PRE – OPERATIVE DETERMINATION OF INTRAMEDULLARY NAIL LENGTH IN TIBIA BY ANTHROPOMETRIC MEASUREMENT – A PROSPECTIVE STUDY

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ABSTRACT

Introduction: Accurate estimation of intramedullary (IM) nail length is vital in the surgical management of tibial shaft fractures. Intraoperative determination methods pose challenges such as radiation exposure and increased operative time. Anthropometric measurements offer a potentially simple, non-invasive alternative for preoperative planning.

Methodology: This cross-sectional observational study was conducted at the Department of Orthopaedics, Silchar Medical College and Hospital, Assam. A total of 40 adult patients undergoing IM nailing for tibial fractures were included after obtaining informed consent. Actual nail lengths used intraoperatively were documented. Pearson's correlation analysis was employed to determine the relationship between each anthropometric parameter and the TT-MM distance, taken as a reference.

Results: Among the six parameters assessed, TT-A and K-A measurements demonstrated strong positive correlations with the TT-MM distance ($r > 0.90$, $p < 0.001$), indicating their high predictive value for nail length estimation. The O-MH and body height showed moderate correlation, while K-MM showed variable correlation across sexes. Age, gender, and BMI had no significant influence on the predictive accuracy.

Conclusion: Anthropometric measurements, particularly TT-A and K-A distances, serve as reliable predictors of ideal tibial nail

length. This preoperative method can enhance surgical planning, reduce intraoperative errors, and improve outcomes, especially in resource-constrained settings.

Keywords: Tibial fractures, intramedullary nailing, anthropometry, nail length prediction, orthopedic surgery.

INTRODUCTION:

Tibial fractures are among the most commonly encountered long bone fractures in Orthopaedic practice, with a substantial proportion requiring surgical intervention for optimal functional recovery. Intramedullary nailing (IMN) remains the preferred modality for managing tibial shaft fractures due to its biomechanical stability, minimally invasive nature, and favorable clinical outcomes. The success of IMN, however, is highly dependent on the accurate selection of nail length, as improper sizing may result in complications such as knee or ankle pain, malalignment, or even fixation failure. Traditionally, intraoperative techniques such as guidewire-based measurements have been employed to determine the appropriate nail length. While widely used, these methods present notable limitations, including prolonged operative time, increased radiation exposure, and potential inaccuracies. Consequently, the development of a reliable and accurate preoperative approach for estimating intramedullary nail length is essential for improving surgical planning and minimizing intraoperative uncertainties. Beyond enhancing surgical precision, preoperative anthropometric estimation of nail length also offers significant economic and logistical benefits. By reducing the reliance on intraoperative fluoroscopy, this approach lowers radiation exposure and shortens operative duration, ultimately decreasing overall healthcare costs. Additionally, it facilitates more efficient implant inventory management, ensuring the availability of appropriate nail sizes prior to surgery and reducing procedural delays. By reducing dependence on intraoperative fluoroscopy, it not only minimizes

radiation exposure but also shortens operative time, thereby lowering overall healthcare costs. Furthermore, thorough preoperative planning improves inventory management within hospitals by ensuring the availability of appropriate implant sizes prior to surgery. This reduces procedural delays and supports optimal utilization of healthcare resources.

AIMS OF THE STUDY

To compare the different anthropometric measurements so asto explore the interrelationship between them for predictingnail size and determining their accuracy.

OBJECTIVES OF THE STUDY

To assess the correlation between six anthropometric parameters and the distance from tibial tuberosity to medial malleolus."

METHODOLOGY: After enrollment, each participant underwent six specific anthropometric measurements using a standard metallic measuring tape. These measurements included:

1. **K-A** (Medial Knee Joint Line to Ankle Joint Line)
2. **K-MM** (Medial Knee Joint Line to Medial Malleolus)
3. **TT-A** (Tibial Tuberosity to Ankle Joint Line)
4. **TT-MM** (Tibial Tuberosity to Medial Malleolus)
5. **O-MH** (Olecranon to Fifth Metacarpal Head)
6. **BHR** (body height ratio)

Each anthropometric measurement was recorded using a standardized proforma specifically developed for this study. The tibial tuberosity to medial malleolus (TT-MM) distance, recognized in prior literature as a reliable

predictor of intramedullary nail length, was used to estimate the reference nail size.

For each of the remaining six anthropometric parameters, a constant was derived and either added to or subtracted from the raw measurement to calculate a proposed nail length. Additionally, a regression equation was applied to the body height ratio (BHR) to estimate the corresponding nail size.

These predicted nail lengths were then compared against the TT-MM–based estimate, which served as the reference standard in this study. The accuracy and reliability of nail length predictions derived from the olecranon to metacarpal head (O-MH) measurement and the BHR regression equations—both developed in this study and drawn from existing literature—were calculated and evaluated accordingly.

RESULTS:

Table 1. Anthropometric and tibial measurement parameters distribution (n=40)

Parameters (cm)	Mean	SD
Tibial tuberosity to medial malleolus	32.7	1.8
Tibial tuberosity to ankle joint	32.8	1.9
Medial knee joint line to medial malleolus	34.5	1.9
Medial knee joint line to ankle joint line	34.5	1.9
Tip of olecranon to fifth metacarpal head	32.9	2.5
Body Height Ratio	32.3	2.5

Inference: The mean anthropometric measurements were as follows: tibial tuberosity to medial malleolus –32.7 ±1.8 cm, tibial tuberosity to ankle joint – 32.8 ± 1.9 cm, medial knee joint line to medial malleolus – 34.5 ±1.9 cm, medial knee joint line to ankle joint line - 34.5 ±1.9 cm, tip of olecranon to fifth metacarpal head – 32.9± 2.5 cm, and body height ratio – 32.3 ±2.5 cm."

Figure 1. anthropometric and tibial measurement parameters distribution (n=40)

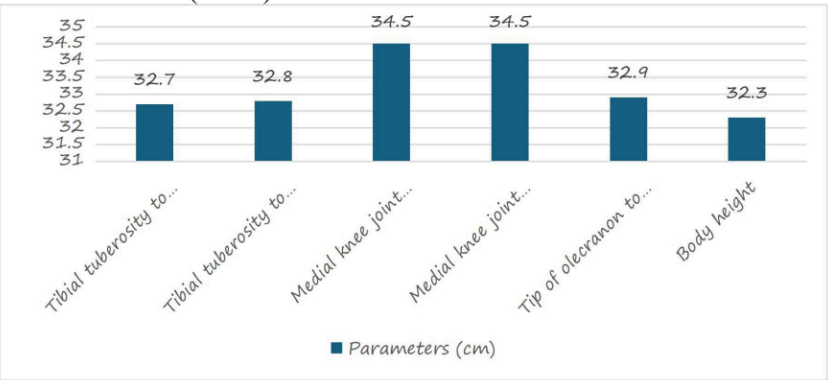


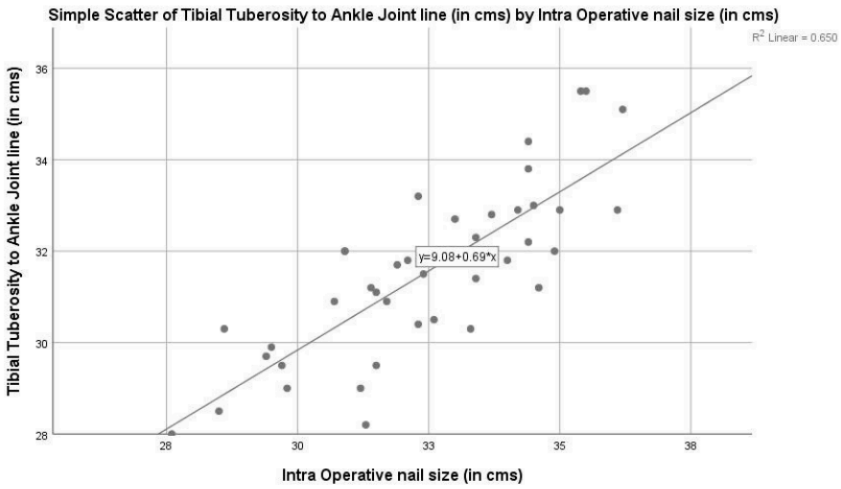
Table 2. Correlation between anthropometric and tibial measurement parameters and intraoperative nail size (n=40)

Parameters (cm)	Intraoperative nail length (cm)	
	r-value	p-value
Tibial tuberosity to medial malleolus	0.867	<0001*
Tibial tuberosity to ankle joint	0.806	<0.001*
Medial knee joint line to medial malleolus	0.772	<0.001*
Tip of olecranon to fifth metacarpal head	0.746	<0.001*
Medial knee joint line to ankle joint line	0.724	<0.001*

body height ratio	0.817	<0.001*

Inference: Significant and strong positive correlations were found for:

- Tibial tuberosity to medial malleolus ($r = 0.867$, $p < 0.001$)
- Tibial tuberosity to ankle joint ($r = 0.806$, $p < 0.001$)
- Medial knee joint line to medial malleolus ($r = 0.772$, $p < 0.001$)
- Tip of olecranon to fifth metacarpal head ($r = 0.746$, $p < 0.001$)
- Medial knee joint line to ankle joint line ($r = 0.724$, $p < 0.001$)
- body height ratio ($r = 0.817$, $p < 0.001$)”



r value represents the Pearson’s correlation coefficient (0 = no correlation; 0 to 0.3 = weak correlation; 0.3 to 0.5 = moderate correlation; >0.5 = strong correlation).

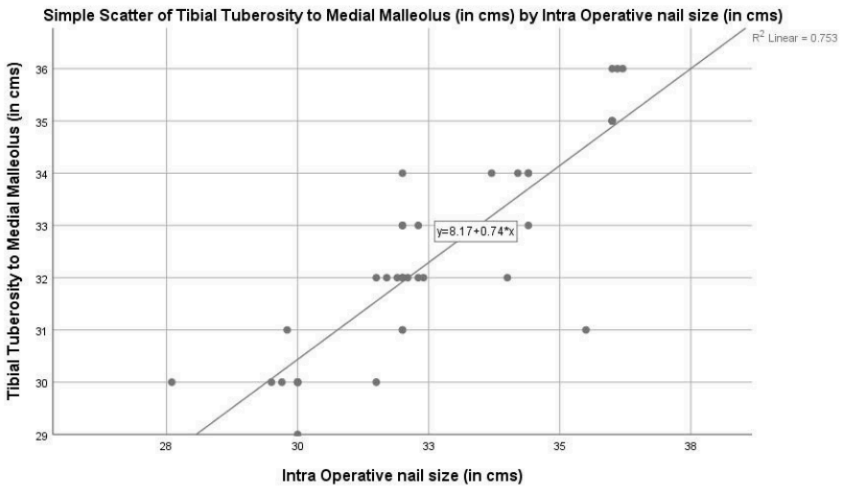


Figure 2. correlation between anthropometric and tibial measurement parameters and intraoperative nail size (n=40)

DISCUSSION

Anthropometric Parameters and Tibial Nail Length Estimation

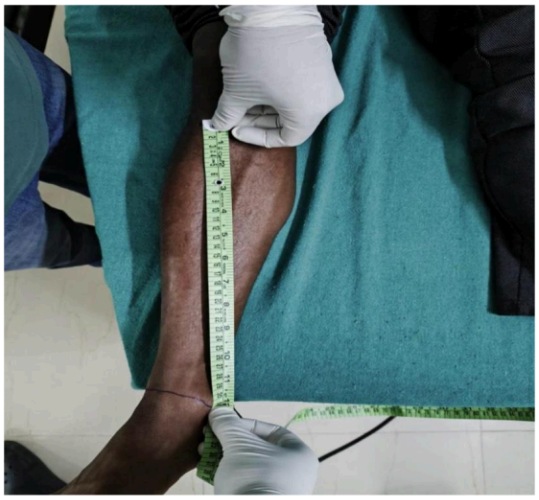
A key objective of the study was to evaluate the correlation between various anthropometric measurements and the intraoperative tibial nail length. The results indicated strong and statistically significant correlations between the intraoperative nail size and all the anthropometric parameters assessed. Among the measurements, the **tibial tuberosity to medial malleolus (TT-MM)** distance showed the highest correlation with intraoperative nail size (r = 0.867), followed by the **tibial tuberosity to ankle joint (TT-A)** distance (r = 0.806), **body height ratio (BHR)** (r =0.817), and the **olecranon to fifth metacarpal head (OMH)** distance (r = 0.746). These findings suggest that anthropometric

measurements, particularly TT-MM, are reliable indicators for preoperative tibial nail size estimation.

These findings corroborate the study conducted by **Sreshtha** et al., which highlighted a strong correlation (r = 0.88) between TT-MM measurements of the contralateral leg and the intraoperatively determined ideal nail length. Similarly, **Albay** et al. identified the TT and JJ (knee to ankle joint) distances as having excellent correlation with ideal nail length, particularly in females, reinforcing the validity of lower limb anthropometric measurements.

"Additionally, **Issac** et al. reported that TT-A (tibial tuberosity to ankle joint) distance was the most accurate single predictor, showing 81% accuracy when corrected appropriately, consistent with the high correlation observed in the present study (r = 0.806)"

Study	Year	Findings
Sreshtha et al.	2021	strong correlation (r = 0.88) between TT-MM measurements of the contralateral leg and the intraoperatively determined ideal nail length
Albay et al.	2021	K-A (knee to ankle joint) distances as having excellent correlation with ideal nail length
Issac et al.	2016	TT-A (tibial tuberosity to ankle joint) distance was the most accurate single predictor, showing 81% accuracy



CONCLUSION

This study underscores the potential of "**anthropometric measurements**, particularly the **tibial tuberosity to medial malleolus (TT-MM)** and **tibial tuberosity to ankle joint (TT-A)** distances, as reliable and accessible methods for **preoperative intramedullary tibial nail length estimation**. With a **high**

correlation ($r = 0.867$, $p < 0.001$), the **TT-MM measurement** emerges as the most effective predictor, demonstrating its strong utility for accurate implant selection. The study also highlights **alternative measurements** such as the **olecranon to fifth metacarpal head (OMD)** distance and **body height ratio (BHR)**, both of which exhibit significant correlations, providing useful options when **lower limb measurements** are difficult to obtain due to **trauma** or **soft tissue compromise**."

Importantly, the study found no **statistically significant differences** in the correlation between nail length and these measurements across **sex** or **age groups**, suggesting that these methods are **universally applicable** across different demographic groups. This consistency supports the widespread adoption of **anthropometric methods** in **preoperative planning** for **tibial shaft fractures** and aligns with findings from previous studies that advocate for their use, particularly in **resource-limited environments** where **fluoroscopic templating** may not be readily available.

"The **practical advantages** of anthropometric measurements are clear, including the potential to **reduce operative time**, **minimize radiation exposure**, and decrease **complications** linked to improper nail sizing. By simplifying the process of **implant selection**, these techniques could contribute to improved surgical efficiency and patient outcomes, particularly in **settings with limited access to advanced imaging technologies**."

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