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ADDIS ABABA UNIVERSITY

COLLEGE OF HEALTH SCIENCE, SCHOOL OF MEDICINE

DEPARTMENT OF ORTHOPEDICS & TRAUMA SURGERY

Assessment of correlation between femoral canal length and olecranon to 5th fingertip measurement and its associated factors at Tikur Anbessa Specialized Hospital.

By**: Kassahun Anteneh |MD|** (Final year orthopedics & Trauma Surgery resident)

A Thesis submitted to the department of Orthopedics and Trauma Surgery, CHS, AAU in a partial fulfillment for the specialization certificate in Orthopedics and Trauma Surgery.

October, 2024 G.C

Addis Ababa, Ethiopia

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October, 2024 G.C

Addis Ababa, Ethiopia

Advisor's Approval Sheet

This is to certify that the thesis entitled "**Assessment of correlation between femoral canal length and olecranon to 5th fingertip measurement and its associated factors at Tikur Anbessa Specialized Hospital"** has been carried out by **Dr Kassahun Anteneh**, a final year Orthopedics and Trauma Surgery resident at college of health Sciences, Addis Ababa University. Therefore, I approve that the student has fulfilled the requirements and hence hereby can submit the thesis to the department of Orthopedics & Trauma Surgery.

Advisor: **Dr. Misgana Temesgen**

Signature: _____

Date: _____

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Acronyms

AAU: Addis Ababa University

BMI: Body Mass Index

CHS: College of Health Sciences

DIPJ: Distal Inter Phalangeal Joint

GT: Greater Trochanter

GT-SP: Greater Trochanter to Superior Pole of Patella

IMN: Intra Medullary Nail

IP: Inter Phalangeal

LMIC: Low- and Middle-Income Countries

MCP: Meta Carpo-phalangeal

O-FT: Olecranon to 5th Finger tip

OPD: Outpatient Department

RTI: Road Traffic Injuries

SIGN: Surgical Implant Generation Network

SOM: School of Medicine

SP: Superior Pole of Patella

TASH: Tikur Anbessa Specialized Hospital

Abstract

Introduction: Accurate preoperative measurement of femoral nail length is crucial in orthopedic trauma surgery to avoid complications and reduce operative time. Various anthropometric methods have been used to estimate femoral length, but these typically require intact contralateral femurs, which is problematic in cases of bilateral fractures or deformities. Recently, forearm plus little finger length (O-FT) has been proposed as an alternative measurement, though its applicability across different populations, including Ethiopia, remains underexplored.

Methods: This descriptive cross-sectional study was conducted at Tikur Anbessa Specialized Hospital in Addis Ababa, Ethiopia, from June to September 2024, involving 151 adult volunteers without prior musculoskeletal deformities or trauma. The O-FT and the distance from the greater trochanter to the superior pole of the patella (GT-SP) were independently measured by two observers using a tape measure. Pearson's correlation, intraclass correlation coefficients (ICC), and multiple linear regression analyses were utilized to assess the correlation and demographic factors' impact.

Results: The average O-FT and GT-SP measurements for Observer 1 were 41.89 cm and 42.32 cm, respectively, while for Observer 2, they were 41.99 cm and 42.49 cm. Both measurements exhibited a strong positive correlation ($r = .903$ and $r = .890$, $p < .001$ for Observers 1 and 2, respectively), with excellent inter-observer reliability (O-FT ICC = 0.960, GT-SP ICC = 0.937). Demographic factors like age, sex, and BMI did not significantly affect the correlation ($p > 0.05$).

Discussion: The findings confirm a strong correlation between O-FT and femoral canal length in the Ethiopian population, aligning with results from other regions. O-FT measurement is a reliable, non-invasive, and cost-effective alternative for preoperative planning of femoral fractures, especially in settings with limited imaging access. Future studies should investigate demographic variability and validate these findings in larger, more diverse populations.

Keywords: Femur, nail, length, olecranon to 5th fingertip, correlation

1. Introduction

1.1. Background

The femur (thigh bone) is the longest, strongest, largest, and heaviest tubular bone in the human body and one of the principal load-bearing bones in the lower extremity.[1] With varying mechanisms of injury, RTIs are frequently cited as the most common cause of femoral shaft fractures in LMICs, accounting for nearly 10% of all nonfatal traffic-related injuries.[2] In studies done in Ethiopia as well shows that injuries of the lower limb accounted for 66% of injuries, the femur being the most affected (22%).[3,4,9]

Adult femur shaft fractures can be treated using many different ways, conservative or surgical. The choice of the method to use considers several factors, including the surgeon's experience, availability of implants, cost, desired anatomical and functional outcomes, and complication rates. [5-8] Intramedullary nailing is the preferred method for the treatment of femoral shaft fractures. This method yields high union rates and low complication rates when vigilance is maintained during preoperative planning, surgical procedures, and the postoperative period.[10] IMN is also more cost-effective than conservative management in the treatment of patients with femoral fractures.[11] The SIGN intramedullary nailing system is a commonly used intramedullary nail in low-income African countries, and it promotes predictable healing of femoral fractures.[12]

Ensuring the correct length of the intramedullary nail is critical for the patient, as incorrect nail length can cause postoperative sequelae that vary from mild (i.e., soft tissue irritation) to severe (i.e., per prosthetic fracture caused by a stress riser from a nail that is too short or violating the intra-articular space of the knee joint from a nail that is too long).[10] Intramedullary nail wastage due to incorrect sizing still represents almost half of the financial burden of implant wastage in orthopedic trauma surgery.[10] In addition to the waste of an implant, these factors can add unnecessary time to the operation, especially if the appropriate nail is not immediately available in the theatre and needs to be retrieved.[14]

Good preoperative planning is essential for restoring the original femoral length using intramedullary nailing. Several methods have been developed to achieve this purpose. Nail templates are available to determine the appropriate nail length, but this usually requires an intact

contralateral femur.[15] However, this method is not cost-effective and causes unnecessary exposure to radiation. Patients can also be assessed by measuring the length from the greater trochanter to the superior pole of the patella; however, this method is inconvenient and painful.[16,17] A new method of femoral length determination has been introduced, which involves the measurement of forearm length extending from the olecranon tip to the end of the little finger. [16, 17, 18]

Considering the limited evidence and skeletal differences among various populations[19,20], the purpose of the current study was to determine how strongly olecranon to 5th fingertip length correlates with the actual femoral length in the local population.

1.2. Statement of the Problem

The measurement of intramedullary femoral nails in patients with femoral shaft fractures, especially in bilateral fractures, amputees, deformities, and in places where there is a scarcity of preoperative radiographic facilities, is always a challenge. A few papers have addressed this problem using the forearm as a reference. However, none of these studies were conducted in Ethiopia or wider Africa to draw a conclusion. These studies were not conducted in our population, and there were no established local data on this correlation.

1.3. Rationale of the study

It is extremely important to measure femoral nail size preoperatively. It has the advantage of reducing operative time, radiation exposure, and complication related to inappropriate nail length. [15,16,17] Ideally, a full range of intramedullary nails should be readily available in the operating room, but in some hospitals' operating rooms, this may not be the case, especially in emergency situations.

Correct evaluation of the femoral length and subsequent IMN implant length is important to accurately restore patient anatomy as much as possible.[21] Most anthropometric methods used for the preoperative measurement of femoral nail sizes require an intact contralateral femur. However, it is difficult to measure the contralateral femur if the patient has a bilateral femoral bone fracture, contralateral congenital or traumatic deformity, contralateral above-knee amputation, or if the patient is obese and has difficulty in palpating anatomical landmarks.

The rationale of this study was to establish a correlation between the femoral length and the forearm with little finger length for the measurement of intramedullary femoral nail length in a local population. This study can facilitate the generation of evidence about this correlation for the local population, and we can use this correlation for the measurement of intramedullary femoral nails in patients with femoral shaft fractures, especially in bilateral fractures and in places where preoperative radiographic facilities are not available.

1.4. Basic Research Questions

1.4.1. Is there a correlation between the femoral canal length and olecranon to 5th fingertip length for the measurement of intramedullary femoral nail length in the Ethiopian population?

1.4.2. Is this correlation affected by demographic variables, such as age, sex, and BMI?

1.5. Objectives

1.5.1. Main Objectives

To assess the correlation between the femoral canal length and the forearm with little finger length and its associated factors for the measurement of intramedullary femoral nail length at the Tikur Anbessa Specialized Hospital.

1.5.2. Specific Objectives

To compare the length between femoral greater trochanter to superior pole of patella and olecranon to little fingertip length.

To identify the factors associated with the measurement outcomes.

2. Literature Review

Preoperative measurements show good application prospects in the evaluation of intramedullary nail length. Few studies have investigated the preoperative measurement and intramedullary nail length of femoral fractures.

Gaurav et al. (2016) conducted a study on 100 healthy adult volunteers, including 41 males and 59 females attending the orthopedic O.P.D of a tertiary medical college in North India, to assess the intramedullary femoral nail length in adults by various methods in the femoral shaft fracture.
They measured the length from the tip of the olecranon to the tip of the little finger and from the tip of the greater trochanter to the upper pole of the patella on the same side using a measuring tape on a couch. They performed statistical analysis and showed that the mean lengths from the tip of the olecranon to the tip of the little finger and from the tip of the greater trochanter to the upper pole of the patella on the same side were 42.175 (SD, 2.0641) and 42.093 (SD, 2.0846), respectively. They found a significant correlation between these two lengths, that is, 0.987 by Pearson co -relation (95% CI, 0.977 to 0.994) ($p<0.001$).

The authors concluded that the length from the tip of the olecranon to the tip of the little finger correlated with the femoral length and is more convenient to perform and can also be used when the patient has sustained bilateral fractures of the femur, regardless of the age, sex, and body mass index of the patient.[22]

Another author, Monappa et al. (2014) from India, tried to assess the correlation between the forearm plus little finger length and the femoral length in 100 volunteers. The forearm plus little finger length and ipsilateral femoral length were measured using a measuring tape, where two observers made the measurements on two separate occasions. The results showed mean of forearm plus little finger length and femoral length to be 39.87 (SD, 2.73) and 39.85 (SD, 2.44) cm, respectively. The mean difference between these two measurements was 0.028 cm (95% CI, –0.109–0.165). They concluded that the forearm with little finger length was strongly correlated with femoral length. As the method is simple and radiation-free, it can be applied in daily practice.[18]
In another cross-sectional study conducted by Shahzad, Atif, et al. in Pakistan on 120 adult volunteers (aged 18–50 years), the femoral length was recorded with the help of a measuring tape

from the superior pole of the patella to the greater trochanter of the intact femur and recorded in centimeters, while the forearm with little finger length was measured with the help of a measuring tape from the olecranon process of the ulna to the tip of the little finger and recorded in centimeters.

Analysis was done and the mean femoral length was 41.47±1.64 cm while the mean length of the forearm plus little finger was 41.47±1.71 cm. The correlation of femoral length and length of the forearm with little finger was positively significant ($r=0.885$, $p<0.0001$), leading them to conclude that the measurement of the forearm plus little finger length is a convenient method to determine the femoral length for intramedullary nailing while avoiding other expensive and possibly harmful means.[23]

Furthermore, Uthman et al. from the UK conducted a prospective study on 30 patients, 16 males and 14 females, with an average age of 51 years, undergoing intramedullary nail fixation of the femur. They wanted to determine whether there was a correlation between the length of the forearm to the distal interphalangeal joint (DIPJ) of the little finger and the length of antegrade intramedullary (IM) femoral nails in adults.

A flexible tape measure was used to determine the length in centimeters from the tip of the ipsilateral olecranon to the DIP joint of the little finger. Following fracture reduction, the length of the nail inserted was determined intraoperatively by an intramedullary guidewire using image intensifier guidance.

Through statistical analysis, the mean forearm to DIP of little finger length and IM length was 38.86 and 38.56 cm, respectively. Similarly, the SD of the forearm to DIP of little finger length and IM length was 2.83 and 2.77, respectively. They were able to show a strong correlation with the precise length of the intramedullary nail, which led them to conclude that the length of the forearm from the tip of the olecranon to the DIP joint of the little finger represents the ideal length of the IM nail for the femur and can serve as a useful adjunct for determining the ideal length in cases where the contralateral femur cannot be used.[17]

3. Methodology

3.1. Study Setting

The study was conducted at the outpatient clinic of the Orthopedic & Trauma Surgery Department of Tikur Anbessa Specialized Hospital, Addis Ababa, Ethiopia. TASH is a tertiary hospital located in Addis Ababa, the capital city of Ethiopia. In the Orthopedic Department, there are currently 27 Orthopedics and Trauma surgeons, two fellows, and 58 residents. The orthopedic outpatient clinic is functional 5 days a week in a 2-shift program, and more than 1000 patients receive the services monthly. There are four functional operation theaters, and more than 15 femur fractures on average monthly are operated by seniors, fellows, and residents under supervision.

3.2. Study Design

Descriptive cross-sectional hospital-based study.

3.3. Study Area

This study was conducted at the TASH.

3.4. Study Period

This study was conducted from June to September 2024.

3.5. Target population

All individuals who visited TASH outpatient clinics of the Orthopedic and Trauma Surgery department.

3.6. Study Population

All individuals who visited the TASH outpatient clinics of Orthopedic and Trauma Surgery department as patient attendants, who were above the ages of 18 years and had no previous musculoskeletal trauma, surgery, congenital or acquired deformities, or amputation during the study period.

3.7. Inclusion and Exclusion Criteria

The inclusion criteria included all individuals above 18 years of age who visited the TASH Orthopedics and Trauma Surgery outpatient department during the study period.

The study excluded those individuals who are age less than 18 years, who had history of previous femoral shaft fracture, forearm fracture, metacarpal fracture, phalanx fracture, wrist joint, MCP joint, IP joint contractures, congenital or acquired deformity and amputation.

3.8. Sample Size: All individuals who visited TASH Orthopedics and Trauma Surgery outpatient department during the study period and fulfil the inclusion criteria.

3.9. Study Variables

3.9.1 Dependent Variable

Femoral Greater trochanter to superior pole of patella (GT-SP) measurement and Olecranon to 5th fingertip (O-FT) measurement.

3.9.2 Independent Variable

Age

Sex

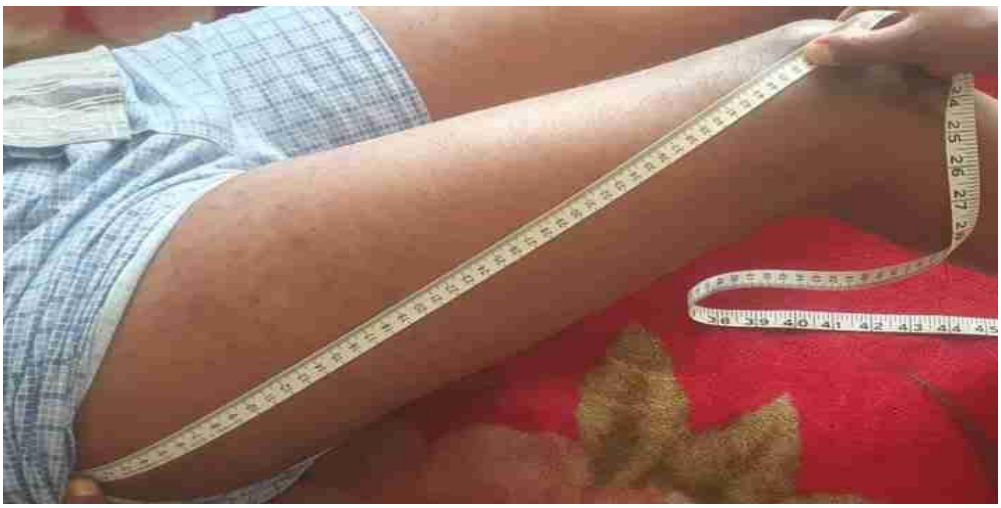
Body mass Index

3.10. Data Collection Procedure

The purpose of the study was explained to individuals who fulfilled the inclusion criteria, and informed consent was obtained from each participant. The age, sex, and body mass index (BMI) of all participants were recorded using a standardized questionnaire. Two observers independently conducted both measurements using a tape meter and the average of their recorded values was determined.

Femoral length estimation was performed from the most prominent tip of the femoral greater trochanter (GT) to the superior pole of the patella (SP) laterally with the knee flexed to around 30°. Olecranon to 5th fingertip measurement was taken from the most prominent part of the olecranon to the distal tip of the 5th finger with the elbow at 90 °flexion, forearm in pronation, wrist in neutral position, and MCP and IP joints in extension. Data collection was taken place from June 01/2024 to July 15/2024 G.C. The data collection procedure was regularly supervised by the

investigator. The data was checked for completeness and edited and entered into SPSS 27.



3.11. Data Management

After the completion of data collection, it was checked for completeness, edited, coded, and cleaned before it is entered into the computer. The data was entered by the principal investigator, and the variables was coded and analyzed using the SPSS software package. The first set of data was tested for normality using both skewness and graphical methods. Pearson's correlation test and Intraclass correlation coefficients (ICCs) was used to assess the correlation between GT-SP and O-FT measurements and inter-observer reliability, respectively. A hierarchical regression analysis was performed to assess the influence of age, sex, and BMI on these measurements and their correlations.

3.12. Data Collection Assurance

Training regarding the data collection process and how to conduct the measurements was provided to the data collectors. The completed questionnaire was checked daily for its completeness and consistency by the assigned supervisor. The investigator was responsible for monitoring the overall data collection process and providing supportive supervision. The collected data was carefully entered using IBM SPSS version 27 and cleaned before analysis.

3.13. Ethical Considerations

The research proposal was submitted to the Department of Orthopedics and Trauma Surgery Research and Publication Committee for approval. The necessary permission and letter of support was requested and obtained from the department's head. A written and informed consent sheet was attached to the questionnaire and provided to the participants after detailed elaboration of the purpose of the study. Provisions was made to address participants' concerns regarding the study.

3.14. Dissemination of Results

The findings of this study will be presented to the Department of Orthopedics and Trauma Surgery at the tertiary training center in Addis Ababa, Ethiopia, in the presence of all consultants and resident doctors. The research paper will be sent to local and international journals for publication of the study findings.

4. Results

A total of 151 volunteers were involved in the study with a sex distribution of 60.9% male (n = 92) and 39.1% female (n = 59) (Figure 1). The age distribution was as follows: 33.1% were aged 18-27 years (n = 50), 41.7% were aged 28-37 years (n = 63), 15.2% were aged 38-47 years (n = 23), and 9.9% were aged 48 years and above (n = 15), as indicated in figure 2. The mean BMI was 21.69 Kg /m^2 as shown in Table 1. Descriptive statistics were computed for the olecranon to 5th

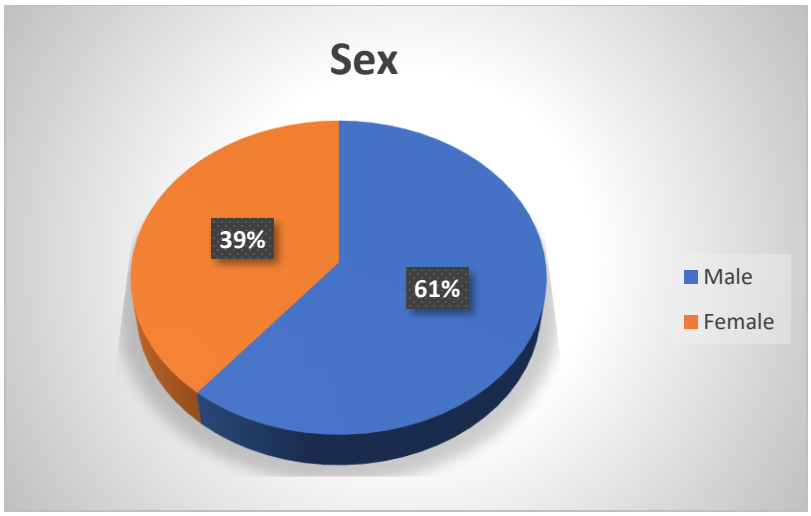


Figure 1:Sex Distributions

Table 1:Body mass index in Kg/m²

N	151
Mean	21.69
Std. Deviation	3.42

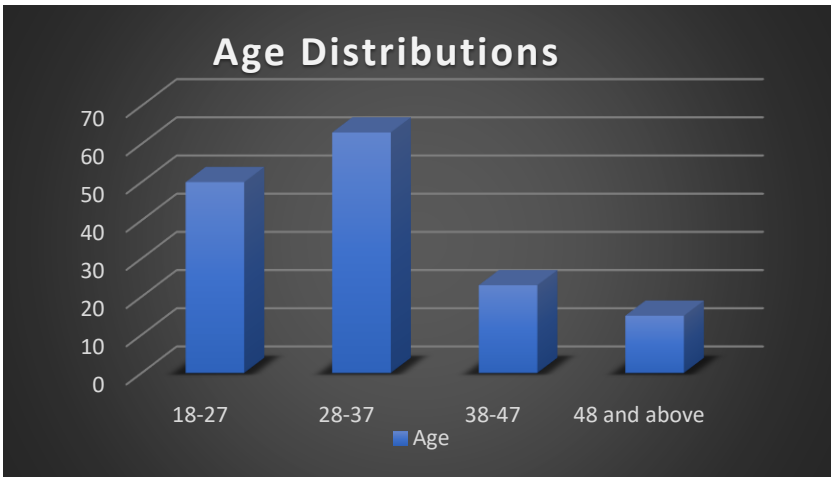


Figure 2: Age distributions

Table 2: Descriptive statistics for two measurements taken by two observers.

	Olecranon to 5th fingertip length in cm for observer 1	Greater trochanter to superior pole of patella in Cm for observer 1	Olecranon to 5th fingertip length in cm for observer 2	Greater trochanter to superior pole of patella in Cm for observer 2
Mean	41.89	42.32	41.99	42.49
Std. Deviation	2.51	2.42	2.40	2.26

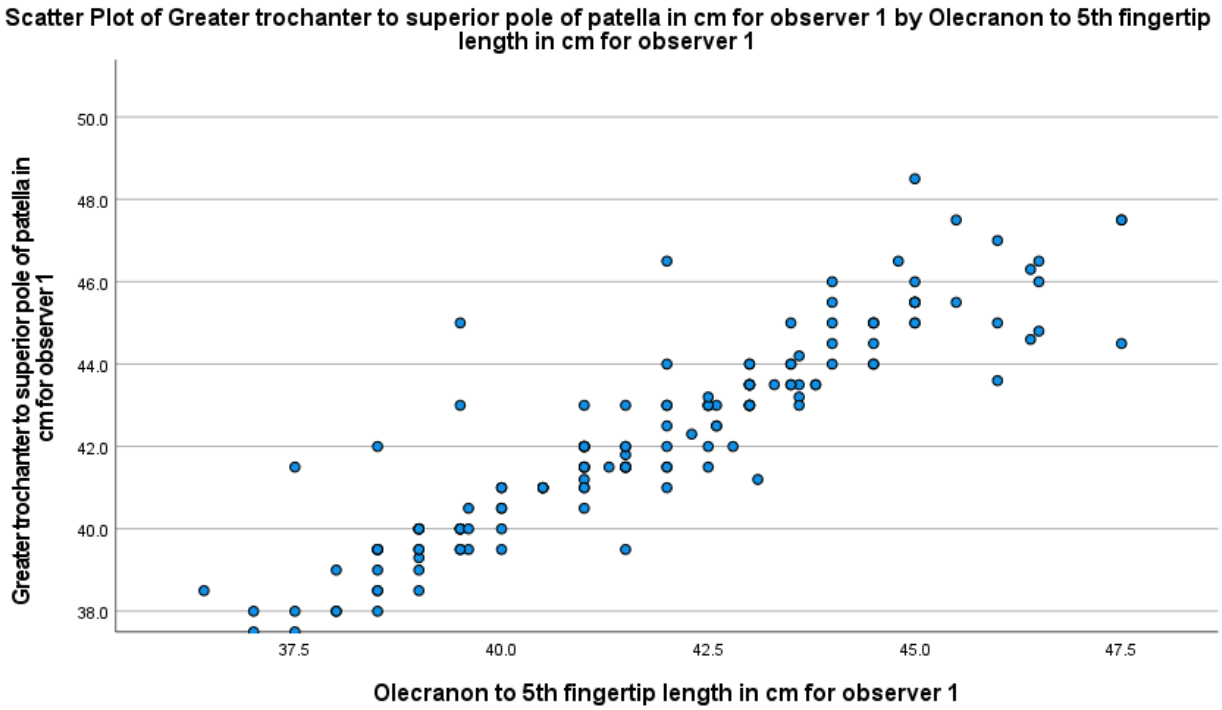


Figure 3: Scatter plot of both measurements for observer 1

Table 3: Correlations between the 2 measurements

Measurement	O-FT +/- SD in cm	GT-SP +/- SD in cm	Mean difference (95% CI)	Pearson Correlations	P value
Observer 1	41.89+/-2.51	42.32+/-2.42	0.43	.903	<0.0001
Observer 2	41.99+/-2.40	42.49+/-2.26	0.5	.890	<0.0001

Table 4: Inter Observer reliability of both measurements Using ICC

O-FT for both observers		Intraclass Correlation	95% Confidence Interval		Sig
			Lower Bound	Upper Bound	
	Single Measures	.960	.945	.971	.000
	Average Measures	.979	.972	.985	.000
GT-SP for both observers					
	Single Measures	.937	.915	.954	.000
	Average Measures	.968	.955	.977	.000

Table 5: Effects of age, sex, and BMI on the correlation between the two measurements

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
	Age	-.090	.094	-.035	-.962	.338
	Sex	-.226	.206	-.046	-1.098	.274
	Body mass index	.015	.026	.022	.594	.554

fingertip length and the greater trochanter to superior pole of patella length, as measured by the two observers. The mean of O-FT was 41.89 cm (SD = 2.51), and GT-SP had a mean of 42.32 cm

(SD = 2.42) for observer 1. Observer 2, had a O-FT mean of 41.99 cm (SD = 2.40), and GT-SP mean of 42.49 cm (SD = 2.26) (Table 2). The correlations between O-FT and GT-SP measurements, as evidenced by Pearson coefficients was r =.903, p<.001 for observer 1 and r =.890, p<.001 for observer 2, respectively (Table 3).

Intraclass correlation coefficients (ICCs) were calculated to assess the reliability of measurements taken by the two observers for the two different measurements. The result shows ICC of O-FT was 0.960 (95% (0.945-0.971), p<0.0001) and 0.979 (95% (0.972-0.985), p<0.0001) for the single and average measures, respectively. While the ICC of GT-SP was 0.97 (95% (0.915-0.954), p<0.0001) and 0.968 (95% (0.955-0.977), p<0.0001) for the single and average reliability, respectively as indicated in Table 4.

Multiple linear regression analysis was carried out for factors: sex, age, and body mass index; with both measurements as dependent variables. The result showed that age: B = −0.090, p = 0.338; sex: B = −0.226, p = 0.274; BMI: B = 0.015, p = 0.554, did not contribute significantly to the model, as indicated in Table 5.

5. Discussions

This present study was undertaken to establish the relation between the length of the olecranon to 5th fingertip (O-FT) and the femoral canal length (GT-SP) with a view to help in the accurate measurement of intramedullary femoral nail length in patients with femoral shaft fractures. According to Gaurav et al. (2016), precise pre-operative measurement of femoral nail size is of paramount importance in minimizing operative time, radiation exposure, and complications pertaining to the use of nails of wrong lengths. In fact, studies conducted elsewhere in places like India and Pakistan have revealed a considerable relationship between these measurements, but on the other hand, similar studies have not been conducted either in Ethiopia or in the African continent as a whole.

151 respondents participated in the study, of which 60.9% were males and 41.7% of the subjects fall within the age category of 28-37 years. The average BMI for the participants is 21.69 kg/m^2. Two observers measured O-FT and GT-SP with high reliability and strong correlation: Observer

1, r = 0.903, p < 0.001; Observer 2, r = 0.890, p < 0.001. Intraclass correlation coefficients also validated high reliability for each measurement: O-FT ICC, Single Measures = 0.960, Average Measures = 0.979; GT-SP ICC, Single Measures = 0.937, Average Measures = 0.968.

Regression analysis did not indicate the significant effect of age, sex, and BMI on the correlation between the measurements of O-FT and GT-SP. This is in accordance with earlier studies where demographic variables did not show any significant effect on the correlation.

The present study thus confirms that the measurement of O-FT is a reliable predictor of GT-SP measurement for ascertaining femoral nail length in the Ethiopian population. Since it is a simple and non-radiographic technique, it is quite useful in situations where preoperative radiographic facilities are limited, just as other studies have pointed out its practicality and effectiveness in varied contexts. This would improve the surgery planning and outcome of femoral fractures in Ethiopia and other similar setups with local data.

6. Strengths & Limitations

The strengths of the study are being the first of its kind in Ethiopia (to our knowledge) which fills a gap in the literature by providing localized data in an Ethiopian population and representing good sample diversity, which enhances the generalizability of the studies. Whereas being a cross-sectional design, being done in a limited geographical scope, and potential measurement bias are the limitations of the study.

7. Conclusion & Recommendation

In conclusion, this study greatly supports olecranon to 5th finger measurement as a reliable predictor for the determination of femoral canal length for the proper intramedullary femoral nail length. When clinically applied, this technique holds great potential for improving patient outcomes, facilitating surgical procedures, and improving resource consumption with regard to the management of orthopedic trauma. Larger sample size and diverse population studies in the future might contribute to the validation of these findings and also extend the measuring methodology for broader clinical use.

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9. Appendices

AAU

COLLEGE OF HEALTH SCIENCE

SCHOOL OF MEDICINE

DEPARTMENT OF ORTHOPEDICS & TRAUMA SURGERY

This questionnaire is prepared for collection of data for the assessment of correlation of femoral canal length with olecranon to 5th fingertip length from June to September 2024G.C. It is prepared by **Dr. Kassahun Anteneh Yimer, a final year Orthopedics and Trauma surgery resident**. Your name will not be mentioned in the questionnaire and the answers for these questions is strictly confidential. You can refuse to respond to any of the questions and you can interrupt at any point in the interview.

During the study period, participants' demographic data and limb length measurements will be assessed. It is important to note that this study poses no risks to your health. If you experience any discomfort or have concerns about the questions or measurement procedure, you are free to withdraw from the study at any time. Only the research team will have access to your responses, and your anonymity will be preserved. Please remember that participation in the study is voluntary, and you have the right to decline involvement. Your honest participation is greatly appreciated.

Would you agree to participate in this study?

A. yes ☐

B. No ☐

Code of the Participant:		
Part I: Sociodemographic Data		
No	Variables	Answers
1.1	Age	
1.2	Sex	
1.3	Weight in Kg.	
1.4	Height in cm.	
1.5	BMI	
Part II: Measurements		
2.1	Greater trochanter to superior pole of patella length in cm.	
2.2	Olecranon to 5^{th} fingertip length in cm.	