Correlation of Various Anthropometric Measurements with Tibia Interlocking Nail Length Measured Intra-Operatively

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Abstract

Background: A proper and accurate size of tibial nail insertion is necessary for better functional outcome and to prevent complications related to improper nail length. Various preoperative and intraoperative measures are used, with varied accuracy for nail size estimation. With aim to find out the best anthropometric measure correlating with the tibial nail length, we correlated various anthropometric measurements to actual size of tibial interlock nail used in 100 cases of tibial shaft fracture.

Material & Methods: 5 anthropometric parameters were measured i.e. (1) distance from medial knee joint line to ankle joint line (K-A) (2) distance from medial knee joint line to medial malleolus (K-MM) (3) distance from tibial tuberosity to ankle joint (TT-A) (4) distance from tibial tuberosity to medial malleolus (TT-MM) (5) distance from tip of olecranon to 5th metacarpal head (O-MH) in 100 cases of tibial shaft fractures treated with interlocking nail and were correlated with the tibial nail size used.

Results: Mean size of nail used was 33.61±1.69 mm (range 28 to 36 mm). Mean of five anthropometric parameters for K-A, K-MM, TT-A, TT-MM and O-MH, were 35.61±1.59 (range 30 to 39 mm), 37.16 +1.36 (range 32 to 41.5 mm), 33.58 ± 1.79 (range 28 to 37 mm), 34.40 ± 1.21 (range 30 to 39 mm), and 33.10 ± 1.61 (range 28 to 36 mm) respectively.

Conclusion: All anthropometric parameters i.e. TT-A, TT-MM, K-A, K-MM and O-MH can be used for nail size prediction. O-MH was nearly accurate to the nail size as compared to other methods because of interpersonal variation in palpation of tibial tuberosity.

Keywords: Tibial interlocking, tibial nail length, anthropometric measurements

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Introduction

Tibial diaphyseal fractures are among most common fractures of the long bones, about three times more common in men and typically occurs in younger adults [1,2]. Intramedullary interlocking nailing has been the gold standard in treatment of these tibial shaft fractures [3,4]. An accurate size of tibial nail and screws selection is of paramount importance, in addition to proper fracture reduction and fixation. A proper size nail avoids irritation of the soft-tissue envelope and enables easy extraction of the nail in future, if needed. This insertion of the correct-sized nail is also essential for satisfactory outcomes. A shorter nail results in mal-reduction 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. To avoid these complications, accurate size nail insertion is very important. Nail size estimation can be done pre-operatively or intra-operatively. Accurate preoperative nail estimation can reduce intra-operative errors, operative time and radiation exposure [5-7].

Various anthropometric measurements provide an easy way to preoperatively estimate tibial nail length [8]. Existing literature provides varying and contrasting accuracies to each anthropometric parameter. Hence we measured various anthropometric measurements in 100 cases of tibial shaft fracture and compared their proximity to actual size of tibial interlock nail used, in order to check, which anthropometric measure correlates best with the tibial nail length.

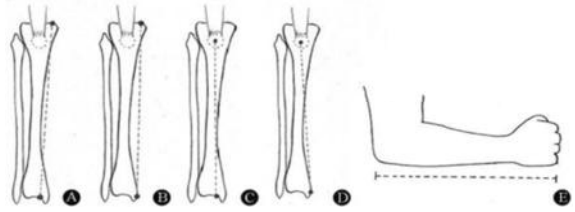
Material and Methods

This study was conducted in 100 cases of tibial shaft fractures treated with interlocking nail admitted in our institute after obtaining Institutional Ethics Committee clearance and written informed consent from all the patients. All skeletally mature patients of tibial shaft fracture, open type I or II as per Gustilo Anderson criteria, operated by closed tibial interlocking nail were included in the study. Skeletally immature patients, injury or prior abnormality to contra-lateral tibia or upper limbs were excluded from the study.

All patients were haemo-dynamically stabilized, followed by proper evaluation of the patient by detailed history and examination. Five anthropometric parameters were measured using a metallic scale on contra-lateral normal leg and ipsilateral upper limb. These were (1) distance from medial knee joint line to ankle joint line (K-A) (2) distance from medial knee joint line to medial malleolus (K-MM) (3) distance from tibial tuberosity to ankle joint (TT-A) (4) distance from tibial tuberosity to medial malleolus (TT-MM) (5) distance from tip of olecranon to 5th metacarpal head (O-MH) (fig 1).

X rays of the involved limb were taken including knee and ankle joints. Patients were investigated and fitness for anaesthesia was obtained. All the patients were treated with tibial interlocking nail in supine position under spinal anaesthesia. Intra-operative tibial nail size was assessed on the fluoroscopic image as seen on C arm and proper size nail was inserted and the size used was noted. Intraoperative nail size used was then compared with that of five anthropometric parameters measured and their correlation to nail size was assessed.

Fig 1. Illustration of anthropometric parameters measured (a) medial knee joint line to ankle joint (K-A) (b) medial knee joint line to medial malleolus (K-MM) (c) tibial tuberosity to ankle joint (TT-A) (c) tibial tuberosity to medial malleolus (TT-MM) (e) tip of olecranon to 5th metacarpal head (O-MH).



Results

100 cases of tibial shaft fractures treated with interlocking nail were included in study. The mean age was 36.4 years (range 18 to 49 years). 74 were male and 26 were females. Road traffic accident was most common mode of injury seen in 79 cases where as rest had injury due to fall.

Mean size of nail used was 33.61±1.69 mm (range 28 to 36 mm). Mean of five anthropometric parameters were 35.61±1.59 (range 30 to 39 mm), 37.16 +1.36 (range 32 to 41.5 mm), 33.58 ± 1.79 (range 28 to 37 mm), 34.40 ± 1.21 (range 30 to 39 mm), and 33.10 ± 1.61 (range 28 to 36 mm) for K-A, K-MM, TT-A, TT-MM and O-MH respectively (table 1).

Table 1. Comparison of nail size with anthropometric parameters

	Mean ± SD (range in mm)	**'t' value**	**P value**
Actual Nail size	33.61 ± 1.69 (range 28 to 36 mm)		
K-A	35.61±1.59 (range 30 to 39 mm)	8.614, df=198	0.001*
K-MM	37.16+1.36 (range 32 to 41.5 mm)	4.326 df=198	0.001*
TT-A	33.58 ± 1.79 (range 28 to 37 mm)	3.800, df=198	0.001*
TT-MM	34.40 ± 1.21 (range 30 to 39 mm)	4.169, df=198	0.001*
O-MH	33.10 ± 1.61 (range 28 to 36 mm)	2.100, df=198	0.037*

O-MH, TT-A and K-A were found to be significantly longer in comparison to the actual nail size used (P=0.001), while TT-MM was found to be significantly smaller in comparison to the actual nail size (p=0.001).

Discussion

A proper and accurate size of tibial nail insertion is equally necessary for better functional outcome, in addition to proper fracture reduction and fixation [1-4]. Improper sized nail, either shorter or larger can cause impingement, soft tissue irritation, patellar tendinitis, joint penetration, mal-reduction, delayed union, stress fractures, and difficulty in dynamization or removal [5-7].

Many methods both preoperative and intraoperative, are mentioned in literature to determine the correct nail size i.e. proper length and diameter of an intramedullary tibial nail to be used. Each method has its merits and demerits, and most are lacking in accuracy.

Intraoperative methods used are nail-against-limb technique, two guide wires technique and by using a radiographic ruler [5-7]. Intraoperative techniques, the guide wire method and use of intraoperative radiographic ruler have an excellent accuracy of 94% according to Galbraith et al [8]. But, inaccuracies may occur due to eccentric C-arm placement, with the measurement being taken from the lowest exposed part of the guide wire or by not holding the radiographic ruler close and paralleled to the tibia [8]. Further, these techniques cannot be utilized in comminuted fractures or bilateral tibial fractures as these use comparisons with the opposite normal side or restoration of normal tibial length as a guide for measurement, which is difficult in bilateral or comminuted fracture cases respectively. Further, these intraoperative techniques take valuable operating time and add radiation exposure to both the patient and the operating room personnel. Two guide wires technique cannot be used when un-reamed nails are used [8]. Intraoperative, primary insertion of inaccurate size nail may need exchange of an incorrect length nail which further increases the radiation and operating time and causes frustration for the surgeon. Hence although, intraoperative measures 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 [6,9].

So preoperative planning for tibial interlocking nail should also include estimation and determination of tibial nail length preoperatively in-order to augment the accuracy of intra-operative tibial length estimation, so that we could avoid these intra-operative problems. This also avoids wastage of inaccurate nails which are discarded during the operative procedure [8]. Accurate preoperative nail estimation also can reduce intra-operative errors, operative time and radiation exposure [5-7].

Preoperative estimation of tibial nail length can be done by radiographic assessment or by anthropometric measurements. The preoperative radiological methods described are krammer splint technique, templating, scanograms, spotograms and direct measurement from radiographs of the contralateral limb. These preoperative methods which rely on conventional radiography can cause inaccuracies due to malrotation in positioning the patient, inadequate exposure and variation and errors in magnification [7]. Krettek et al reported a magnification of 7% in standard tibial radiographs and found templates unreliable in selecting implant length, because magnification varies depending on the splint used, position of limb at time of X rays and distance of the cassette and tube [5]. The problem of magnification can be overruled by use of a radiographic ruler or marker [6]. But routinely use of such a radiographic ruler for all cases is not feasible and is difficult especially in a poly trauma patient. Further if the radiographic marker is not kept at proper level it could result in poor accuracy in determining the correct nail length [6]. Digital radiograph although helps to assess the fracture pattern better, but its modularity to change the magnification of the length of tibia to fit the size of X ray film, makes them unsuitable for estimation of tibial nail length. Digital aids and scanogram are not routinely

recommended for trauma cases and availability and cost is also an issue.

Anthropometric measurements can be done quickly, easily and freely, even in uncooperative or polytrauma patients. Several anthropometric methods have been described for the preoperative estimation of tibial nail length. Most commonly used 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) [9-12].

Existing literature provides varying and contrasting accuracies to each anthropometric parameter used. Hence, in order find out the best anthropometric measure correlating with the tibial nail length, we measured various anthropometric measurements in 100 cases of tibial shaft fracture and compared their proximity to actual size of tibial interlock nail used. We found that in our study the mean nail size was 33.61, whereas mean K-A was 35.61, mean K-MM was 37.16 +1.36, mean TT-A was 33.58, mean TT-MM was 34.40 and mean O-MM was 33.10 ± 1.61. The mean TT-A and O-MH was the closest length of actual sized tibial nail used. Among the two we found O-MH distance to be the most accurate as the tip of olecranon and metacarpal head are easy to palpate, in comparison to tibial tuberosity, which is difficult to palpate as it may not be prominent or it wide enough to take as a reference point, causing intra observer errors.

Conclusion

Accurate size tibial nail insertion is of paramount importance for satisfactory outcome. Various anthropometric measurements help to assess the tibial length size preoperatively, among which distance between the olecranon tip to 5th metacarpal head, correlates best with the ideal nail size to be used. When, one of the landmarks, for the measurement cannot be easily palpated or to increase the accuracy of nail size prediction, other anthropometric measurements can be used.

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