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Original Article

# Correlation between tibial nail length and olecrenon to 5th metacarpal head measurement: An anthropometric study

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ABSTRACT

*Purpose:* During fracture fixation, the size of tibial nail is a vital factor affecting the outcomes and thus preoperative estimation of tibial nail length is very important. This study aims to find out whether "olecranon to 5th metacarpal head" (O-MH) measurement can be used to reliably predict the tibial nail length.

*Methods:* This was a cross sectional study involving 100 volunteers. Measurements were done and recorded by two observers on two separate occasions. Tibial nail length estimation measurement was done from highest point of tibial tuberosity to the tip of the medial malleolus (TT-MM). O-MH measurement was taken from tip of olecranon to the tip of 5th metacarpal head with wrist in neutral position and hand clenched. Statistical analysis was done to find out correlation between two measurements and influence of age, gender and body mass index on them.

*Results:* Paired *t*-test showed no systematic error between the readings. Intraclass correlation coefficient showed strong agreement in inter and intra observer settings. Strong correlation was found between the TT-MM & O-MH measurements using Pearson's correlation coefficient test ($r = 0.966$). Hierarchical regression analysis showed age, gender and BMI have no statistically significant bearings on these measurements and their correlations.

*Conclusion:* O-MH measurement is a useful and accurate means of estimating tibial nail length preoperatively.



## Introduction

Intramedullary interlocking nailing is the gold standard in the treatment of tibial shaft fractures in adults.[1] It is important to do preoperative estimation of tibial nail length so that a correct size range can be available in the operation theater. Moreover insertion of the correct-sized nail is essential to obtain satisfactory outcomes. A shorter nail results in malreduction and inadequate working length, leading to failure of the implant. A longer nail would distract the fracture site and impinge on the patellar tendon, causing pain. Forceful insertion of a longer nail could cause penetration of the nail into the tibio-talar joint.

Intraoperative methods used to estimate tibial nail length include the two guide wires technique, nail-against-limb technique and using a radiographic ruler.[2–4] Although intraoperative techniques of nail length estimation are most accurate, they can cause increase in operative time and radiation exposure.

Several methods of estimating tibial nail length preoperatively have been described, such as radiographic templates[3,5] and patient height.[6] The simplest method is to measure the distance from tibial tuberosity to medial malleolus. This can be measured directly[7] or indirectly.[8] Most methods require an intact contralateral tibia for measurement and are therefore not suitable for bilateral tibial fractures. Furthermore, the contralateral tibia may be difficult to measure because of wounds, obesity, other fractures, or a previous malunited tibial fracture.

Purpose of this study was to find out whether olecranon to 5th metacarpal head (O-MH) distance can be used as a reliable alternative method to estimate tibial nail length in cases where indirect measurements using contralateral tibia cannot be used.

## Methods

This was a cross sectional study conducted in our hospital in the month of May 2018. One hundred volunteers of more than 18 years

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of age were selected for the study. Out of them 65 were males and 35 were females. People with congenital or traumatic deformities in the lower limbs were excluded from the study.

Age, sex and body mass index (BMI) of all the patients were recorded. Measurements were done and recorded by two observers on two separate occasions. Tibial nail length estimation measurement was done from highest point of tibial tuberosity to the tip of the medial malleolus (TT-MM), as shown in Fig. 1. O-MH measurement was taken from tip of olecranon to the tip of 5th metacarpal head with wrist in neutral position and hand clenched, as shown in Fig. 2.

There were a total of 8 reading from two observers (1 & 2) for each volunteer. They were first tested for systematic errors using paired *t*-test. Then intraclass correlation coefficient test was used to find out intra and inter observer correlations. Pearson's correlation test was used to assess correlation between TT-MM and O-MH measurements. Hierarchical regression analysis was done to assess influence of age, gender and BMI on these measurements and their correlations.

## Results

All the volunteers were of South Indian ethnicity. All the 8 readings from two observers showed no statistically significant systematic errors in paired *t*-test, when all combinations of readings were used (Table 1). Then intraclass correlation coefficient tests showed excellent agreement in both intra and inter observer settings (intraclass correlation coefficient > 0.9) (Tables 2 and 3). Since there was excellent agreement in both settings, 1st reading from the 1st observer was selected for assessing correlation between TT-MM and O-HM (Table 4). Pearson's correlation test showed strong correlation between TT-MM and O-MH ($r = 0.966$) (Fig. 3). There were no statistically significant differences in the two readings (TT-MM & O-MH) between two genders ($p$ values: 0.237 for males and 0.141 for females).

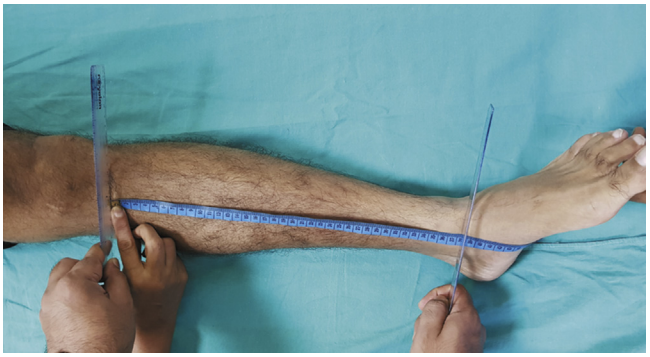

**Fig. 1.** Tibial tuberosity to medial malleolus (TT-MM) measurement.

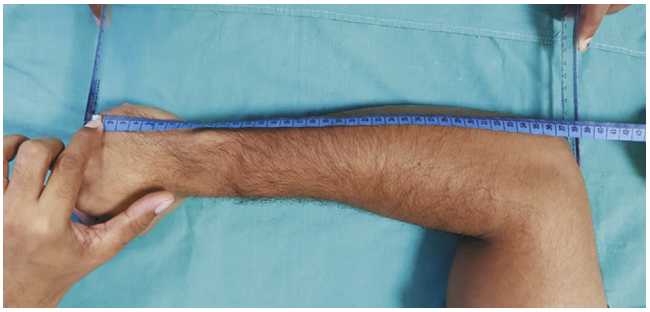

**Fig. 2.** Olecranon to 5th metacarpal head (O-MH) measurement.

**Table 1**
Paired *t*-test to find systematic errors.

| Measurements | Observer-readings | Mean | Std. deviation | *p* value |
|---|---|---|---|---|
| O-MH (cm) | Observer 1-1 | 34.72 | 1.18 | 0.461 |
| | Observer 1-2 | 34.69 | 1.18 | |
| | Observer 2-1 | 34.71 | 1.18 | 0.766 |
| | Observer 2-2 | 34.70 | 1.15 | |
| | Observer 1-1 | 34.72 | 1.18 | 0.744 |
| | Observer 2-1 | 34.71 | 1.18 | |
| | Observer 1-2 | 34.69 | 1.18 | 0.903 |
| | Observer 2-2 | 34.70 | 1.15 | |
| TT-MM (cm) | Observer 1-1 | 34.67 | 1.18 | 0.125 |
| | Observer 1-2 | 34.72 | 1.18 | |
| | Observer 2-1 | 34.63 | 1.16 | 0.559 |
| | Observer 2- 2 | 34.65 | 1.17 | |
| | Observer 1- 1 | 34.67 | 1.18 | 0.119 |
| | Observer 2-1 | 34.63 | 1.16 | |
| | Observer 1-2 | 34.72 | 1.18 | 0.127 |
| | Observer 2- 2 | 34.65 | 1.17. | |

Data were analyzed by *t*-test and no significant difference was found.
Observer 1-1: 1st observer 1st reading; Observer 1–2: 1st observer 2nd reading; Observer 2-1: 2nd observer 1st reading; Observer 2-2: 2nd observer 2nd reading.

Hierarchical regression analysis was done to assess influence of age, gender and BMI on these measurements and their correlations (Table 5). TT-MM measurement was considered as a dependent variable and it was tested with different constants (O-MH, age, gender and BMI). Results of this analysis showed that age, gender and BMI have no statistically significant bearing on these measurements and their correlation.

## Discussion

The direct or indirect measurement of the distance between the tibial tuberosity and medial malleolus gives the best estimate of tibial nail length preoperatively. This is supported by many studies.[7–10] Our study aimed to compare the O-MH measurement to tibial tuberosity to medial malleolus measurement, and also to find out influence of age sex and BMI on these correlations.

Even though preoperative anthropometric measurements in contra-lateral tibia give a good estimate of tibial nail length, it may not be possible to get an accurate measurement in obese patients, swollen limbs, bilateral tibial fractures and congenital or acquired deformities. Therefore an alternative measurement, especially in upper limb, which can closely correlate to TT-MM measurement, will be very useful in such scenarios.

Intraoperative techniques such as the guide wire method and the radiographic ruler have an excellent accuracy of 94% according to Galbraith et al.[11] Inaccuracies may occur due to eccentric C-arm placement, with the measurement being taken from the lowest

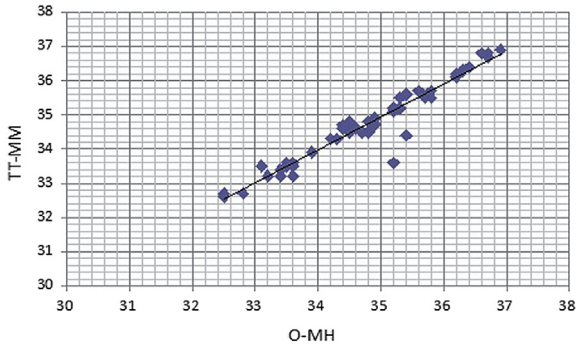


**Fig. 3.** Correlation between TT-MM & O-MH (Pearson's correlation $r = 0.966$).

**Table 2**
Intra-observer correlation.

| Measurements, Observer, Reading | Intraclass Correlation Coefficient | 95% confidence interval of the difference | | *p* value |
|---|---|---|---|---|
| | | Lower | Upper | |
| O-MH observer 1-1 vs. O-MH observer 1-2 | 0.989 | 0.980 | 0.994 | <0.001 |
| O-MH observer 2-1 vs. O-MH observer 2-2 | 0.985 | 0.974 | 0.992 | <0.001 |
| TT-MM observer 1-1 vs. TT-MM observer 1-2 | 0.992 | 0.986 | 0.996 | <0.001 |
| TT-MM observer 2-1 vs. TT-MM observer 2-2 | 0.987 | 0.977 | 0.993 | <0.001 |

Observer 1-1: 1st observer 1st reading; Observer 1-2: 1st observer 2nd reading; Observer 2-1: 2nd observer 1st reading; Observer 2-2: 2nd observer 2nd reading.

**Table 3**
Inter-observer correlation.

| Measurements, Observer, reading | Intraclass correlation coefficient | 95% confidence interval of the difference | | *p* value |
|---|---|---|---|---|
| | | Lower | Upper | |
| O-MH observer 1-1 vs. O-MH observer 2-1 | 0.995 | 0.991 | 0.997 | <0.001 |
| O-MH observer 1-2 vs. O-MH observer 2-2 | 0.977 | 0.960 | 0.987 | <0.001 |
| TT-MM observer 1-1 vs. TT-MM observer 2-1 | 0.994 | 0.990 | 0.997 | <0.001 |
| TT-MM observer 1-2 vs. TT-MM observer 2-2 | 0.984 | 0.973 | 0.991 | <0.001 |

Observer 1-1: 1st observer 1st reading; Observer 1-2: 1st observer 2nd reading; Observer 2-1: 2nd observer 1st reading; Observer 2-2: 2nd observer 2nd reading.

exposed part of the guide wire or by not holding the radiographic ruler close and paralleled to the tibia.[11] These techniques cannot be utilized in comminuted fractures of tibia as restoration of normal leg length requires comparison with the opposite side. Intra-operative methods lead to added fluoroscopic exposure to operating room personnel as well as increased operating time. Though they are considered to be the most accurate methods, they provide no scope for preoperative planning and are not recommended in isolation for estimation of tibial nail length.[9,11]

In our study, we found a strong correlation between the TT-MM and O-HM measurements. Also variables like age, gender and BMI have no statistically significant bearings on these measurements and their correlation. Limitations of this study could be non-availability of volunteers from different ethnic groups. Hence a multicentric study covering different ethnic groups would be required to further substantiate these findings.

In conclusion O-MH measurement is a useful and accurate means to estimating tibial nail length preoperatively. This can be reliably used in patients of both genders and in different age groups and different BMIs.

**Table 4**
Group statistics of 1st observer 1st reading ($n$=100).

| Parameters | Minimum | Maximum | Mean | Std. deviation |
|---|---|---|---|---|
| Age (years) | 20 | 87 | 42.56 | 17.99 |
| Height (cm) | 141 | 180 | 160.53 | 10.89 |
| Weight (kg) | 35 | 85 | 58.66 | 13.76 |
| Body mass index | 13.1 | 34.2 | 22.77 | 4.48 |

**Table 5**
Hierarchical regression analysis.

| Model | Unstandardized coefficients | | Standardized coefficients | *t* value | *p* value |
|---|---|---|---|---|---|
| | B | Std. error | Beta | | |
| 1 Constant | 1.205 | 1.298 | | 0.928 | 0.358 |
| O-MH observer 1-1 | 0.964 | 0.037 | 0.966 | 25.799 | 0.000 |
| 2 Constant | 0.561 | 1.405 | | 0.399 | 0.692 |
| O-MH observer 1-1 | 0.984 | 0.041 | 0.985 | 24.188 | 0.000 |
| Age | 0.003 | 0.003 | 0.042 | 0.977 | 0.334 |
| BMI | −0.006 | 0.011 | −0.021 | −0.533 | 0.597 |
| Sex | −0.051 | 0.095 | −0.022 | −0.535 | 0.595 |

Dependent variable: TT-MM observer 1-1.
Observer 1-1: 1st observer 1st reading.

## Funding

Nil.

## Ethical statement

Institutional ethical committee clearance has been taken.

## Conflicts of interest

Authors declare no conflicts of interest.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.cjtee.2019.07.002.

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