAD	TMD	OMD	Predicted IM nail length	BH
1	37.5	41	40.5	34.5	34	34.5	32	168
2	37	35	36	32.5	33.5	35	33	172
3	32	32	33.5	29.5	31	32.5	30	158
4	32	32.5	34	30.5	32.5	30	28	149
5	30	31	32	26.5	27.5	30	29	153.5
6	34	35	36	30	31	33	32	165.5
7	32.5	33	34	31	32	29.5	28	150.5
8	31	30	31	28	29	29	27	146
9	34.5	34	35.5	30.5	32	34	31	164.5
10	31	31	32	29.5	30.5	29.5	28	150
11	35.5	36	38	33	35	35	33	173
12	36.6	35	36	32	33	32	31	163.5
13	33	33	34	30	31	31	30	156
14	34	35	36	30	31	34	32	167
15	33	33	34	30.5	31.5	32	29	151.5
16	33	33	34	30	31	30.5	29	155
17	34	32	34	30	32	32	30	157.5
18	32	32	33	30	31	31	28	151
19	33	32	33.5	29.5	31	34.5	31	161.5
20	31.5	30.5	32	28	29.5	29	29	151.5
21	32.5	33	34	30	31	31.5	30	156.5
22	33	34	35	31	32	31.5	29	152.5
23	35	36	37.5	32	33.5	35.5	30	157
24	33.5	34	35	32	33	31.5	29	155.5
25	32.5	32	33.5	30.5	31.5	32.5	30	157.5
26	31	31	32	27.5	28.5	30.5	28	149
27	33.5	33	34	30	31	31	30	158
28	36.5	36	37	33	34	35.5	30	160
29	35.5	35	36	32	33	34	30	157.5
30	31	32.5	33.5	29.5	30.5	31.5	29	153
Incorrect	0/30	22/30	28/30	30	30	26	30	
Accuracy	100%	27%	7%	0%	0%	13%	0%	
95% CI		32.59 - 34.24	33.79 - 35.31	29.79 - 31.07	30.94 - 32.19	31. 36 - 32.84	29.26 - 30.41	154.78 - 159.96
Too long		12	25	0	0	3	0	
Correlation to ideal IM nail length		0.867	0.892	0.877	0.846	0.785	0.743	0.779
P-value		0.000	0.000	0.000	0.000	0.000		0.000

Table 3: Correlation of each anthropometric parameters with the ideal tibial IM nail length with accuracy and 95% confidence intervals (CI).

TAD (29.79 - 31.07), TMD (30.94 - 32.19) and the predicted tibial IM nail length derived from BH regression (29.26 - 30.41) resulted to 0% accuracy and were found to be too short. The anthropometric parameters varied between too long and too short which suggests that there is no simple adjustment that could be made to improve the results.

Results however indicated a strong correlation between ideal tibial IM nail length and KAD (r = .867, p = .000); KMD (r = .892, p = .000); TAD (r = .877, p = .000); TMD (r = .846, p = .000); OMD (r = .785, p = .000); BH (r = .779, p = .000).

Discussion

In this study, the researcher compared the six anthropometric parameters with the ideal tibial IM nail length based on the AP scanogram of the tibia.

Anthropometric measurements for the preoperative assessment of tibial IM nail length have been studied previously, with varying accuracies.

In this study, KAD had an accuracy of 27%. KAD in the studies of Venkateswaran., *et al*. had 86% accuracy, Isaac., *et al*. had 76% accuracy, and Galbraith., *et al*. had 56% accuracy. KAD had the highest accuracy in all of the anthropometric parameters in this study [2,4,5].

OMD in this study had 13% accuracy as compared with the results of the study conducted by Venkateswaran., *et al*. (57% accuracy), Galbraith., *et al*. (56% accuracy) and Isaac., *et al*. [4] (51% accuracy) [2,4,5].

KMD only had an accuracy of 7% as compared to the work of Venkateswaran., *et al*. of 79% or Galbraith., *et al.* of 50% [2,4].

TAD and TMD in this study had 0% accuracy. TMD in the study of Colen., *et al*. had 71% accuracy, while TMD in the study of Venkateswaran., *et al*. showed 64% accuracy. Isaac., *et al*. on the other hand recommended that TAD (81% accuracy) was as an excellent anthropometric parameter for determining the ideal tibial IM nail length [3-5].

The tibial IM nail sizes based upon the BH regression equation did not match with the ideal tibial IM nail length and showed 0% accuracy. This is contrary to the results generated by Isaac., *et al*. (34%) and Galbraith., *et al*. (13%) [2,5].

Of all the 6 anthropometric parameters, KAD was found to have the highest accuracy for determining the ideal tibial IM nail length. However, as noted KAD had only an accuracy of 27%. All six anthropometric parameters were found to be strongly correlated with ideal tibial IM nail length based on the AP scanogram of the ipsilateral tibia. Among them, KMD had the highest correlation.

Conclusion

In conclusion, we found out that there was a strong correlation between the 6 anthropometric parameters and the ideal tibial IM nail length based on the AP scanogram of the ipsilateral tibia, and that the highest correlation was with KMD. The six anthropometric parameters however were not accurate in predicting the ideal tibial IM nail length, but KAD and OMD along with KMD can be used for estimating the range of tibial IM nail lengths.

Recommendations

It is highly recommended to utilize KMD, KAD and OMD measurements simultaneously in order to increase the accuracy of tibial IM nail length prediction. The researcher also suggests to increase sample size to elicit more valid data in future researches. More parallel studies on this particular group is advocated.

Disclosure

No external funds were received in support of this study.

Appendix

Appendix A: Demographic profile of the participants.

Figure 1

Appendix B: Mean distributions of the 6 anthropometric measures.

Figure 2

Appendix C: Correlation of the 6 anthropometric measures with the ideal nail length.

Figure 3

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