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Original article

Preoperative determination of tibial nail length: An anthropometric study

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ABSTRACT

Objective: To assess the correlation between five anthropometric parameters and the distance from tibial tuberosity to medial malleolus in 100 volunteers.
Methods: Six anthropometric parameters were measured 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). Nail size predicted based upon TT-MM measurement was chosen as ideal nail size. A constant was derived for each of the six anthropometric parameters which was either added or subtracted to each measurement to derive nail size. A regression equation was applied to BH measurements. Nail sizes calculated were compared with that obtained from TT-MM measurement and accuracy was evaluated. Accuracy of O-MH and BH regression equations recommended by other authors were calculated in our data.
Results: 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%. Nail size prediction based upon body height regression equation derived correct nail sizes in only 34% of the cases. Regression equation analysis by other authors based on O-MH and BH distances yielded correct sizes in 11% and 5% of the cases respectively.
Conclusion: TT-A, K-A and K-MM measurements can be used simultaneously to increase accuracy of nail size prediction. This method would be helpful in determining nail size preoperatively especially when one anatomic landmark is difficult to palpate.

Introduction

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

Various methods have been mentioned in literature to estimate the accurate nail size. The intraoperative methods used are the two guide wires technique, nail-against-limb technique and using a radiographic ruler.[3–5] The two guide wires technique cannot be used when unreamed nails are used.[6] The preoperative radiological methods described are krammer splint technique, templating, scanograms, spotograms and direct measurement from radiographs of the contralateral limb.[5,7]

Anthropometric measurements described for the preoperative estimation of tibial nail length are knee joint line to ankle joint line (K-A), knee joint line to medial malleolus (K-MM), tibial tuberosity to ankle joint line (TT-A), tibial tuberosity to medial malleolus (TT-MM), olecranon to fifth metacarpal head (O-MH) and body height (BH).[6–10]

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Intraoperative techniques consume valuable operating time and add radiation exposure of both the patient and the operating room personnel. So if the tibial nail length can be determined accurately preoperatively, we could avoid these problems. This also avoids wastage of inaccurate nails which are discarded during the operative procedure.[8] Exchanging an incorrect length nail increases the operative time, X-ray irradiation and causes the frustration of the surgeon. Preoperative methods which rely on conventional radiography can cause inaccuracies due to malrotation in positioning the patient, inadequate exposure and variation in magnification.[7] Anthropometric measurements provide an easy way to preoperatively estimate tibial nail lengths accurately.[8] Existing literature provides varying and contrasting accuracies to each anthropometric parameter used currently and investigates their interrelationship.

This study aimed to compare the different anthropometric measurements so as to explore the interrelationship between them for predicting nail size and determining their accuracy.

Methods

A hundred medical students (fifty males and fifty females) were included in the study. This study was approved by the ethics committee and informed written consents were taken. All participants had an age more than 18 years and the patients with previous fractures of the tibia, forearm and metacarpals were excluded. The following anthropometric parameters were measured using a metallic scale in each participant: K-A, K-MM, TT-A, TT-MM, O-MH and BH (Fig.1). The anatomical landmarks used for measurement of each parameter were defined based upon previous studies in literature.[6–9]

K-A was measured from a point on the medial knee joint line 3 cm medial to the medial edge of patellar tendon to another point on the medial ankle joint line felt as a depression just medial to the tibialis anterior tendon at the medial corner of the ankle joint.[6,8] K-MM was measured from the medial knee joint line 3 cm medial to the medial edge of patellar tendon to the most prominent point on the medial malleolus.[6] TT-A was determined by measuring the distance between the most prominent point on the tibial tuberosity and the medial ankle joint line. TT-MM was defined as the distance between the most prominent points on the tibial tuberosity and medial malleolus.[6,7] These parameters were measured when the participant was in the supine position with the knee flexed to 90°, the ankle dorsiflexed and the leg externally rotated. Distance between the tip of olecranon to the 5th metacarpal head constituted O-MH.[6,9] This measurement was taken with the elbow and metacarpophalangeal joints at 90°of flexion and the wrist in neutral position. Body height was measured in a standing position.

Nail size predicted from the TT-MM measurement was chosen as the ideal nail size. If the predicted nail length fell between available nail sizes, the shorter nail size was selected except if it was within 5 mm of the available larger sized nail. In that situation, the higher sized nail was chosen. For example, if the TT-MM measurement was 350 mm, 345 mm was chosen as the nail size for that method. However, if the measurement was 355 mm, 360 mm was selected.

Statistical analysis was done using Microsoft Excel Software. The mean value of the differences between the TT-MM measurement and each anthropometric parameter was calculated. By this method and based upon the highest degree of correlation calculated by Pearson's correlation coefficient, a constant was derived which was either added or subtracted from each anthropometric measurement to calculate the predicted nail size. To predict nail size based on BH measurements, a regression equation was derived using linear regression analysis (BH equation).

The nail size predicted based upon each anthropometric parameter was compared with that derived from the TT-MM measurement. Accuracy of the nail size calculation based upon each anthropometric parameter measurement was evaluated as a percentage and the 95% confidence interval (CI) was calculated. Nail size calculation applying the regression equations recommended by Fischmeister et al[10] (nail length $= -5.05729 + 0.222 \times$ BH) and Blair[9] (nail length $= 9.1 + 0.93 \times$ O-MH) was also done. This was compared with the ideal nail size calculated from the TT-MM distance to measure the accuracy of these two methods in our study population.

Results

Nail size derived from each anthropometric parameter was compared with the ideal nail size calculated from the TT-MM measurement. The results are summarized in Table 1. The average of the differences between TT-MM and TT-A distance was 11 mm. Adding 11 mm to the TT-A distance gave the highest correlation ($r = 0.989$) to the TT-MM measurement (Table 2). So adding 11 mm to each TT-A measurement derived the nail size predicted by that method.

Similar calculations were done with the K-MM, K-A and O-MH parameters too (Table 2). Nail sizes were predicted by subtracting 33 mm from each K-MM measurement and 25 mm from each K-A measurement. The 6 mm was added to the O-MH distance to arrive at a nail size. The regression equation calculated for BH measurement was as follows: TT-MM $= 4.498 + 2.107 \times$ BH.

Among all the anthropometric parameters, TT-A distance was the most accurate (accuracy of 81%, 95% CI 0.73–0.89) in predicting the nail size (Table 3). Correlation to the ideal nail size was also the

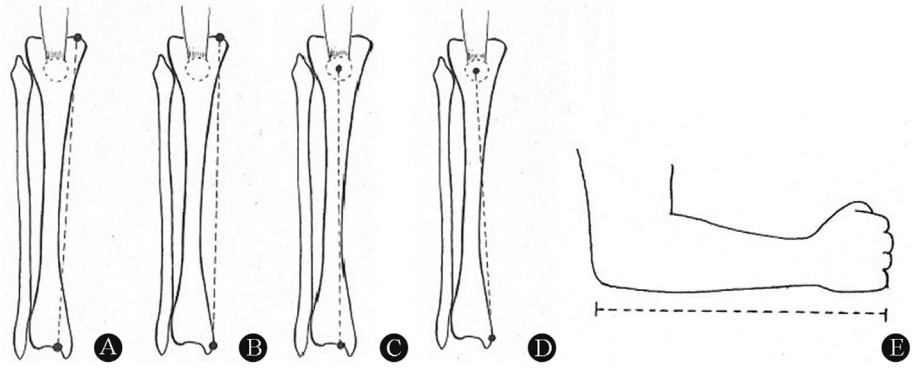

Fig. 1. Anthropometric measurements. A: K-A; B: K-MM; C: TT-A; D: TT-MM; E: O-MH.