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Research Article

Comparison of Pre-Surgery Methods of Intramedullary Nail Length Measurement: Determining the Best Estimation Method in Femur and Tibia Fractures

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Abstract

Introduction: Tibia and femur fractures are common in orthopedics. Their standarad treatment is intramedullary nailing. This study investigated the best pre-surgery method for estimating the intramedullary nail length.

Methods: First, we assessed intra- and inter-observer reliabilities by examining healthy volunteers. Then, we measured the pre-surgery intramedullary nail length of 82 patients with tibia and 25 patients with femur shaft fractures. This size was compared with the suitable nail length used at operation.

Results: Almost all of the examined methods had "good" inter- and intra-observer reliability. In patients with femur fractures, the greater patella method had the best intraclass correlation coefficient (0.876) and the lowest standard error of measurement (0.777). In tibia fractures, medial malleolus-tubercle method had the best intraclass correlation coefficient (0.860) and the lowest standard error of measurement (0.602). Bland–Altman plots were created for the findings of the second part of the study. For femur fractures, 64% of the pre-surgery measurements with greater patella method were more than the actual nail used at operation. These percentages were 93% and 100% in olecranon fifth finger and greater-epicondyle methods, respectively. For tibia fractures, 40.9% of medial malleolus-tubercle, 37.3% of olecranon-metacarp and 65.06% of radiogram methods' measurements were more than the actual nail at operation.

Conclusion: The medial malleolus-tuberosity method seems to be more accurate for tibia fractures. The greater patella method seems to be more accurate for femur fractures. However, we found no completely accurate method in the examined methods.

Keywords: Femur Fracture, Tibia Fracture, Intramedullary Nail, Preoperative Measurement

Introduction

Tibia fractures are common in long bone fractures [1]. Femur shaft fracture is also common, occurring in 10% of road accidents [2]. The standard treatment in both cases is intramedullary nailing [3,4]. Both antegrade and retrograde methods seem to be equally successful in femur fractures [5], although it seems that antegrade method has less complication [6]. Accurate pre-surgery assessment ascertains the surgeon of accessable appropriate-sized nails. Still, incorrect measurement in comminuted fractures may shorten or enlarge the limb [6,7]. Hence, templates have been designed in femur fractures [8].

Pre-surgery methods of nail length measurement for femur fractures are: 1) the greater trochanter to superior pole of patella distance in the unbroken limb, which is the statndard method [9]; 2) the greater trochanter to lateral epicondyle (6); and 3) olecranon to the fifth finger's tip [10,11]. The common methods for tibia fractures are: 1) medial malleolus to tuberosity distance, which is the most common method [12]; 2) intact limb radiography [13]; 3) olecranon to the fifth metacarpal head distance [14]; and 4) estimation based on patient's height [15].

To our knowledge, no study has assessed the accuracy of these methods in practice. Therefore, this study tried to find the most accurate pre-surgery method for estimating the intramedullary nail length

Patients and Methods

This study was done in two stages with two groups of participants from 2013 until 2015 in a hospital in Kerman city, Iran. One group consisted of healthy volunteers (control group) and the other of patients with tibia or femur fractures (investigation group). In the first stage, three orthopedic residents with adequate education and experience in different pre-surgery methods of nail length measurement for femur and tibia fractures were chosen as observers. Then, 23 healthy volunteers were invited (control group). Among the nail length measurement methods for tibia fractures, assessment based on patient's height and the intact leg radiogram

methods were ignored; since one is calculated based on a formula and the other requires doing radiaition on a healthy volunteer.

Each observer measured the appropriate nail length for hypothetical left femur fracture, left tibia fracture, and on right limbs of the volunteers in supine position. Each time the observer used one method for measuring hypothetical femur and tibia fractures and then moved to the next volunteer. After the first method was examined on all volunteers, the observer returned to the beginning of the line and used the second method. Each measurement was recorded by a voluneteer out of study. Greater trochanter to patella, greater trochanter to medial epicondyle and olecranon to fifth finger's tip methods were used for femur fracture. The tuberosity to medial malleolus distance and olecranon to fifth metacarpal head distance were used for tibia fracture. One month later the process was repeated.

In the second stage, 25 patients with femur fractures and 82 with tibia fractures were enrolled in the study (investigation group). The inclusion criteria were having unilateral femur or tibia fracture and suitabile fracture for intramedullary nailing. The exclusion criteria were having: 1) limb deformity; 2) limb length discrepancy; 3) pathology or previous limbs fracture; and 4) defromity or fracture in upper limbs. All participants signed an informed consent before their participantion in the study. The ethics committee of our university approved the study protocol (Ir. KMU. REC.1394.569).

Nail length was estimated for tibia fractures with these methods: 1) olecranon to fifth metacarpal bone with the elbow flexed at 90 degrees and a fist made; 2) medial malleolus to tuberosity on the intact side; and 3) placing a ruler on the intact leg and doing radiography. Nail length estimation based on patients' height was not included, because most participants of investigation group had no an accurate estimation of their height.

Nail length was estimated for femur fractures with these methods: 1) greater trochanter to superior pole of patella distance in the intact limb; 2) greater trochanter to lateral epicondyle distance in the intact limb; and 3) the distance from olecranon to fifth finger's tip.

The three orthopedic residents did all the measurements for participants with tibia and femur fractures. Each resident did it with a single method for all participants, while he was not aware of the other two researchers' results. In each case the measurement which was the nearest to standard nails was selected.

The measurements were compared with the actual nail size used at operation. They were considered appropriate on post-surgery radiograms: for femur fractures, the nail should extend to the superior pole of patella and for tibia fractures, the nail should be in line with the fibular head in proximal and 0.5 to 2 cm from the distal tibia articular surface [16].

Statistical analysis

The data were analysed with statistical package for social sciences (SPSS) software version 19.0 (Chicago, IL, USA) and measurement of intraclass correlation coefficient (ICC) two-way mixed model on absolute agreement. ICC was interpreted using a previous established method [17], so that ICC of 0.9 to 0.99 meant excellent, 0.8 to 0.89 meant good, 0.7 to 0.79 meant fair and less than 0.69 meant poor agreement.

In addition, coefficient of variance percentage was calculated and analysed with analysis of variance (ANOVA) test. Coefficient of variance percentage or standard deviation of the means is a measure of dispersion of data around the mean: the lower the measure, the better the data agreement.

We also calculated standard error of measurement (SEM). SEM estimates how repeated measures on the same variable are distributed around the true score: the lower the value, the better the test accuracy. Microsoft Excel 2010 was used for these calculations. Lastly, Bland-Altman plots were created for the data of investigation group using MedCalc software version 15. This method acts based upon the difference of data means and 95% confidence intervals.

Results

Almost all of the examined methods had "good" inter- and intra-observer reliability (Tables 1 and 2). It is not possible to demonstrate all the variance percentage's coefficients for the first stage, because of the high number of cases (30 cases). However, for femur fractures it ranged from 2.45% to 5.20% and for tibia from 2.92% to 4.01%. The analysis showed no significant difference among inter- or intra-observer reliability results (P > 0.20).

		Trochanter, patella	Olecranon, fifth finger	Olecranon, fifth finger
Intraobserver	ICC	0.801	0.827	0.850
	SEM*	0.648	0.528	0.588
Interobserver	ICC	0.801	0.828	0.898
	SEM	0.792	0.715	0.570

Table 1: Inter- and intra-observer reliability of different methods for femur fractures.

***SEM:** Standard Error of measurement; ICC: Intraclass Correlation Coefficient.

		Medial malleolus, tuberosity	Olecranon, fifth metacarp
Intraobserver	ICC	0.850	0.826
	SEM	0.441	0.489
Interobserver	ICC	0.796	0.895
	SEM	0.512	0.466

Table 2: Inter- and intra-observer reliability of different methods methods for tibia fractures.

	Trochanter, patella	Olecranon, fifth finger	Traochanter, epicondyle
ICC	0.876	0.651	0.687
SEM	0.777	1.268	1.434
CV%	5.44	5.10	6.14

Table 3: Agreement of actual nail size with its pre-surgery estimation by different methods in femur fractures.

	Medial malleolus, tuberosity	Radiogram	Olecranon, fifth metacarp
ICC	0.860	0.754	0.664
SEM	0.602	1.08	0.945
CV%	4.81	6.34	4.98

Table 4: Agreement of actual nail size with its pre-surgery estimation by different methods in femur fractures.

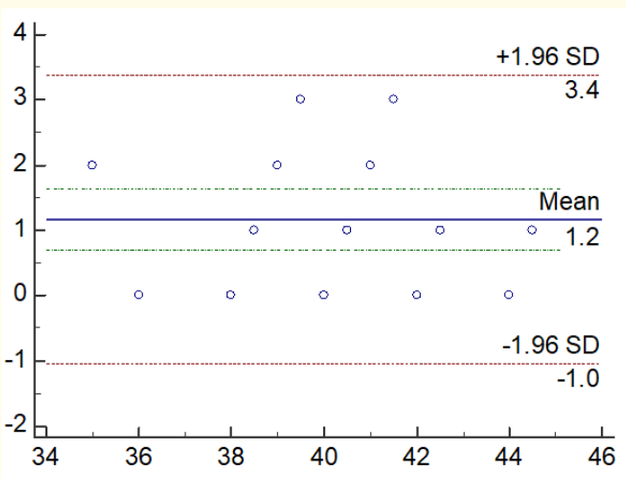

Figure 1: Greater, patella method.

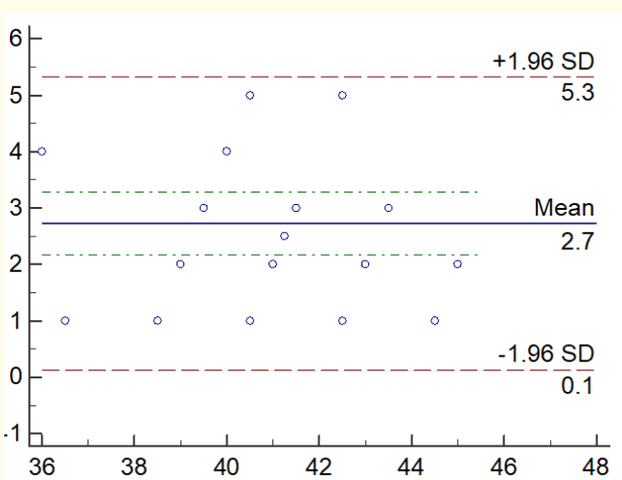

Figure 2: Greater trochanter, epicondyle method.

SEM and ICC were calculated for femur and tibia fractures (Tables 3 and 4). Coefficient of variance percentage for the final nail length was 5.76% for femur fractures and 6.41% for tibia fractures, which was not significantly different. Bland-Altman plots for different methods are shown in the figure 1-6.

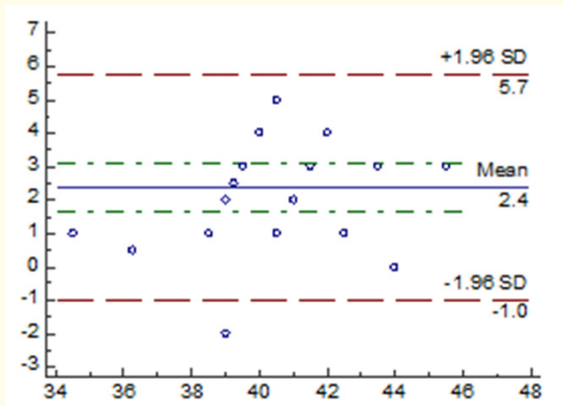

Figure 3: Olecranon Fifthe finger method.

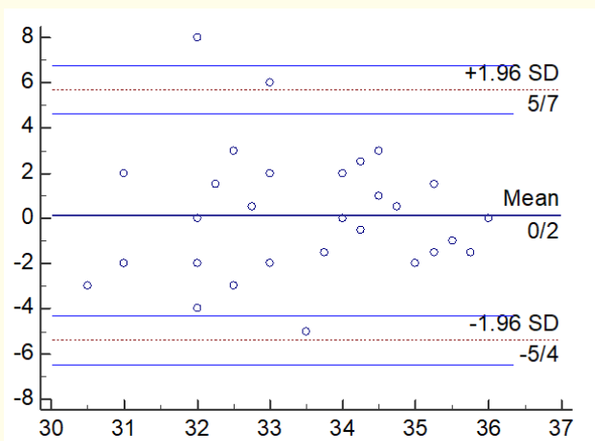

Figure 4: Medial Malleolus to tuberosity method.

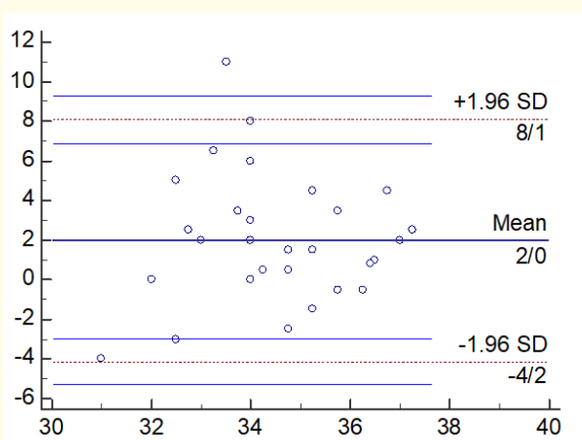

Figure 5: Intact limb radiogram method.

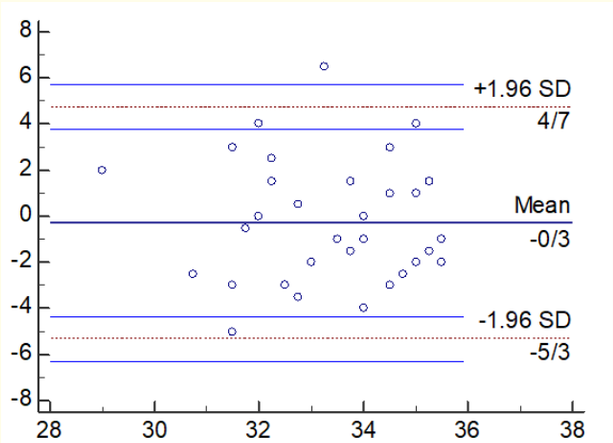

Figure 6: Olecranoin fifth metacarp method.

The pre-surgery estimated nail size for patients with femur fractures was equal to the actual used nail size in nine cases (36%) with greater patella method, in four cases (16%) with olecranon fifth method and in none with grater lateral epicondyle method. On the other hand, the pre-surgery estimated nail size was more than the actual size in 16 participants (64%) with greater patella method, in 23 participants (93%) with olecranon fifth finger method, and in all participants (100%) with the greater to latral epicondyle method.

For patients with tibia fractures, the pre-surgery estimated size was equal to actual size in nine participants (10.8%) with medial malleolus method, 13 participants (15.6%) with intact limb radiogram and eight participants (9.6%) with the olecranon fifth metacarpal head method. The pre-surgery estimated nail length was longer than the actual size in 31 participants (37.3%) with olecranon fifth metacarp method, in 34 participants (40.9%) with medial malleolus method and in 54 participants (65.06%) with radiogram method.

Discussion

Our study had two stages. In the first stage, we assessed the inter- and intra-observer reliability of different nail measurement methods and concluded that the best method for femur fractures would be the greater patella method, although all methods had high ICC, low SEM and acceptable coefficient of variance percentage without significant difference (Table 1). Two methods were compared for tibia fractures. Each showed better characteristics in some aspects and thus, no conclusion can be made (Table 2).

In the second stage, we examined each method in practice and on real fractures. Comparing the pre-surgery measurements with the actual nail size, we found out that probably the greater patella method is best method for femur fractures and the medial malleolus to tuberosity method for tibia fractures. The Bland-Altman plots confirmed these results, since the data had the least bias from the mean.

Every measurement is subject to error. When a method is compared to the ideal, their agreement would be assessed; but the best statistical method to assess this agreement is not clear. Many studies have used correlation between measurements, which does not seem to be a sound way [18]. Still, an accepatable method is the Bland-Altman plots that was suggested more than 30 years ago [19] and is used frequently nowadays [20,21].

What is the "best" method? In our case, which is pre-surgery nail size estimation, the best method is the one that can estimate the correct size in most cases and its inter- and intra-observer relaiability is high or at least acceptable. However, none of the studied methods had an excellent inter- and intra-observer relaiability and none could guess the correct nail size in an accepatable percentage of cases.

Although no method can accurately guess the nail size in all cases, perhaps a "longer" estimation is a greater mistake, as there is the possibility of fracture distraction and damage to the distal articular surface [15]. Our results showed that all methods had a greater chance to guess a longer than actual nail size than a shorter or correct size. Other studies have had similar results and in a cadaver study, the medial malleolus method had a 30% chance to give a nail longer than the standard [15].

Few studies have been done on this subject. In a cadaver study, Colen and colleagues [15] compared four different methods of tibial nail length estimation. Their methods were scanogram, spotogram, template and medial malleolus to tibial tubercle distance. According to their findings, the best estimation was the medial malleolus to tibial tubercle distance.

Venkateswaran and colleagues [13] retrospectively compared the intact limb and olecranon fifth metacarpal methods. Then in a prospective manner, they examined the knee to ankle distance method and ultimately found the most accurate method. In another cadaver study, Galbraith and colleagues [22] compared the various methods of nail size estimation in tibia fractures and computed tomography scan. Also, Lahey and colleagues [14] studied different methods for femur nail size estimation in healthy volunteers. These studies have compared different methods, though some studies have assessed a single method [23-26]. To our knowledge, no study has investigated nail size estimation in actual patients with tibia or femur fractures.

In the second part of the study, we hired different observers to do the measurements. The reason was to prevent the probable bias that might happen in serial measurements in a small time period by a single observer, as we could not postpone a patients' operation for the sake of our investigation. Although the second stage of the study had accepatable interobserver reliability, this is not important since there was no other way.

Limitations

The most important limitation of our study was that doing some methods is impossible on some patients, or in some cases just a single method is possible; for example, in bilateral fractures or pre-existing contralateral limb deformity. In addition, the fact that we could not examine all methods was another limitation

Conclusion

The medial malleolus-tuberosity method seems to be more accurate for tibia fractures. The greater patella method seems to be more accurate for femur fractures. However, we found no completely accurate method in the examined methods. The best method for pre-surgery nail size estimation still cannot be determined. Perhaps future studies may calculate a formula to guess the correct or best nail size in femur and tibia fractures.

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Bibliography

1. Pan RH., *et al*. "Epidemiology of Orthopedic Fractures and Other Injuries among Inpatients Admitted due to Traffic Accidents: A 10-Year Nationwide Survey in Taiwan". *Scientific World Journal* (2014): 637872.
2. Agarwal-Harding KJ., *et al*. "Estimating the global incidence of femoral fracture from road traffic collisions: a literature review". *Journal of Bone and Joint Surgery America* 97.6 (2015): e31.
3. Neumann MV1., *et al*. "Management of femoral shaft fractures". *Acta Chirurgiae Orthopaedicae Et Traumatologiae Cechoslovaca* 82.1 (2015): 22-32.
4. Bong MR., *et al*. "Intramedullary nailing of the lower extremity: biomechanics and biology". *Journal of the American Academy of Orthopaedic Surgeons* 15.2 (2007): 97-106.
5. Zhang F., *et al*. "Retrograde versus antegrade intramedullary nailing for femoral fractures: a meta-analysis of randomized controlled trials". *Current Medical Research and Opinion* 31.10 (2015): 1897-1902.
6. Ricci WM., *et al*. "Retrograde versus antegrade nailing of femoral shaft fractures". *Journal of Orthopaedic Trauma* 15.3 (2001): 161-169.
7. Nork SE. "Femoral shaft fracture". In: Rockwood and Green's fractures in adults. Vol1.Bucholz RW, Heckman JD. Lippincott Williams and Wilkins (2015): 2149-2223.
8. Wolinsky PR., *et al*. "Reamed Intramedullary nailing of the femur: 551 cases". *Journal of Trauma* 46 (1999): 392-399.
9. Krettek C., *et al*. "Accuracy of Intramedullary templates in femoral and tibial radiographs". *The Journal of Bone and Joint Surgery. British* 6 (1996): 963-964.
10. Wolinsky P., *et al*. "Controversies in intramedullary nailing of femoral shaft fractures". *Instructional Course Lectures* 51 (2002): 291-303.
11. Nazir A., *et al*. "Estimation of femoral length for intramedullary nail using forearm as reference". *The Journal of Bone and Joint Surgery. British* 91.1 (2009): 37.
12. Kuhn S., *et al*. "Extending the indications of intramedullary nailing with the Expert Tibial Nail". *Acta Chirurgiae Orthopaedicae Et Traumatologiae Cechoslovaca* 75.2 (2008): 77-87.
13. Venkateswaran B., *et al*. "An easy and accurate preoperative method for determining tibial nail lengths". *Injury* 34.10 (2003): 752-725.
14. Lakhey S., *et al*. "Pre-operative assessment of K-nail length in fracture shaft of femur". *Kathmandu University Medical Journal (KUMJ)*4.3 (2006): 316-318.
15. Colen RP and Prieskorn DW. "Tibial tubercle-medial malleolardistance in determining tibial nail length". *Journal of Orthopaedic Trauma* 14.5 (2000): 345-348.
16. Rudloff LM. "Fracturtes of the lower exterimiy". In: Canale ST, Beaty JH, eds. Campbell's Operative Orthopedics, 12th edition. Elsevier, Mosby Philadelphia, Pennsylvania (2013): 2213 -2247.
17. Currier D. "Elements of research in physical therapy". 3rd edition. Baltimore, MD: Williams and Wilkins (1990).
18. Giavarina D. "Understanding Bland Altman analysis". *Biochemia Medica (Zagreb)* 25.2 (2015): 141-451.
19. Bland JM and Altman DG. "Statistical methods for assessing agreement between two methods of clinical measurement". *Lancet* 1.8476 (1986): 307-310.
20. Maricar N1., *et al*. "Interobserver and Intraobserver Reliability of Clinical Assessments in Knee Osteoarthritis". *The Journal of Rheumatology* 43.12 (2016): 2171-2178.
21. Suojärvi N., *et al*. "Radiographical measurements for distal intra-articular fractures of the radius using plain radiographs and cone beam computed tomography images". *Skeletal Radiology* 44.12 (2015): 1769-1775.
22. Galbraith JG1., *et al*. "Preoperative estimation of tibial nail length--because size does matter". *Injury* 43.11 (2012): 1962-1968.

23. Karakas HM and Harma A. "Estimating femoral nail length in bilateral comminuted fractures using fibular and femoral head referencing". *Injury* 38.8 (2007): 984-987.

24. Naik MA., *et al*. "Correlation between the forearm plus little finger length and the femoral length". *Journal of Orthopaedic Surgery (Hong Kong)* 21.2 (2013): 163-166.

25. Singh G., *et al*. "A study to evaluate importance of length from tip of olecranon to the tip of little finger in pre-operative assessment of K-nail in fracture shaft of femur in a tertiary care hospital of Bareilly district". *International Surgery Journal* 3.2 (2015): 751-753.

26. France MA., *et al*. "Preoperative assessment of tibial nail length: accuracy using digital radiography". *Orthopedics* 29.7 (2006): 623-627.