

Estimation of Femoral and Tibial Nail Length Using Forearm Plus Little Finger as Reference in Sudanese Patients

Hassan Elbahri¹, Mohamed Hamid Awadelseid^{2*}, Riyadh Omer Abdelgadir³

¹Departement of Orthopedic International University of Africa-Khartoum, Sudan

²Departement of Orthopedic Excellence Trauma Centre- Khartoum, Sudan

³Departement of Orthopedic Alamal National Hospital -Khartoum, Sudan

*Corresponding author: Mohamed Hamid Awadelseid, Departement of Orthopedic Excellence Trauma Centre- Khartoum, Sudan. Email: mhawad3055@gmail.com

Citation: Elbahri H, Awadelseid MH, Abdelgadir RO (2021) Estimation of Femoral and Tibial Nail Length Using Forearm Plus Little Finger as Reference in Sudanese Patients. Annal Cas Rep Rev: ACRR-278.

Received Date: 06 September, 2021; **Accepted Date:** 13 September, 2021; **Published Date:** 20 September, 2021

Abstract

Introduction: Selecting the correct tibial and Femoral nail length is essential for satisfactory outcomes. And accurate preoperative nail estimation has the potential to reduce intra-operative errors, operating on time and radiation exposure.

Methods: Study was conducted in Khartoum Teaching Hospital and Alamal National Hospital from May to November 2015 on 140 adult who underwent an intramedullary nailing for tibial or Femoral fractures. 91 of them had tibial fracture and 49 had Femoral fracture.

Measurement of the distance in surface anatomy between the olecranon and metacarpal head of the little finger and also measurement of the distance in surface anatomy between the tibial tuberosity and the medial malleolus, were correlated together and to the size of the inserted nail for fixation of fracture tibia for the same patient.

Measurement of the distance in surface anatomy between the olecranon and tip of the little finger and also measurement of the distance in surface anatomy between the greater trochanter and superior patella of the leg, both were correlated together and to the size of the inserted nail for fixation of fracture Femur for the same patient.

Results:

For the tibia: Analysis showed that the mean of tibia tuberosity -medial malleolar distance (TMD) were 35.87 cm while the mean of olecranon - metacarpal head of the little finger distance (OMD) were 35.84cm and the mean of the nail tibia that inserted were 35.64 cm, and correlation between OMD, TMD and Nail tibia size are significant at the 0.01 level.

For the Femur: Analysis showed that the mean of olecranon -little finger distance (OLFD) was 42.97cm, while the mean of Great tuberosity -superior patella distance (GTSPD) was 45.30 cm, and the mean of the nail femur that inserted were 42.93cm, and correlation between OLFD, GTSPD and Nail Femur size are significant at the 0.01 level.

Recommendations: based on this study we recommend Using the OMD in estimating the tibial nail length preoperatively. Using the TMD in estimating the tibial nail length preoperatively. Using OLF in estimating the femoral nail length preoperatively. Using the GTSP in estimating the femoral nail length preoperatively. They all provide easy accurate and simple means preoperatively to determine the appropriate nail length with the advantage of avoiding unnecessary radiation exposure, shorten the operation time and anticipation of intraoperative surprises.

Keywords: Femoral, Tibial, Nail, Length, Forearm, Little Finger.

Literature review

Tibial shaft fractures comprise 2% of all adult fractures. Intramedullary interlocking nailing is the gold standard in the treatment of tibial shaft fractures in adults. 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 the penetration of the nail into the tibiotalar joint [1].

Several direct and indirect methods of estimating the Femoral nail length have been described [2]. Direct measurement of the intact Femur (from the tip of the greater trochanter to the proximal pole patella) on the opposite side can serve as a rough guide, but may be inaccurate in obese patients. The use of radiographs can

solve this problem, but involves radiation exposure, and radiological magnification may lead to inaccuracy.

Other methods include the use of a nail template, radio-opaque ruler, or Kuntscherossimeter. All these methods require an intact contralateral Femor. In bilateral comminuted fractures, measurement is made on the less-comminuted side. Several methods of estimating tibial nail length have been described, such as radiographic templates and patient height [2].

Most methods require an intact contralateral tibia for measurement and therefore not suitable in bilateral fractures. Furthermore, the contralateral tibia can be difficult to measure because of wounds, obesity, other fractures or previous tibial fracture.

The main reason for preoperative estimation of tibial or femoral nail length is to have the correct range of nails lengths available in the operating theatre. Intraoperative estimation is the most accurate method, but it allows no preoperative planning. Ideally full range of tibial or femoral nail length should be available, but this is not always the case, particularly where emergent surgery is involved.

The aim of this study is to assess Femoral and tibial nail lengths preoperatively using forearm and little finger as reference.

Problem statement & Justification

Preoperative estimation of intramedullary Femoral and tibial nails length has the advantages of reducing intraoperative radiation exposure to the surgeon and the patient to avoid the potential risk related to it. In addition it reduces operative time while attempting to determine the nail length intraoperatively by imaging the contralateral side and this will be reflected in reducing the complications commonly results from prolonged operative time e.g., bleeding and infection rate and this may jeopardize the success rate of any operation. Furthermore reducing intraoperative time will help in increasing the number of patients operated in busy lists.

Ideally full range of Femoral/tibial nail lengths should be available, but in some operative theatres this is not always the case, making Preoperative estimation of intramedullary Femoral and tibial nails length a necessity to overcome this obstacle.

Preoperative estimation of intramedullary Femoral and tibial nails length is especially important if the patient has bilateral fractures rendering attempting to determine the nail length using the other contralateral bone as a reference imprecise. It also helps the surgeon not to violate the sterilization process using the contralateral limb for nail length determination. There are few papers that address this issue coming mostly from East Asian countries, whose population physique is quite different from ours in Sudan; this poses the need for undertaking this study in Sudan to determine the applicability of their results in our patients.

Nazir A, et al in his study (Estimation of Femoral length for intramedullary nail using forearm as reference). He took

measurements on 100 volunteers from the tip of olecranon to the tip of little finger and tip of greater trochanter to palpable joint line on the lateral side of the knee. and used an ordinary plastic tape measure. His statistical analysis revealed a very strong correlation (with Pearson correlation factor of 1) between the two lengths. Difference between the two means was 0.16 Mm. He concluded that forearm reference represents maximum nail length required (7). Issac RT, et al., in his paper Preoperative determination of tibial nail length, which was an anthropometric study. He studied six anthropometric parameters in 50 male and 50 female medical students using a metallic scale:

medial knee joint line to ankle joint line (K-A), medial knee joint line to medial malleolus (K-MM), tibial tuberosity to ankle joint (TT-A), tibial tuberosity to medial malleolus (TT- MM), olecranon to 5th metacarpal head (O-MH) and body height (BH).

He predicted the Nail size based upon TT-MM measurement and chosen this as ideal nail size.. Nail sizes calculated were compared with that obtained from TT-MM measurement and accuracy was evaluated.

His came with the conclusion that adding 11 mm to TT-A distance had highest accuracy (81%) and correlation (0.966) in predicting nails correctly. Subtracting 33 mm from K-MM measurement and 25 mm from K-A distance derived accurate sizes in 69% and 76% respectively. Adding 6 mm to O-MH distance had a poor accuracy of 51%.

He described the method he used as helpful in determining nail size preoperatively especially when one anatomic landmark is difficult to palpate (1).

Galbraith JG, et al. in his paper (Preoperative estimation of tibial nail Length because size does matter.), examined 16 cadaveric tibiae and compared the most commonly used radiological, anthropometric and intra-operative techniques to determine ideal nail lengths.

He took different anthropometric measurements from each intact cadaver including: knee joint line to ankle joint line distance (JJD), medial knee joint line to medial malleolus distance (MMD), tibial tuberosity to medial malleolus distance (TMD), olecranon to 5th metacarpal head distance (OMD) and body height (BHR). For each tibia he got antero-posterior (AP) and lateral scanograms and used Computerized tomography to determine the ideal nail length for each tibia. Two orthopedic surgeons recorded each anthropometric and radiological measurement independently. He used an expert tibial nail that is inserted after nail length estimation was performed using a guide wire technique and an intra-operative radiographic ruler. In his study he found that the AP scanogram is 100% accurate in selecting ideal nail length. The lateral scanogram was also found to be reasonably accurate but in 19% (3/16) 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% (1/16) of cases producing an incorrect nail size. In general, the anatomical measurements gave a poor indication of ideal nail size

compared with the other techniques. The following accuracies were noted in his study: JJD 56%, MMD 50%, TMD 38%, BHR 13% and OMD 56%.

He found that radiological methods such as using an AP radiograph with known magnification and intra-operative radiographic ruler were able to predict nail length very accurately and he suggest that these measurements should be performed routinely. The guide wire technique was also effective but he recommends that it not be used in isolation as errors can occur. He concluded that anatomical measurements are not accurate for predicting tibial nail length (3).

Colen RP, et al.in his study used the Tibial tubercle-medial malleolar distance to determine tibial nail length. He compared Four methods of tibial nail length determination. He determined the nail lengths for each of fourteen cadaveric lower extremities using full-length scanograms, spotograms, acrylic template overlays, and the distance between the tibial tubercle and the medial malleolus (TMD). Each tibia was then nailed.

The full-length scanogram method resulted in incorrect nail lengths in eleven of fourteen (79 percent) cases. Six of fourteen (43 percent) incorrect nail lengths resulted from the use of spotograms. All measurements made with the Template technique yielded nails that were too short (100 percent). The TMD method rendered four of fourteen (29 percent) nails of incorrect size. In his study he came with the conclusion that The tibial tubercle-medial distance (TMD) proved an easy, inexpensive, and accurate method of preoperative nail assessment [4].

Blair S.measuredThe OMD in 60 members of staff (42 male and 18 females) at Don Castor royal infirmary, along with the tibial tuberosity to medial malleolus distance of the ipsilateral tibia. The contralateral tibia was also measured to exclude significant leg length discrepancy.

- To measure the tibial tuberosity to medial malleolus distance (TMD),he used the direct distance between tibial tuberosity and medial malleolus, as described by colen. the most prominent point of the tibial tuberosity was used, he stated that this is not always clear mark, and is a potential source of error. He described that his method differs slightly from the method described by Lotters who described a method measuring the vertical distance from the medial malleolus to the level of tibial tuberosity.
- He compared the OMD with the TMD to look for a correlation.
- His results were as follows: The mean TMD was 342mm (range 300-410mm)
- The mean OMD was 352mm (range 312-415mm)
- In no case was the TMD longer than the OMD:
- The measures were equal in 3 cases.
- The greatest difference between the OMD and TMD was 35mm.
- Applying the linear regression, the Pearson correlation coefficient (r) is 0.93 (P less than 0.005).

He came with the same conclusion a Nazir et al and Blairs, Forearm referencing provides a useful method of estimating tibial nail length when the contralateral tibia cannot be used to do so. it provides a simple method of estimation that can easily be applied in clinical practice. The surgeon can then ensure that the correct range of nails is available in operating theatre before embarking on the surgical procedure [6].

Venkateswaran et al.In a retrospective study of 16 patients in his unit, only three had ideal nail sizes. In these patients, he measured their normal leg's length from knee joint line to ankle joint line. An ideal nail length for each of these patients was estimated from a whole length radiograph of the nailed tibia. Comparing these two data, he found that deducting 20 mm from the leg measurement gave appropriate nail lengths. he also compared this with three other anthropometric measurements; tibial tuberosity to medial malleolus, joint line to medial malleolus and olecranon to head of V metacarpal head distance. The joint line to joint line measurement was the most reliable and showed the best correlation with ideal nail lengths (0.982).

In phase II of his study, a prospective study on 15 patients, we used the joint line to joint line measurement to determine nail sizes. A postoperative review of the radiographs showed all the nails to be of adequate length. This strengthened the fact that the joint line to joint line measurement is the most accurate and easy method to determine tibial nail lengths [5].

Monappa A Naik et al measured the forearm plus little finger length and the ipsilateral femoral length of 68 male and 32 female volunteers aged 19 to 55 (mean, 35.8) years using a measuring tape. The forearm plus little finger length was measured from the tip of the olecranon to the tip of the little finger, whereas the femoral length was measured from the tip of the greater trochanter to the level of proximal pole of the patella over the outer aspect of thigh.

The mean forearm plus little finger length and femoral length were 39.87 (SD, 2.73) and 39.85 (SD, 2.44) cm, respectively. The mean difference between these 2 measurements was 0.028 (95% CI,-0.109 to 0.165) cm. The correlation between these 2 measurements was 0.861 ($p < 0.001$). Patient age, sex, and body mass index did not affect this correlation.

He concluded that the forearm plus little finger length correlated with the femoral length. This method is simple, radiation-free, and can be applied in day-today practice [2].

Objectives

General: - To estimate Femoral & tibial nail length using forearm plus little finger as reference.

Specific: -

1. To compare between the femoral nail length inserted and (olecranon to little finger tip distance & greater trochanter to superior patellar distance).
2. To compare between the tibial nail length inserted and (olecranon to fifth metacarpal head distance, tibial tuberosity to medial malleolus distance)

3. To compare between (olecranon to little finger tip distance & greater trochanter to superior patellar distance).
4. To compare between (olecranon to fifth metacarpal head distance) and (tibial tuberosity to medial malleolus distance).

Methodology

Descriptive cross-sectional hospital-based study, Convenient sampling type. 140 subjects

Postoperative patients underwent tibial or femoral nailing either inpatients or presented to the outpatient of orthopedic department. in Khartoum teaching hospital & Almal National hospital in the period from May to November 2015.

Inclusion criteria: Adults (18 years and above). Adults underwent intramedullary nailing (Femoral or tibial)

Exclusion criteria: Subjects with congenital or traumatic deformities of the limbs.

Subjects in whom inappropriate nail length is inserted after reviewing the postoperative x-ray.

Data collected using a checklist and measurements done using an elastic tape.

For the Femoral nail length estimation:

- The forearm plus little finger length will be measured from the tip of the olecranon to the tip of the little finger while the elbow will be flexed to 90° and the wrist and fingers were in a neutral position.
- The Femoral length (unfractured side) will be measured from the tip of the greater trochanter to the level of proximal pole of the patella over the outer aspect of thigh.
- The thigh will be slightly flexed and adducted to make the greater trochanter more prominent.
- Then the actual nail size inserted will be checked from patient operation notes.
- Post operative x-ray is examined to check that the appropriate nail length is inserted.

For the tibial nail length estimation:

- Measurement from the Olecranon to head of 5th Metacarpal with elbow flexed and clenched fist will be done.
- Measurement from tibial tuberosity to medial malleolus (unfractured side)

- Then the actual nail size will be checked from patient operation notes.
- Post operative x-ray is examined to check that the appropriate nail length is inserted.

Data analysis done using SPSS (20 version).

Results

The results of the study showed the following:

Males (67%) females (33%) refer to figure 1. Intramedullary nail inserted: femur (35%) tibia (65%) refer to figure 2. Olecranon metacarpal head distance was mostly 35,36 cm. refer to figure 3. tibial tuberosity to medial malleolus distance is mostly 34,36 cm refer to figure 4.

Nail tibia length (44% size 36) (26% size 34). tibial tuberosity to medial malleolus distance mean (35.88) and Nail tibia lengths mean (35.64) and the Correlation is significant at the 0.01 level between them refer to table 1.

Olecranon metacarpal head distance mean (35.85) and Nail tibia lengths mean (35.64) and the Correlation is significant at the 0.01 level between them refer to table 2.

Correlation between tibial tuberosity to medial malleolus distance mean (35.85) and olecranon metacarpal head distance (35.88) mean is significant at the 0.01 level refer to table 3.

Olecranon little finger tip distance showed that 40cm is the most common frequency (28 subjects) refer figure 6. Greater trochanter superior patella distance showed 45 cm (32 subjects) refer figure 7. nail femur length frequency size 44 (45%), size 42 (33%) refer to figure 8.

Correlation between olecranon little finger tip distance mean (42.98) and Nail Femur lengths mean (42.94) is significant at the 0.01 level refer Table 1.

Correlation between greater tuberosity superior patella distance mean (45.31) and Nail Femur lengths mean (42.94) is significant at the 0.01 level refer to Table 2.

Correlation between OLF distance mean (42.98) and GTSPD mean (45.31) significant at the 0.01 level refer Table 6.

General Results

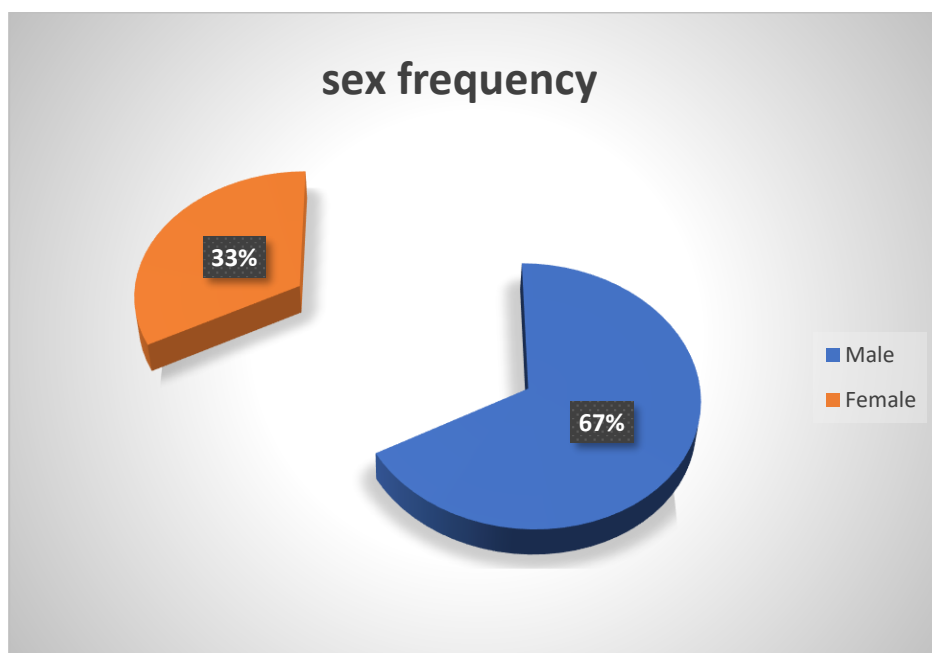


Figure 1: Sex frequency.

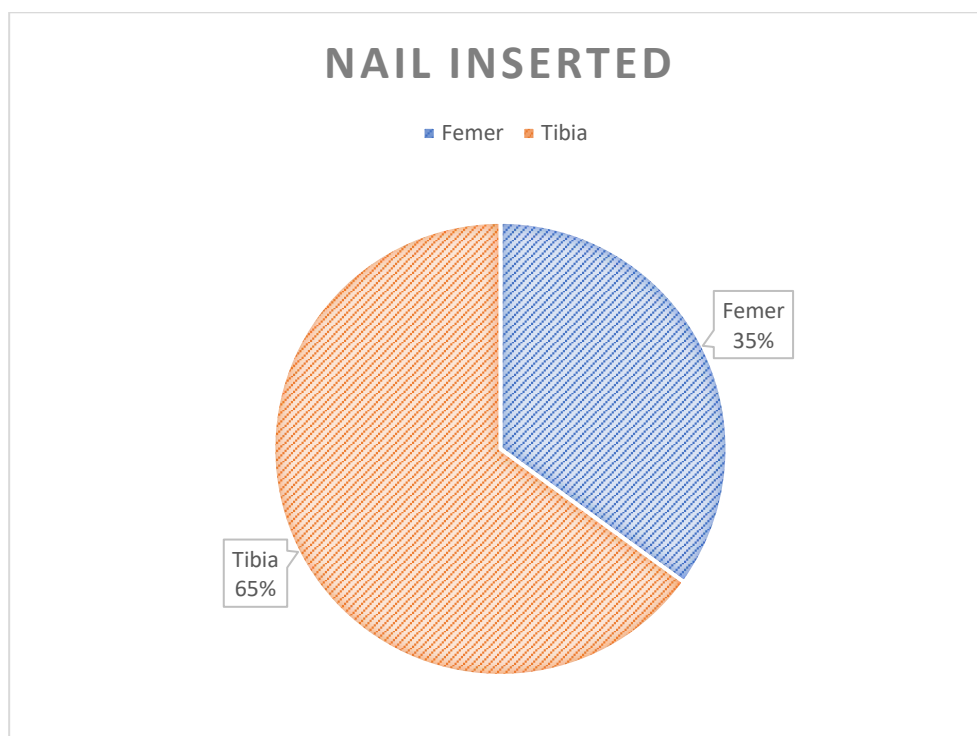


FIGURE 2: type of nail inserted ,91 of the study population had fracture tibia, while 49 had fracture Femor, both under went internal fixation by intramedullary nail.

Tibia:

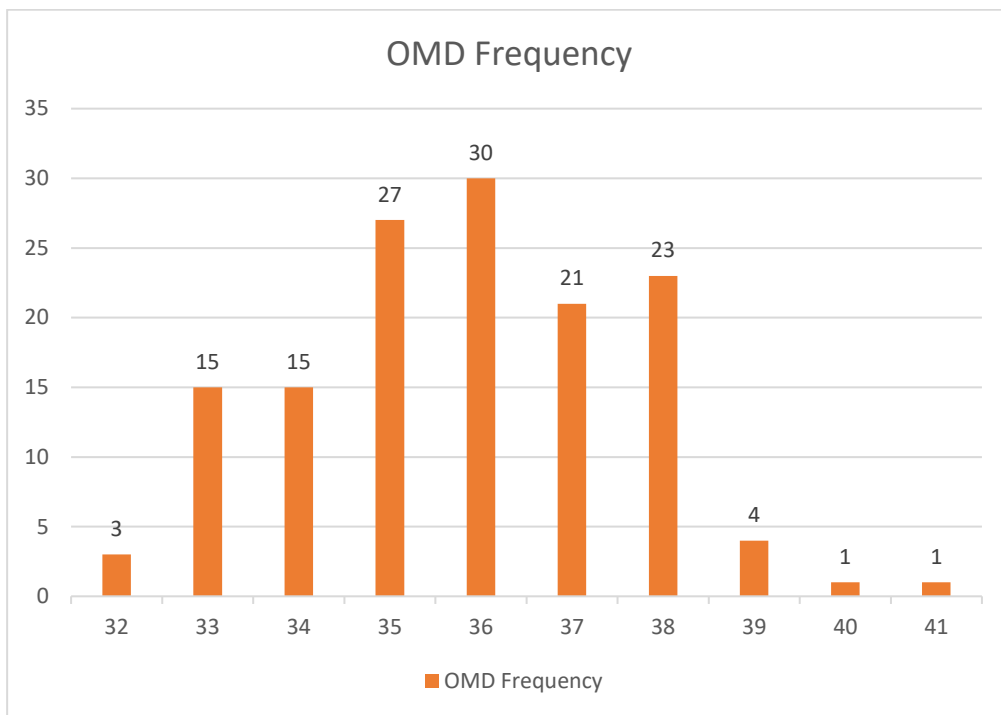


FIGURE 3: OMD distance frequency, The OMD in most of the study population was 36 cm.

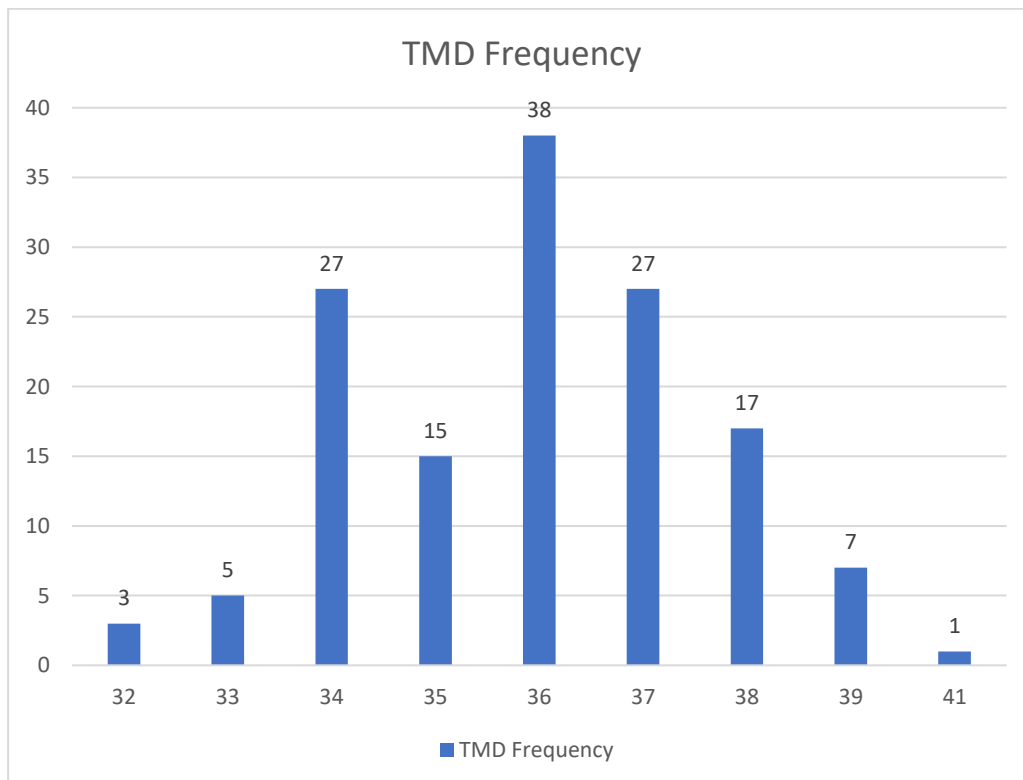


Figure 4: TMD distance frequency. The TMD in most of the study population was 36 cm.

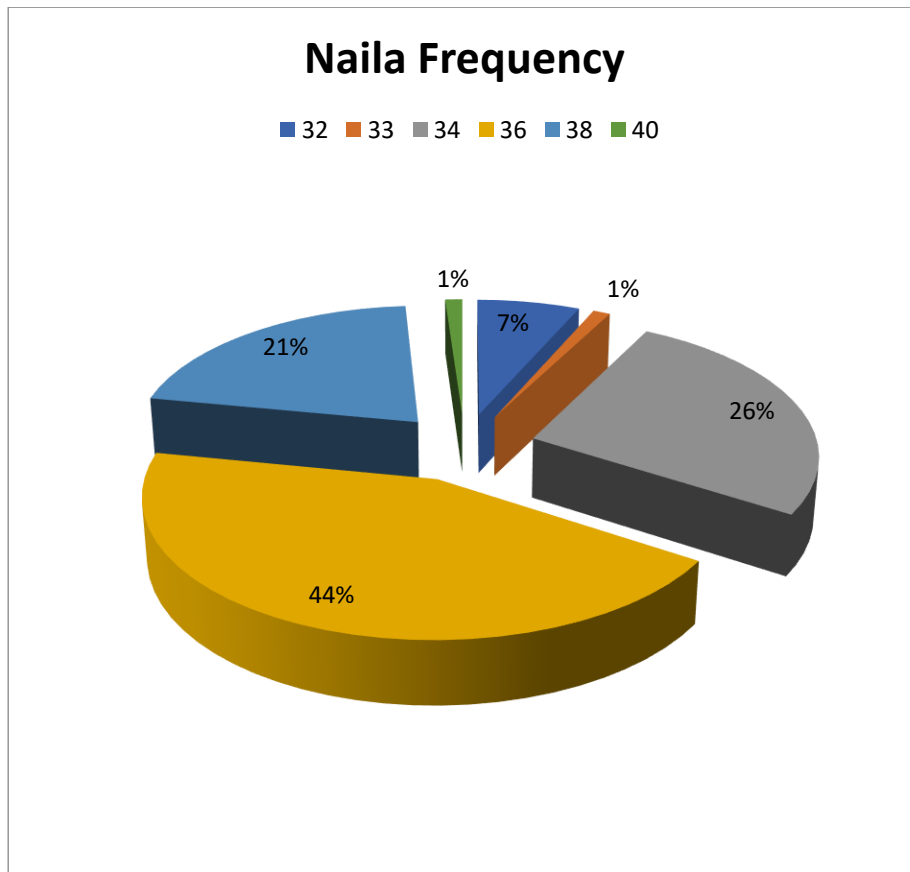


FIGURE 5: Nail tibia lengths frequency, The length of the nail that used in most of the study population was 36 cm.

Table 3: correlation between TMD mean and Nail tibia lengths mean.

	Mean
TMD	35.88
Nail	35.64

Correlation is significant at the 0.01 level

TABLE 4: CORRELATION BETWEEN OMD MEAN AND NAIL TIBIA LENGTHS MEAN.

	Mean
OMD	35.85
Nail	35.64

Correlation is significant at the 0.01 level

TABLE 5: CORRELATION BETWEEN TMD MEAN AND OMD MEAN

	Mean
OMD	35.85
TMD	35.88

Correlation is significant at the 0.01 level

Femor:

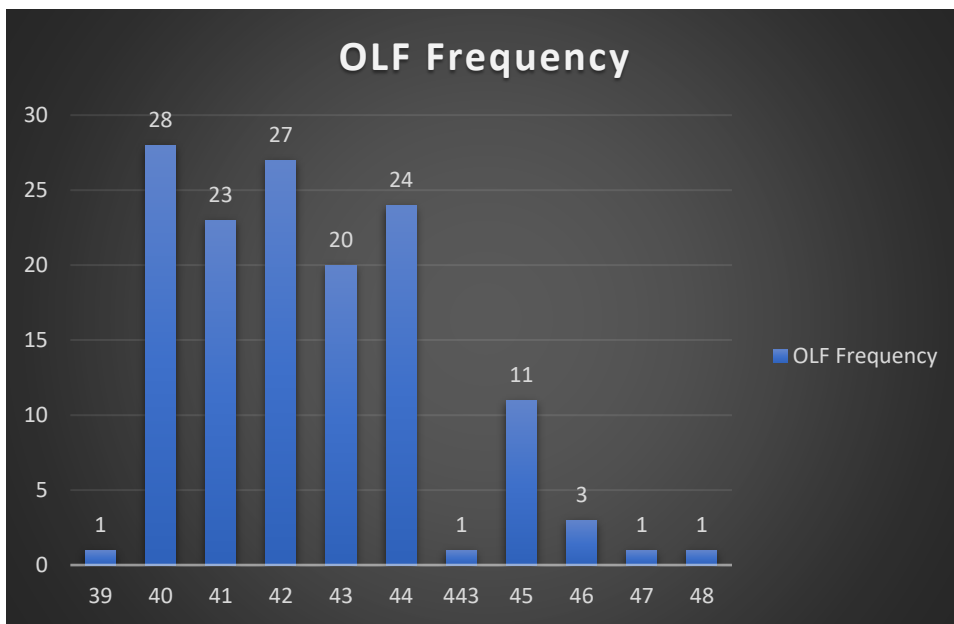


Figure 6: OLF frequency, The OLF in most of the study population was 40 cm.

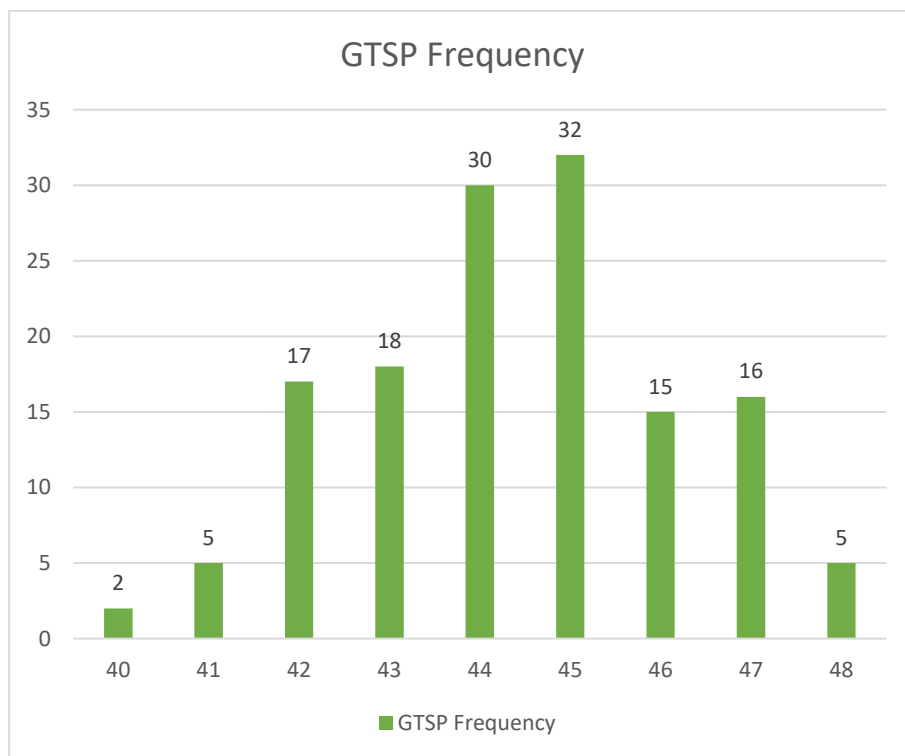


Figure 7: GTSPD frequency. The GTSPD in most of the study population was 45 cm.

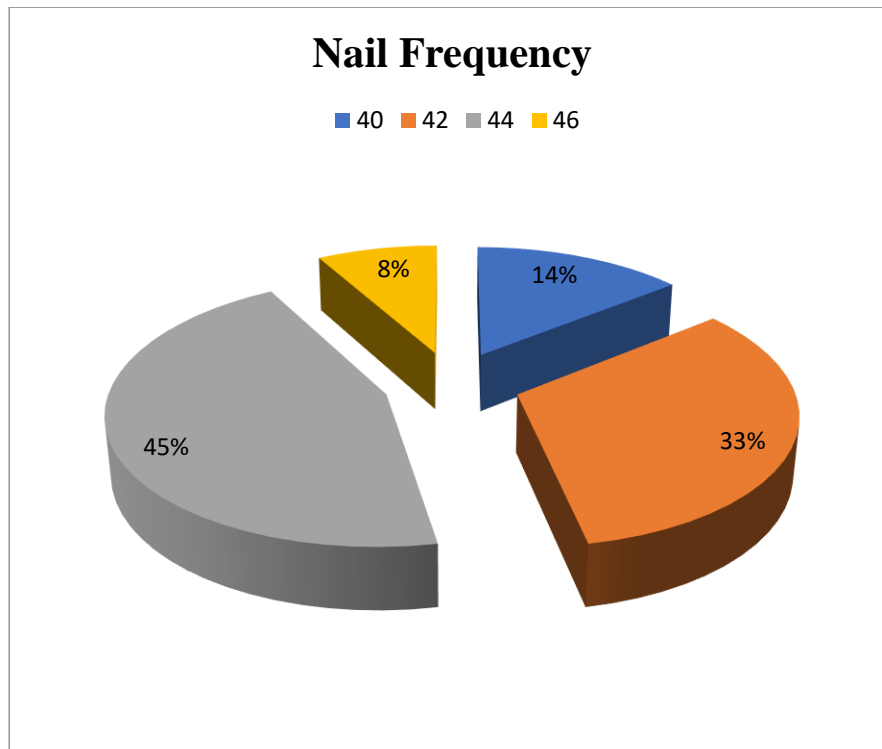


FIGURE 8: Nail Femor lengths frequency.

TABLE 6: correlation between OLF D mean and Nail Femor lengths mean.

	Mean
OLF D	42.98
Nail	42.94

Correlation is significant at the 0.01 level

Table 7: correlation between GTSPD mean and Nail Femor lengths mean.

	Mean
GTSPD	45.31
Nail	42.94

Correlation is significant at the 0.01 level

Table 8: correlation between OLF D mean and GTSPD mean.

	Mean
GTSPD	45.31
OLF D	42.98

Correlation is significant at the 0.01 level

Discussion

For the Tibia:In descriptive analysis the most frequent OMD, TMD and lengths of nail Tibia was 36 cm. Blair S. in his study (Estimating tibial nail length using forearm referencing) (6) found the mean TMD 34.2.OMD 35.2. This may reflect slightly taller attitude of Sudanese patients in comparison to his study population.

Statistical analysis shows significant correlation between OMD and TMD (P less than 0.01). this goes with Blair S.in his study (Estimating tibial nail length using forearm referencing) (6) as he found that a significant correlation between these two variables.

Statistical analysis shows significant correlation between OMD and Nail tibia (P less than 0.01). This in contrary to Galbraith JG, et al. in his study Preoperative estimation of tibial nail (3) where he found OMD only 58% accurate in estimating the tibial nail length.

Statistical analysis shows significant correlation between TMD and Nail tibia (P less than 0.01). this goes with Colen RP, et al. in his study Tibial tubercle-medial malleolar distance in determining tibial nail length (4). Where he found the TMD the most accurate (70%) in determining the tibial nail length.

This result does not go with Galbraith JG, et al. In his study (Preoperative estimation of tibial nail Length because size does matter) (3) where he found TMD is only 38% accurate in estimating tibial nail length.

Issac RT, et al. in his study (Preoperative determination of tibial nail length) (1) used the TMD as the standard for the accurate nail length and compared the other anthropometric measurements to it. This signify TMD precision in determining the appropriate nail size.

For the Femur: Statistical analysis shows significant correlation between OLF and GTSPD (P less than 0.01). This goes with Monappa A Naik et al in his study Correlation between the forearm plus little finger length and the femoral length (2).as Nazir A, et al in his study Estimation of Femoral length for intramedullary nail using forearm as reference (7) used the lateral joint line of the knee as reference (instead of GTSPD in our study), comparison between the two studies cannot be done.

Statistical analysis shows significant correlation between OLF and Nail Femor (P less than 0.01). (No previous studies-as far as we know- compared these two variables).

Statistical analysis shows significant correlation between GTSPD and Nail Femor (P less than 0.01). (No previous studies-as far as we know- compared these two variables).

Conclusion

Preoperative estimation of tibial and or femoral nail length is very usefull. After performing this study, we have found that there is significant correlation between olecranon to fifth metacarpal head distance and tibial tuberosity medial malleolus diatance. And a significant correlation between both (olecranon to fifth metacarpal head distance, tibial tuberosity medial malleolus diatance) and tibial nail length.

In addition, there is a significant correlation between olecranon to little finger distance and greater trochanter to superior patella distance.

furthermore, a significant correlation between both (olecranon to little finger distance and greater trochanter to superior patella distance) and femoral nail length.

Recommendation

Based on this study we recommend:

1. Using the OMD in estimating the tibial nail length preoperatively.
2. Using the TMD in estimating the tibial nail length preoperatively.
3. Using OLF in estimating the femoral nail length preoperatively.
4. Using the GTSP in estimating the femoral nail length preoperatively.

They all provide accurate simple means preoperatively to determine the appropriate nail length with the advantage to avoid unnecessary radiation exposure, shorten the operation time and anticipation intraoperative surprises.

References

1. Issac RT, et al., Preoperative determination of tibial nail length: An anthropometric study, Chinese Journal of Traumatology (2016),
2. Monappa A Naik,1 Premjit Sujir,1 Sujit Kumar Tripathy,2 Tarun Goyal,3 Sharath K Rao. Correlation between the forearm plus little finger length and the femoral length Journal of Orthopaedic Surgery 2013;21(2):163-6
3. Galbraith JG, O'Leary DP, Dailey HL, et al. Preoperative estimation of tibial nail Length because size does matter. Injury. 2012; 43:1962e1968.
4. Colen RP, Prieskorn DW. Tibial tubercle-medial malleolar distance in determining tibial nail length. J Orthop Trauma. 2000; 14:345e348.
5. Venkateswaran B, Warner RM, Hunt N, et al. An easy and accurate preoperative method for determining tibial nail lengths. Injury. 2003; 34:752e755.
6. Blair S. Estimating tibial nail length using forearm referencing. Injury. 2005;36: 160e162 (28).
7. Nazir A, Roy S, Mathur K, Alazzawi S. Estimation of Femoral length for intramedullary nail using forearm as reference. J Bone Joint Surg Br 2009;91(Suppl 1):37.