ISSN: 2457-0400
Impact Factor: 6.711

WORLD JOURNAL OF ADVANCE HEALTHCARE RESEARCH

www.wjahr.com

Volume: 10, Issue: 2
Page N. 118-125
Year: 2026

Original Article
Coden USA: WJAMA3

VALIDITY OF THE PREOPERATIVE ANTHROPOMETRIC PARAMETERS FOR PROPER CHOOSING OF LENGTH AND DIAMETER OF THE TIBIAL NAIL IN COMPARISON WITH ACTUAL PARAMETERS TAKEN BY RADIOLOGICAL METHOD

[1]*Khalid Jamal Mubdir, [2]Prof. Dr. Midhat M. Mahdi

[1]M.B.Ch.B.
[2]M.B.Ch. B, C.A.B.S.

Article Received: 29 December 2025 **Article Revised:** 19 January 2026 **Article Published:** 01 February 2026

***Corresponding Author: Khalid Jamal Mubdir**
M.B.Ch.B.
DOI: https://doi.org/10.5281/zenodo.18440787

How to cite this Article: [1]Khalid Jamal Mubdir, [2]Prof. Dr. Midhat M. Mahdi, (2026). Validity of The Preoperative Anthropometric Parameters For Proper Choosing of Length and Diameter of The Tibial Nail In Comparison with Actual Parameters Taken By Radiological Method. World Journal of Advance Healthcare Research, 10(2), 118–125.

ABSTRACT

Background: Tibial shaft fractures are common high-energy injuries that require precise implant selection to ensure stability, promote healing, and minimize complications. While intramedullary nailing is the gold standard of the management, accurate preoperative estimation of nail length and diameter remains challenging, often relying on intraoperative trial-and-error. **Aim of the study:** This study evaluated the accuracy of simple anthropometric and radiological measurements in predicting appropriate Tibial nail dimensions. **Methods:** A cross-sectional study was conducted from June 2024 to June 2025 in Basrah hospitals, Iraq, including 60 adult male patients with unilateral tibial shaft fractures. Preoperative measurements of the intact contralateral limb—Tibial tuberosity to joint line of the ankle-(TT-JL)—Tibial condyle-medial malleolus (TC-MM)—Tibial tuberosity-medial malleolus (TT-MM) and measurement of tibial canal diameter at the isthmus, were recorded and correlated with intraoperative measurements determined nail length and diameter. Statistical comparisons employed paired t-tests for length and Wilcoxon signed-rank tests for diameter, with accuracy assessed at ±10 mm and ±5 mm (length) and ±0.5 mm (diameter). **Results:** The tibial tuberosity–to–joint line (TT-JL) method yielded the smallest mean difference from intraoperative nail length (3.13 mm, $p = 0.004$) and the highest accuracy within ±10 mm (85%), outperforming Tibial Tuberosity-Medial malleolus (TT-MM) (80%) and Tibial Condyle-Medial malleolus (TC-MM) (76.67%) methods. Accuracy within ±5 mm was highest for Tibial Tuberosity-Medial malleolus (TT-MM) (68.33%), followed by Tibial Tuberosity to joint line of ankle (TT-JL) (66.67%) and Tibial Condyle-medial malleolus (TC-MM) (51.67%). Preoperative diameter estimates consistently underestimated intraoperative values (mean difference −1.29 mm, $p < 0.001$), with low precision (±0.5 mm accuracy: 16.67%). Mean operative time was 88.48 minutes, with a mean of 42.82 fluoroscopic exposures. **Conclusion:** Anthropometric measurements, particularly the TT-JL distance, can reliably estimate tibial nail length preoperatively, potentially reducing operative time and intraoperative adjustments. However, plain radiographic assessment of nail diameter remains unreliable, indicating the need for refined imaging protocols or advanced measurement tools. Standardizing preoperative length estimation methods could enhance surgical efficiency and safety in tibial shaft fracture management.

KEYWORDS: Tibial shaft fracture, intramedullary nailing, preoperative planning, anthropometry, nail length estimation, fluoroscopy.

1. INTRODUCTION

Tibial fractures are among the most common long bone injuries, often associated with high-energy trauma such as vehicular accidents or falls from 3 meters.[1] Due to their proximity to the skin, these fractures pose unique challenges, making them susceptible to complications such as infection and delayed healing.[2] Epidemiological studies have consistently shown a rising incidence of tibial fractures, further emphasizing their clinical significance.[3]

The tibia, or shinbone, is the primary weight-bearing bone of the lower limb, extending from the knee to the ankle.[4] It articulates proximally with the femoral condyles at the knee joint and distally with the talus at the ankle joint/[4] The tibial plateau forms the upper surface of the tibia and is a critical load-bearing structure that plays a key role in knee stability and movement.[5] The shaft of the tibia is triangular in cross-section and lies just beneath the skin, making it highly susceptible to open fractures, particularly in high-energy injuries.[6] At the distal end, the tibia forms the medial malleolus, contributing significantly to ankle joint stability.[4] The bone receives its blood supply mainly from the nutrient artery which is arising mainly from the posterior tibial artery, supported by periosteal and metaphyseal vessels, which are crucial for fracture healing.[6] Due to its minimal soft tissue coverage, tibial fractures carry a higher risk of complications such as infection, delayed union, and nonunion, especially in cases of open or high-energy trauma.[4] The tibia has a triangular cross-section proximally that becomes more oval distally, with the mediolateral diameter wider than the anteroposterior throughout. At the tibial plateau, the mediolateral diameter averages 70–80 mm compared to 40–50 mm anteroposteriorly, while the shaft narrows to about 25–35 mm mediolateral and 20–30 mm anteroposterior. Distally, the bone remains oval with a mediolateral width of 35–45 mm, and its intramedullary canal tapers from 12–16 mm proximally to 8–10 mm distally, features that are critical for weight-bearing mechanics and surgical fixation.[4]

Tibial fractures are commonly categorized based on anatomical location into proximal, diaphyseal (shaft), and distal fractures to guide clinical assessment and treatment decisions.[6] Proximal tibial fractures, especially those involving the tibial plateau, are most frequently classified using the Schatzker system, which consists of six distinct types based on fracture morphology and the involved compartment.[6] Despite its clinical utility, the Schatzker classification may not fully capture complex fracture configurations, especially with advances in imaging modalities.[7] To address this, the AO/OTA classification system has been widely adopted, offering a more detailed framework by dividing proximal fractures into extra-articular (Type A), partial articular (Type B), and complete articular (Type C) types.[7]

For tibial shaft fractures, the AO/ASIF system is the most utilized, categorizing fractures by pattern into simple, wedge, or complex types while considering location along the diaphysis.[8] This classification is integral for planning operative intervention and evaluating prognosis.[8]

The diagnosis of tibial fractures begins with a thorough clinical assessment, including history of trauma, visible deformity, swelling, tenderness, and functional impairment of the affected limb. Standard biplanar radiographs (anteroposterior and lateral views) remain the first-line imaging modality and are often sufficient for detecting most shaft and plateau fractures.[9] However, in cases of complex or subtle fractures—such as non- displaced posterior malleolar fractures or stress injuries, computed tomography (CT) is recommended to better delineate fracture geometry and guide surgical planning.[10] For stress fractures, especially in athletes or military populations, bone scintigraphy or MRI is preferred due to their high sensitivity in early detection before radiographic changes appear.[11] In pediatric cases or high- energy trauma, associated injuries such as growth plate damage or compartment syndrome must also be evaluated clinically and with imaging.[12]

The management of tibial fractures depends on fracture location, complexity, and associated soft tissue injury, with treatment ranging from conservative casting to complex surgical interventions.[13] For proximal tibial fractures, operative techniques such as minimally invasive plate osteosynthesis (MIPO), locking compression plating, and intramedullary nailing are commonly used depending on fracture type and joint involvement.[14] Newer concepts like the three-column and 10-segment classification systems help guide more tailored surgical approaches, with growing evidence supporting the use of arthroscopically- assisted reduction for joint surface accuracy.[15] In diaphyseal fractures, intramedullary nailing remains the gold standard of the management, with most trauma surgeons preferring reamed or unreamed nailing based on case specifics and soft tissue condition.[16] Bone stimulators, such as low-intensity pulsed ultrasound or electrical stimulation, are often used adjunctively in difficult-to-heal fractures to enhance union, especially in complex or open injuries.[17] Open tibial fractures require special consideration, with initial management focused on surgical debridement, prophylactic antibiotics, and early stabilization using either external fixators or intramedullary nails depending on soft tissue viability.[18] Soft tissue coverage is a critical component and should ideally be achieved within 5–10 days to reduce infection risk, with orthoplastic collaboration improving outcomes.[19] In cases of distal tibial fractures (Any fracture occurring in the metaphyseal region of the tibia), multiple techniques are available including intramedullary nailing, MIPO, and external fixation, with treatment selection guided by fracture pattern, soft tissue condition, and the need to minimize devascularization.[20] For complex or comminuted fractures, especially in high-energy trauma, staged management using external fixation followed by definitive internal fixation is often employed.[21] Ultimately, the key to successful tibial fracture treatment lies in choosing a modality that balances fracture stability, biological preservation, and soft tissue care.[22]

Accurate selection of nail length and diameter during intramedullary nailing significantly contributes to surgical success. Incorrect sizing may result in complications such as malalignment, implant failure, or delayed union, underscoring the importance of precision.[23] Proper sizing ensures mechanical stability, optimizes load transfer, and accelerates the healing process.[2] Current advancements in imaging and measurement techniques aim to refine preoperative planning for better outcomes.[3]

The primary objective of this study is to assess the accuracy and validity of preoperative nail length and diameter assessments in reducing surgical time and fluoroscopic exposure. By leveraging advanced radiological techniques, the study aims to establish a robust framework for preoperative measures that minimize intraoperative complications and optimizes outcomes.

2. PATIENTS AND METHODS

This cross-sectional study was conducted over a one-year period from June 2024 to June 2025. The research took place in Basra hospitals-orthopedic department, Iraq. The study population included adult patients (aged >18 years) admitted with tibial shaft fractures to hospitals in Basra. Patients were selected consecutively based on eligibility criteria. Measurements were conducted on the intact contralateral limb to ensure accurate morphometric assessment.

The study included patients aged more than or equal to 18 years with availability of intact contralateral tibia for measurement, diaphyseal fractures of the tibia (both open and closed, especially those extending from just below the tibial tubercle to 5 cm above of the ankle joint) or displaced or unstable tibial shaft fractures (Spiral, oblique, comminuted, or segmental patterns). Additionally, the study included patients with open tibial shaft fractures (after appropriate debridement and soft tissue management), and those with polytrauma patients (early stabilization of long bone fractures reduces systemic complications (e.g., fat embolism, ARDS). Furthermore, Pathological fractures of the tibial diaphysis, nonunion and malunions of the tibial shaft requiring re-stabilization were included in this study. On the other hand, the study excluded patients with malunion or prior surgical intervention (e.g., plating) on the ipsilateral tibia or the contralateral side, patients with any bony pathology or metabolic bone disease (e.g., osteogenesis imperfecta) affecting the contralateral tibia, patients with congenital or acquired deformities affecting canal morphology of the tibia, patients with prior amputation of the contralateral lower limb, obese patient (posses' difficulties in measurements), open fracture, bullet injury and bone loss.

Anthropometric measurements were obtained from the contralateral, intact tibia using a standard flexible tape measure with the patient in a supine position and knee slightly flexed. The anatomical landmarks were palpated and marked carefully using a skin-safe marker. The following distances were recorded using the tape:

1. Tibial condyle to Medial Malleolus Distance (TC-MM)
2. Tibial Tuberosity to Medial Malleolus Distance (TT-MM)
3. Tibial Tuberosity to Ankle Joint Line Distance (TT-JL)
4. Tibial canal diameter at tibial isthmus.

Preoperative anthropometric measurements were performed using radio-opaque measurement tapes, confirmed by anteroposterior (AP) and lateral X-rays of the intact contralateral tibia. The diameter was measured at the isthmus level (narrowest point) of the intramedullary canal, typically at 8–12 cm distal to the tibial tuberosity.[24]

The optimal tibial nail length was defined as the distance from approximately 1 cm below the tibial plateau to 1 cm above the distal tibial plafond (ankle joint line), ensuring both end fixation and avoidance of joint penetration.[33] Intraoperative nail length and diameter were determined using sterile radiopaque rulers and nail templates under C-arm fluoroscopy. Nail length was confirmed by overlaying the radiographic ruler parallel to the tibia on the AP view and verified on the lateral view. Preoperative measurements were validated with intraoperative findings to assess their predictive accuracy. An optimal measurement was defined as one that fell within ±10 mm of the actual nail length and ±0.5 mm of the actual nail diameter used intraoperatively.

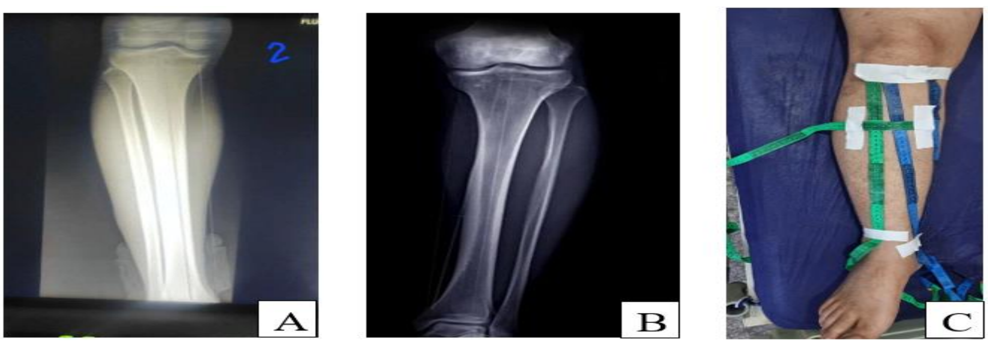

Figure 1: Intraoperative tibial measurement (A and B), Pre-operative tibial measurement (C).

Data were analyzed using SPSS version 26. Continuous variables were presented as mean ± SD, and categorical variables as frequencies and percentages. Paired t-tests compared preoperative length measurements (Tibial Condyle -medial malleolus (TC-MM), Tibial Tuberosity-Medial Malleolus (TT), and Tibial Tuberosity to Joint Line (TT-JL)) with intraoperative nail lengths. The Wilcoxon signed-rank test was used for comparing preoperative and intraoperative nail length and diameter. Accuracy was calculated as the percentage of measurements within ±10 mm and ±5 mm for length, and ±0.5 mm for diameter. A p-value < 0.05 was considered statistically significant.

3. RESULTS

The study sample comprised exclusively male participants (100%), with a mean age of 37.9 years (range 19–64), indicating a relatively young to middle-aged cohort. Educational attainment was predominantly at the college (48.3%) and primary (43.3%) levels, with very few participants having higher education (1.7%). The vast majority were married (90.0%) and employed as workers (75.0%), suggesting a socially and economically active population. All participants were classified as physically active, and the most frequent fracture pattern was transverse (68.3%), followed by spiral (13.3%) and short oblique (11.7%), with more complex patterns (comminuted, butterfly) being rare (3.3% each). Most tibial fractures were located in the middle third (29 cases, 48.33%), followed by fractures extending from the middle to distal third (20 cases, 33.33%), and fewer involved the upper to middle third region (11 cases, 18.33%), highlighting the middle third as the most commonly affected anatomical site. Negative past medical and surgical histories in two-thirds of cases, indicating a generally healthy baseline population, potentially influencing surgical recovery outcomes. Medical histories were positive in 20 cases; Hypertension (11.7%), Diabetes mellitus (15.0), ischemic heart disease (6.7%).

Table 1: Demographic and Clinical Characteristics.

Variable		Frequency (n)	Percentage (%)
Age Mean ± SD (min–max)		37.9 ± 11.47 (19–64)	
Sex	Male	60	100.0
Education	College	29	48.3
	Primary	26	43.3
	Intermediate	4	6.7
	Higher	1	1.7
Marital status	Married	54	90.0
	Divorced	4	6.7
	Unmarried	2	3.3
Occupation	Worker	45	75.0
	Student	8	13.3
	Retired	7	11.7
Activity	Active	60	100.0
Fracture pattern	Transverse	41	68.3
	Spiral	8	13.3
	Short oblique	7	11.7
	Comminute	2	3.3
	Butterfly	2	3.3
Site of the fracture	Middle third	29	48.55%
	Middle1/3-distal1/3	20	33.33%
	Upper1/3-middle1/3	11	18.33%
Past medical history	No	40	66.7
	Hypertension	7	11.7
	Diabetes mellitus	9	15.0
	Ischemic heart disease	4	6.7
Past surgical history	No	41	68.3
	Yes	19	31.7

Spinal anesthesia was overwhelmingly preferred (90.0%) over general anesthesia (10.0%), reflecting a likely institutional or procedural preference. The tourniquet was not used in (85.0%), with only 15.0% definitively recorded as tourniquet use. The mean operative time (from induction till recovery) is reported as 88.48 ± 27.3 minutes with a stated range of 40–160 minutes, indicating a probable typographical or unit error in the mean value, as it falls outside the reported range. Fluoroscopic exposure was substantial, with a mean of 42.82 ± 22.31 image intensifier shots (range 11–144).

Table 2: Intraoperative Characteristics.

Variable		Frequency (n)	Percentage (%)
Type of anesthesia	Spinal	54	90.0
	General	6	10.0
Tourniquet use	Yes	9	15.0
	No	51	85.0
Operative time (Mean ± SD (min–max))		88.48 ± 27.3 (40–160)	
Number of image intensifiers Mean ± SD (min–max)		42.82 ± 22.31 (11–144)	

All preoperative length estimation methods (TC, TT, TT-JL) showed statistically significant differences when compared to intraoperative nail lengths, with the TC -MM method demonstrating the largest mean difference (7.40 mm) and TT-JL the smallest (3.13 mm), indicating greater precision in the latter. The TT-MM and TT-JL methods both maintained differences below 5 mm, which is clinically more acceptable. Preoperative diameter estimates were significantly smaller than intraoperative measurements (mean difference −1.29 mm, $p < 0.001$).

Table 3: Measurement Means, Differences, and Statistical Significance.

Comparison	Preoperative Mean ± SD	Intraoperative Mean ± SD	Mean Difference ± SD	P-Value
TC -MM vs Intraoperative Nail Length	355.40 ± 12.04	348.00 ± 10.62	7.40 ± 10.02	<0.001
TT-MM vs Intraoperative Nail Length	352.25 ± 14.92	348.00 ± 10.62	4.25 ± 15.06	0.032
TT-JL vs Intraoperative Nail Length	351.13 ± 10.22	348.00 ± 10.62	3.13 ± 8.14	0.004
Preoperative anthropometric measures vs Intraoperative Diameter	10.14 ± 0.72	11.43 ± 0.57	-1.29 ± 0.54	<0.001

Accuracy within ±10 mm was highest for the TT-JL of ankle method (85.00%), followed by TT-MM (80.00%) and TC-MM (76.67%), reinforcing the superior reliability of TT-JL for length prediction. When the tolerance was narrowed to ±5 mm, accuracy dropped across all methods, most notably for TC-MM (51.67%) compared to TT-MM (68.33%) and TT-JL of ankle (66.67%). For diameter estimation, accuracy within ±0.5 mm was notably poor (16.67%), aligning with the consistent underestimation seen in Table 4 and highlighting the challenge of precise preoperative diameter prediction.

Table 4: Accuracy Rates for Preoperative Measurements.

Preoperative Measurement	Accuracy (%)
TC -MM (±10 mm)	76.67%
TC -MM (±5 mm)	51.67%
TT-MM (±10 mm)	80.00%
TT-MM (±5 mm)	68.33%
TT-JL (±10 mm)	85.00%
TT-JL (±5 mm)	66.67%
Pre-op Diameter (±0.5 mm)	16.67%

Table 5 shows that distal locking accounts for the largest share of fluoroscopic shots (40.0%, mean 15.77 ± 9.58), followed by reduction, reaming, and nailing (20.0%), final confirmation (16.6%), and entry points (13.6%), with proximal locking lowest at 9.8%. The concentration during distal locking suggests a key area for reducing radiation exposure through improved technique or targeting devices.

Table 5: Fluoroscopic shots distribution.

Fluoroscopic stage shots	Mean ±SD	Percentage of the total radiological shots
Entry points	5.37± 3.25	13.6%
Reduction, reaming, nailing	7.89± 4.81	20.0%
Distal locking	15.77± 9.58	40.0%
Proximal locking	3.88± 2.41	9.8%
Final confirmation	6.57± 4.02	16.6%

4. DISCUSSION

Tibial shaft fractures remain a common and complex injury, especially among young adults, and continue to challenge orthopedic surgeons due to risks like malalignment, infection, and delayed healing.[26] Intramedullary nailing stands as the preferred method for treating these injuries: it preserves soft tissue, supports effective load-bearing, and promotes early mobilization while minimizing surgical trauma.[27] Still, determining the correct nail length and diameter before surgery remains difficult, and inaccuracies can increase operative time, radiation exposure, or destabilize the fixation.[28] In response, modern preoperative techniques and templating strategies are being developed to improve measurement accuracy, reduce intraoperative guesswork, and enhance overall surgical efficiency.[29] Our study contributes to this evolving paradigm by evaluating simple but potentially practical anthropometric predictors for nail length and diameter in a real-world clinical setting, focusing on how they compare, and which offer the most reliable estimations.

In our cohort of 60 male patients with a mean age of 37.9 years—most of whom were manual workers, with transverse tibial shaft fractures being the commonest—and approximately one-third presenting with comorbidities, we observed demographics and injury patterns that align with established epidemiological data. For example, epidemiological surveillance in Denmark reports an overall tibial shaft fracture incidence of 16.9 per 100,000 people per year, with higher rates in males who typically present in their late 30s—closely matching our mean age and gender distribution.[30] Likewise, a large-scale U.S. study analyzing over 27,000 tibial shaft fracture cases revealed a bimodal age distribution with peaks in the 20s and 50s and a predominance of male patients.[31] Occupational links are implied by these demographic tendencies and mirrored in our data, where most patients were manual workers, a group commonly exposed to trauma risks. Additionally, transverse fracture patterns, like those we observed, are often associated with direct, high-energy impacts—mechanisms frequently cited in the literature.[32] Finally, the presence of comorbidities in one-third of patients mirrors findings in larger trauma cohorts, where underlying health conditions significantly influence recovery trajectories and complication rates.[31]

Spinal anesthesia was the predominant choice (90%), the mean operative time was 88.48 minutes, and the mean number of intraoperative fluoroscopic shots was 42.82. The preference for epidural anesthesia aligns with evidence showing its benefits in reducing postoperative pain and facilitating early mobilization compared to general anesthesia in lower limb fracture surgery.[31] Our operative time is consistent with previously reported ranges of 80–100 minutes for tibial intramedullary nailing in comparable settings[33], suggesting that preoperative anthropometric planning may have contributed to efficiency. However, the relatively high mean number of fluoroscopic exposures reflects the continued reliance on intraoperative imaging for verification—a pattern also observed in other series despite preoperative templating, raising concerns about radiation exposure to both patients and surgical teams.[31]

The TT-JL measurement showed the smallest mean difference from the intraoperative nail length (3.13 mm), followed by TT-MM (4.25 mm) and TC-MM (7.40 mm), while preoperative diameter estimation consistently underestimated the actual canal size by an average of 1.29 mm. The superior accuracy of TT-JL closely aligns with findings from a prospective study in Italy, where tibial tuberosity-to-joint line measurements demonstrated the highest correlation with intraoperative nail lengths among multiple anthropometric methods.[34] Similar conclusions were reached by Panayi et al., who reported that TT-JL reduced nail length estimation error compared to more traditional reference points.[29] Conversely, our underestimation of nail diameter echoes observations that plain radiographic measurements often misrepresent intramedullary canal dimensions due to magnification errors and anatomical variation.[35] These findings reinforce that while certain anthropometric methods can reliably predict nail length, diameter estimation remains a persistent limitation in preoperative planning.

TT-JL of ankle achieved the highest accuracy within ±10 mm (85%), outperforming TT-MM (80%) and TC-MM (76.67%), while its ± 5 mm accuracy (66.67%) was also superior to the other methods. These results are in line with Mao et al., (2015) who found TT-JL to be the most reliable anthropometric predictor for tibial nail length, particularly when aiming for higher precision margins.[29] Our findings also align with Cox et al., (2000), who found that the tibial tubercle– medial malleolus distance provided a straightforward and comparatively accurate preoperative estimate of tibial nail length, reinforcing the utility of tuberosity-based anthropometric measures.[34] In contrast, preoperative diameter estimation had a notably low accuracy (16.67%), a limitation widely reported in the literature—such as by Lee et al. (2025), who found that simple radiographs significantly over- or underestimated canal diameter in femoral shaft fractures when compared to computed tomography, highlighting the limited reliability of plain radiographic measurements.[36]

In this study, distal locking was the most radiation-intensive stage of tibial intramedullary nailing, accounting for 40 % of total fluoroscopic shots, with an average of 15.77 ± 9.58 exposures per case. Reduction, reaming, and nailing contributed 20 % of exposures, followed by final confirmation at 16.6 %, entry points at 13.6 %, and proximal locking at only 9.8 %. This distribution clearly indicates that distal locking is the primary driver of intraoperative radiation, representing the most critical target for exposure reduction. Our findings align with previous reports that distal locking is consistently the most radiation-demanding phase of intramedullary nailing. Wang et al. (2018) found that distal locking under fluoroscopy required a mean of 19.09 ± 10.41 seconds of exposure, far exceeding other procedural steps, and demonstrated that electromagnetic navigation reduced this to 2.13 ± 0.73 seconds while improving accuracy.[37] Similarly, Dursun et al. (2013) reported that a magnetic-guided locking system lowered exposure from ~40 seconds to ~8 seconds and shortened operative time.[38]

This study was conducted on a relatively small sample size of 60 patients, all of whom were male, which limits the generalizability of the findings to female patients and broader populations. As the research was confined to hospitals in Basrah, Iraq, the results may reflect regional injury patterns, healthcare resources, and surgical practices, and may not be fully applicable in other settings. We relied on anthropometric measurements and confirmed by plain x-ray for preoperative measurements, which are subject to magnification errors and anatomical variations, potentially affecting the accuracy of the estimates. Finally, intraoperative measurements were taken by many surgeons, introducing the possibility of interobserver variation in technique and recording.

5. CONCLUSIONS AND RECOMMENDATIONS

This study demonstrates that

1. Accurate length estimation can reduce intraoperative adjustments and improve surgical precision.
2. Nail diameter remains difficult to predict accurately using plain radiographs, indicating a need for better techniques or imaging tools.
3. Incorporating preoperative planning into routine practice can help reduce operative time, minimize fluoroscopic exposure, and improve overall surgical efficiency in tibial shaft fracture management.

Adoption of the tibial tuberosity–to–joint line (TT-JL) distance is the preferred method for preoperative nail length prediction due to its high accuracy. To improve diameter assessment**,** the orthopedic surgeon should avoid relying solely on plain radiographs for nail diameter estimation; but exploring more precise imaging or digital templating tools. Focus minimizing of fluoroscopy time, especially during distal locking, through improved techniques or guided systems (Electromagnetic Navigation Systems) Implementing consistent training and protocols to reduce inter-surgeon variability in measurement and planning. Future research should include more varied patient groups to improve generalizability.

CONFLICT OF INTEREST

The authors of this study report no conflicts of interest.

REFERENCES

1. Aljuhani WS AY, Alanazi AM, Alothri MA, Almutairi SA, Aljaafri ZA, et al. Risk of infection and conversion time from external to definitive fixation in open tibial fracture. J Orthop Surg Res., 2024; 19(1): 38.
2. Thompson JH, Koutsogiannis P, Jahangir A. Tibia Fractures Overview. 2023 Jul 31. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing, 2025 Jan–. PMID: 30020639.
3. Sleem B, Abdul Khalek J, Hajj A. Pediatric tibial shaft fractures: a comprehensive review. Surg Res Pract, 2024; 5: 1–9.
4. Eltorai AEM EC, Daniels AH. Orthopedic Surgery Clerkship: A Quick Reference Guide for Senior Medical Students. Orthop Surg Clerksh A Quick Ref Guid Sr Med Students, 2017; 1–811.
5. Kumar, Surendra & Yadav, Ashok & Chaudhary, Sanjay & Tomar, Shashank. Functional assessment of tibial plateau fracture by various modalities of treatment. International Journal of Orthopaedics Sciences, 2018; 4: 623-627.
6. Zhang Y, & Wang, J. Classification of Tibial and Fibular Fractures. InClinical Classification in Orthopaedics Trauma, 2018; 451-528.
7. Besa P, Angulo, M., Vial, R., Vega, R., Irribarra, L., Lobos, D., Sandoval, F., & Irarrázaval, S .The AO classification system for tibial plateau fractures: An independent inter and intraobserver agreement study. Injury, 2023; 54(6).
8. Johner R, Wruhs O. Classification of tibial shaft fractures and correlation with results after rigid internal fixation. Clin Orthop Relat Res., 1983; 178: 7–25.
9. Rudran B, Little C, Wiik A, Logishetty K. Tibial plateau fracture: anatomy, diagnosis and management. *Br J Hosp Med (Lond),* 2020; 81(10): 1–9.
10. Marchi Neto ND, Tomazini Nesello PF, Bergamasco JM, Costa MT, Christian RW, Severino NR. Importance of computed tomography in posterior malleolar fractures: added information to preoperative X-ray studies. World J Orthop, 2023; 14(12): 868–76.
11. Orava S, Karpakka J, Hulkko A, Väänänen K, Takala T, Kallinen M, Alén M. Diagnosis and treatment of stress fractures located at the mid-tibial shaft in athletes. Int J Sports Med., 1991; 12(4): 419–22.
12. Vaghela K, Barry M. Paediatric tibial fractures. In: Barry M, editor. Paediatric orthopaedic trauma in clinical practice. London: Springer, 2015; 129–43.
13. Jindal R, Arora G. Comparison of different treatment modalities for tibial fractures: a clinical study. Int J Orthop Sci., 2017; 3(1): 213–5.
14. Garnavos C. Management of proximal tibial fractures. In: Bentley G, editor. European surgical orthopaedics and traumatology: the EFORT textbook. Berlin: Springer, 2014; 89–116.
15. Busse J, Morton E, Lacchetti C, Guyatt G, Bhandari M. Current management of tibial shaft fractures: a survey of 450 Canadian orthopedic trauma surgeons. Acta Orthop, 2008; 79(6): 689–94.
16. Hull P. The management of open tibial fractures. *Eur J Orthop Surg Traumatol*, 2008; 18(5): 441–7.
17. Nicolaides M, Pafitanis G, Vris A. Open tibial fractures: an overview. *J Clin Orthop Trauma,* 2021; 20: 101528.
18. Solanki R, Salunkhe R, Shevate I, Deshmukh A, Kandari A. Comparison between outcomes of

various modalities of management of distal tibia fractures. *Indian J Orthop Surg,* 2021; 7(1): 20–6.
19. Dhar S, Mir M, Butt M, Hussain A, Ahmed M, Mumtaz M. Management of unstable tibial fractures by a composite technique. *Injury,* 2008; 39(2): 260–6.
20. Mistry D, Paraoan V, Ward J. Plateaus, shafts and pilons: principles of tibial fractures. *Surgery (Oxf),* 2023; 41(4): 236–43.
21. Packer TW, Naqvi AZ, Edwards TC. Intramedullary tibial nailing using infrapatellar and suprapatellar approaches: a systematic review and meta-analysis. *Injury,* 2021; 52(3): 307–15.
22. Ludwig M, Hymes RA, Schulman J, Pitta M, Ramsey L. Intramedullary nailing of open tibial fractures: provisional plate fixation. *Orthopedics,* 2016; 39(5): e931–6.
23. Baker HP, Strelzow J, Dillman D. Tibial alignment following intramedullary nailing via three approaches. *Eur J Orthop Surg Traumatol,* 2022; 32(7): 1247–55.
24. Tosun N, Aydinlioğlu A, Akpinar F, Dogan A, Islam C. Anatomical characteristics of the tibial medullary canal and their implications for intramedullary fixation. J Int Med Res., 2003; 31(6): 557–60.
25. Guran O, Ozmanevra R, Husemoglu RB, Havitcioglu H, Altinoz O. Intramedullary nailing at different distal tibial fracture levels: a biomechanical study. Medicine (Baltimore), 2024; 103(22): e38353.
26. Hendrickx LA, Virgin J, van den Bekerom MP, Doornberg JN, Kerkhoffs GM, Jaarsma RL. Complications and subsequent surgery after intramedullary nailing for tibial shaft fractures: review of 8110 patients. Injury, 2020; 51(7): 1647–54.
27. Zelle BA, Bhandari M. Safe surgical technique: intramedullary nail fixation of tibial shaft fractures. Patient Saf Surg [Internet], 2015; 9(1): 6.
28. Li X CK, Xue H, Cheng J, Yu X. Efficacy comparison between intramedullary nail fixation and plate fixation in distal tibia fractures: a meta-analysis of randomized controlled trials. J Orthop Surg Res., 2024; 19.(1)
29. Mao Z, Zhang L, Chen S, Du H, et al. Intramedullary nailing versus plating for distal tibia fractures without articular involvement: a meta-analysis. J Orthop Surg Res [Internet], 2015; 10(1): 95.
30. Patterson JTM, Albright PD, Jackson JH, Eliezer EN, Haonga BT, Morshed S, et al. Travel barriers, unemployment, and external fixation predict loss to follow-up after surgical management of lower extremity fractures in Dar es Salaam, Tanzania. OTA Int., 2020; 3(1): e071.
31. Anandasivam NS, Swallow MS, Basques BA, Samuel AM, Ondeck NT, et al. Tibial shaft fracture: a large-scale study defining the injured population and associated injuries. J Clin Orthop Trauma [Internet], 2017; 8(3): 225–31.
32. Do DA. Estudo epidemiológico das fraturas diafisárias de tíbia. Acta Ortop Bras, 2002; 10(4): 10–7.
33. Schemitsch EH, Bhandari M, Guyatt G, Sanders DW, Swiontkowski M, Tornetta P 3rd, et al. Prognostic factors for predicting outcomes after intramedullary nailing of the tibia. J Bone Joint Surg Am., 2012; 94(19): 1786–93.
34. Venkateswaran B, Warner RM, Hunt N, Shaw DL, Tulwa N, Deacon P. An easy and accurate preoperative method for determining tibial nail lengths. Injury, 2003; 34(10): 752–5.
35. France MA, Hiebert R, Tejwani N, McLaurin TM, Egol KA. Preoperative assessment of tibial nail length: accuracy using digital radiography. Orthopedics, 2006; 29(7): 623–7.
36. Krettek C, Blauth M, Miclau T, Rudolf J, Könemann B, Schandelmaier P. Accuracy of intramedullary templates in femoral and tibial radiographs. J Bone Joint Surg Br., 1996; 78(6): 963–4.
37. Wang Y, Shi Z, Fu Y, Ye Y, Jing J, et al. Comparison of free-hand fluoroscopic guidance and electromagnetic navigation in distal locking of tibia intramedullary nails. Medicine (Baltimore), 2018; 97(27): e11312.
38. Dursun M, Aytekin MN, Çelik I, Uğurlu M. Does the magnetic-guided intramedullary nailing technique shorten operation time and radiation exposure? Eur J Orthop Surg Traumatol, 2014; 24(6): 1005–11.