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Original Research Article

Clinical measurement of femur length as a guide to choose the size of cephalic lag screw (calcar screw) in proximal femur nailing surgery

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Abstract

Background: Proximal femur fractures such as intertrochanteric andsubtrochanteric fractures typically occur in elderly patients from low-energy falls fromstanding height, blow to the greater trochanter, or secondary to osteoporosis. Thesefractures in elderly patients are considered severe and have a significant impact onmorbidity and mortality. most of the intertrochanteric and sub-trochanteric fracturesrequire surgery in the form of Internal fixation with intramedullary nailing whichhappens to be one of the treatment modalities for fracture intertrochanteric and subtrochanteric femur. A large proportion of implants supplied by the companies are instandard sizes, Therefore, the purpose of this study was to analyze the femur length ofpatients with extracapsular proximal femur fractures clinically to establish a correlation between the femur length and calcar screw size of the proximal femur nail used in thisfracture fixation.

Materials and Methods: the study population included 100 patients whounderwent proximal femur nail fixation for intertrochanteric (Boyd & Griffin type 1 andtype 2) and subtrochanteric femur fractures (Seinsheimer type 1 and type 2). Femur length is measured in the uninjured limb clinically in a supine position from the tip of thegreater trochanter to the lateral knee joint line using a measuring tape and recorded incentimeters. Radiographic assessment of the proximal femur was done in the studypopulation in anteroposterior view and lateral view. Using DICOM software,measurement of the tip apex distance is done.

Results: The study group included 74 males and 26 females with a mean age of75.97810.94 years and 63.4215.10 years respectively. The mode of injury included 83% fall on the floor and 7% road traffic accident. The fracture pattern involves 85%intertrochanteric and 15% subtrochanteric fractures. shows Significant correlation between the femur length and calcar screw size i.e., correlation coefficient (r) = 0.9128,p < 0.001.

Conclusion: The purpose of the study was not to suggest concrete screw size for but to offer a general starting point to increase operative efficiency.

Keywords: PFN, Lag screw, Intertrochanteric fracture

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1. Introduction

Proximal femur fractures such as inter trochanteric and sub trochanteric fractures typically occur in elderly patients from low energy falls from standing height, blow to the greater trochanter or secondary to osteoporosis.[1] These fractures in elderly patients are considered severe and have significant impact on morbidity and mortality.[1]

Inter trochanteric fractures are extra capsular metaphyseal fractures and commonly leads to malunion if managed conservatively.[1] In elderly patients' internal fixation of fracture is preferred because prolonged bed rest with traction leads to complications such as deep venous thrombosis, bed sores, pneumonia etc.[1] so, most of the inter trochanteric and sub trochanteric fractures require surgery in the form of Internal fixation with intramedullary nailing which happens to be one of the treatment modalities for fracture inter trochanteric and sub trochanteric femur.[2] The need for a perfect fixation with ideal implant size is very important in intertrochanteric fracture patients as implant failure can have severe complications and surgeries to correct these complications can be a risky procedure depending on the already morbid

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condition of the patient.[3] Therefore, evidence providing the detail of an ideal implant and its size would ensure an appropriate fixation of intertrochanteric fractures. With evolving operating methods for intertrochanteric fractures, numerous nail designs are developed which incorporate a single compression screw or a compression screw coupled with antirotation screw such as PFN are now popular for the treatment of intertrochanteric fractures. Although PFN considered to have an upper hand when compared with extramedullary devices for unstable IT fractures, screw cut-out, z effect and reverse z effect, varus collapse and rotational instability continued to pose as significant postoperative complications, accounting for 31% of total operated case of intertrochanteric fracture.[4]

Modern nailing systems depend on proximal and distal interlocking for axial and rotational stability.[5] The soft tissue cover about the proximal femur is composed of taut fascia enveloping the thick quadriceps musculature, drilling for and placing these screws can be challenging and time consuming. A number of depth gauge designs are available from manufacturers but our impression is that few were specifically designed for the typical anatomy in this area and few aren't and thus it is time consuming.

A large proportion of implants supplied by the companies are in standard sizes.[6,7] There are multiple nail designs for the fixation of fracture like 2 screw system (PFN) and one with a single helical blade (PFNA), both have their own pros and cons.[8] For a good surgery pre operative planning should be done to match the preplanned internal fixation devices (PFN) thereby decreasing the multiple attempts of changing calcar screws to decreasing amount of X-ray exposure, soft tissue trauma, followed by decreased chances of implant loosening and patient discomfort. An appropriate Tip-apex distance (TAD), which represents both the position and depth of a screw in the femoral neck and head, has been shown to be an accurate predictor of lag screw cut-out both PFN and Dynamic hip screw. Although previous studies have stated that there is no statistical difference in cut-out between SHS fixed with either IM nails or side plates.[9]

IM devices are susceptible to cut-out at TAD values greater than 25 mm. Hence, surgeons should strive for a TAD less than 25 mm when using IM devices, especially in the treatment of comminuted intertrochanteric hip fractures to help avoid lag screw cut-out.[9,10]

Studies had shown that the inferior position of the lag screw provide the highest axial and torsional stiffness. Anterior and posterior positioning of lag screw produced the lowest stiffnesses and load-to-failure. Inferior placement of the lag screw on the anteroposterior radiograph and central placement on the lateral radiographs is recommended.[11]

As a result of this an accord has been reached for preoperative assessment of femur geometry with accepted methods such as full limb radiographs, scanogram, computerized tomography and computerized digital radiographs.[12,13] These methods are highly reliable and valid but are also expensive, not feasible for everyone and expose the subject to radiation, which limits their use in routine clinical settings.[14]

Therefore, the purpose of this study was to analyze the femur length of the patients with extracapsular proximal femur fractures clinically to establish a correlation between the femur length and calcar screw size of proximal femur nail used in this fracture fixation. Therefore, an accurate and reproducible assessment of femur length done clinically (from the tip of greater trochanter to the proximal pole of patella) on the opposite uninjured limb[15,16,17,12] can serve as a guide for choosing the accurate calcar screws of the PFN pre operatively. This method also guides us in case of PFNA (helical blade) for the proper placement of helical blade which has superior mechanical stability than PFN.[18]

2. Materials and Methods

The present observational cross sectional study was conducted in the Department of Orthopedics, Dr. S. N. Medical college, jodhpur. The study was approved by the ethical committee with reference number SNMC /IEC/2021/ Plan /400. The study population included 100 patients who underwent proximal femur nail fixation for inter trochanteric (Boyd & Griffin type 1 and type 2) and sub trochanteric femur fractures (Seinsheimer type 1 and type 2). Persons who had femur fracture of the opposite limb, Obvious congenital skeletal deformities, Revision surgeries of the proximal femur, TAD >25mm were excluded from the study.

Informed written consent was obtained from each participant. Femur length is measured in uninjured limb clinically in supine position from the tip of the greater trochanter to the lateral knee joint line using a measuring tape and recorded in centimeters. Radiographic assessment of proximal femur done in the study population in antero-posterior view and lateral view. Using DICOM software, measurement of the TAD is done. Actual calcar screw (lag screw) size used in fracture fixation recorded using patients operative notes. Pearson's correlation coefficient was used to measure the association between the 2 measurements. A p value <0.05 was considered statistically significant. Regression formulae was obtained and prediction of calcar screw sizes were done and analyzed using pivot table.

3. Results

The study group included 74 males and 26 females with mean age of 75.978 ± 10.94 years and 63.42 ± 15.10 years respectively. The mode of injury included 83% fall on floor and 7% road traffic accident. The fracture pattern involves 85% intertrochanteric and 15% sub trochanteric fractures. **Figure 1** shows Significant correlation between the femur length and calcar screw size i.e. correlation coefficient (r) = 0.9128, $p < 0.001$. **Table 1** shows the regression equations for calcar screw size that were obtained from the data. The equation has been expressed as a independent variable i.e. femur length. The constants a and b are regression coefficients of femur length and calcar screw size respectively. **Table 2** shows the comparisons of actual calcar screw size and estimated calcar screw size obtained from the regression formulae in the study for different femur lengths.

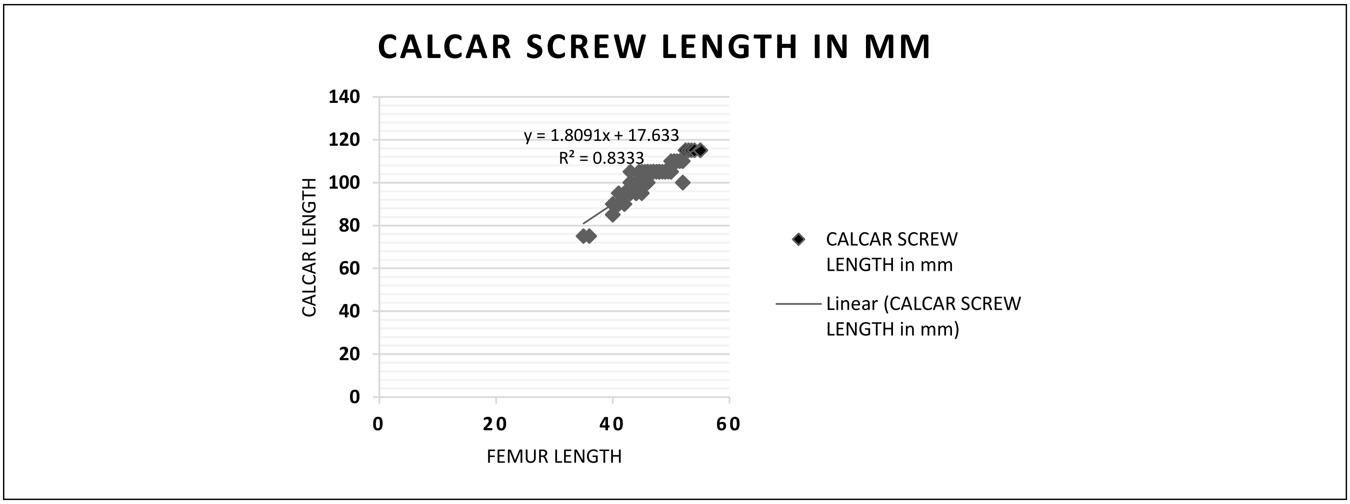

Figure 1: Scatter graph showing strong linear correlation between the femur length and calcar screw size.

Table 1: Regression equation formulae for calcar screw size in mm and femur length in cm

Group	Regression equation	R2
Study population	Calcar screw size = 1.8091 × femur length + 17.633	0.8333

Table 2: Comparing the count of estimated screw to actual screw used in fracture fixation.

Estimated calcar screw size (mm)	Actual calcar screw Size (mm) used in fracture fixation									
	75	80	85	90	95	100	105	110	115	Grand total
80	1									1
85	1									1
90			3	5	1					9
95				2	16	6	1			25
100					2	9	9			20
105							21			21
110						2	4	9		15
115									8	8
Grand total	2	0	3	7	19	17	35	9	8	100

4. Discussion

Proximal femur fractures such as inter trochanteric and sub trochanteric fractures typically occur in elderly patients.[1] In elderly patients internal fixation of fracture is preferred because prolonged bed rest with traction leads to complications such as deep venous thrombosis, bed sores, pneumonia etc.[1] so, most of the inter trochanteric and sub trochanteric fractures require surgery in the form of Internal fixation using intramedullary nail with calcar screws.[2] For a good surgery pre operative planning to be done to match the approppriate size calcar screw maintaining a TAD < 25mm[10] of proximal femur nail thereby decreasing the multiple attempts of changing calcar screws for accurate length. Preoperative assessment of screw size decreases amount of x-ray exposure, soft tissue trauma, operative time, less blood loss followed by post operatively decreased chances of implant loosening and patient discomfort.

According to our study, it seems reasonable to forgo the depth gauge measurement along with repeated intraoperative changing of the screw to get accurate screw size and proceed with placement of estimated calcar screws (lag screw) obtained pre operatively by measuring femur length in unaffected limb clinically.

In our study, 90mm estimated screw size matched with 71% of actual screw used, 95mm estimated screw size matched with 84% of actual screw used, 100mm estimated screw size matched with 52% of actual screw used, 105mm estimated screw size matched with 60% of actual screw used, 110mm estimated screw size matched with 100% of actual screw used, 115mm estimated screw size matched with 100% of actual screw used for fracture fixation.

The placement of a calcar screw that is too short or too long is clinically relevant and is readily addressed in the literature. Short sized calcar screws can result in screw backout and cut out because of less purchase in subchondral region of the femur head.[18] An excessively long calcar screw in this area likely result in migration of screw into the joint space and subsequently causing articular damage, limitation of range of motion and secondary osteoarthritis. Sometimes inaccuracy in screw length may result in some amount of irritation of the iliotibial band and vastus muscles.

So, by using pre estimated calcar screw sizes there is an impact in decreasing operating room time, blood loss, better impaction of calcar screw and potential surgical trauma to the proximal femur. According to the statistical analysis, there is significant linear relationship between the femur length and calcar screw, $r = 0.9128$, $p < 0.001$ which is accurate in predicting the actual calcar screw size and avert substantial mismatch between the estimated screw size and the actual screw used intra-operatively for fracture fixation.

5. Conclusion

Finally, the purpose of the study was not to suggest concrete screw size for each male and female, but to offer a general starting point or an idea of proper screw size to increase operative efficiency in an effort to decrease patient time under anesthesia and along with the amount of operative trauma to the proximal thigh thereby reducing surgical site infections. Overall decreasing blood loss as well as post operative morbidity resulting in early recovery of the patients. Putting a proper size calcar screw is must for a proper fixation and reducing post operative implant related complication and this study guides us a preoperative idea of calcar screw size.

Obviously, this analysis of calcar screw size might be considered more exact by taking surgical trails intraoperatively but the major strength of this study is that it is the first attempt that has tried to assess the calcar screw size in this area to see if the actual calcar screw lengths could be used by prediction. However, it is also important to note that our study recommendations apply only for the fractures included in the inclusion criteria and nails having angle of 130° and tip of calcar screws placed in the subchondral region (TAD < 25 mm). For nailing system that fall further away from the above standards, these estimated calcar screw sizes from femur length cannot be used as an actual screw size. Further investigation might focus on radiological tool in pre operative assessment in other locations of femur in patients posted for proximal femur nailing, which has the potential to decrease implant inventory and operative time.

6. Limitations

Our study is not without its limitations. Bowing of the femur, fatty thighs, implant positioning, entry point of nail may alter the femur length measurement. Reduction of fracture fragments during surgery also affects the calcar screw sizes. Neck shaft angle also plays a crucial role in determining the screw size. With the study being done in only a single tertiary level hospital and despite being a large study population this study alone cannot capture the diversity observed around the country and globally.

7. Source of Funding

None.

8. Conflict of Interest

None.

9. Ethical No.

Not required.

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None.

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