



Determining the Optimal Level of Proximal Locking Screw Insertion in Femoral Nailing

Femur intramedüller çivilemede proksimal kilitleme vidası uygulaması optimal seviyesinin saptanması

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Abstract

Objective: The aim is to investigate the optimum level of insertion for proximal locking screw in the proximal femurs.

Material-Method: The distance between the trochanteric fossa and lesser trochanter and the medial- lateral femur canal diameters 20 mm proximal and 20 mm distal to the lesser trochanter within an intervals of 10 millimeters on AP radiograms of 208 patients in both genders and different age groups were measured.

Results: The average distances between the trochanteric fossa and lesser trochanter level were 60.8 mm in male and 52.2 mm in female populations (p=0.000). The average femoral canal diameter at the level of the lesser trochanter was 29.2 ± 4.3 mm, whereas 10 mm proximal to the lesser trochanter it was 39 ± 4.6 mm, the difference was statistically significant with p=0.000.

Conclusions: Lesser trochanter level is the optimal level for transverse proximal locking screw insertion since it contains the relatively narrowest canal in the proximal femur. Orthopedic surgeons should be aware of choosing the femoral nails with a proximal tip to proximal screw hole distance of a 61 mm in male and a 52 mm in female populations to increase three point bending resistance of proximal locking screw and to prevent early implant failure.

Keywords: Femur Fracture, Intramedullary Nailing, Proximal Locking Screw, Three Point Bending

Özet

Amaç: Çalışmanın amacı femur intramedüller çivilemede proksimal kilitleme vidası uygulamasının optimal yerleşim seviyesini saptamaktır.

Materyal-Method: Her iki cinsiyetten ve farklı yaş gruplarından 208 hastanın kalça anteroposterior grafileri değerlendirilmiştir. Trokanter minor seviyesinin 20 mm distal ve 20 mm proksimal aralığı 10 mm lik aralıklara bölündü. Trokanterik fossa ile trokanter minor arası mesafe ve yukarıda belirlenen seviyeler arasında mediolateral femoral kanal çapları ölçüldü.

Bulgular: Trokanterik fossa ve trokanter minor arası ortalama mesafe erkeklerde 60,8 mm kadınlarda ise 52,2 mm olarak saptandı(p=0,000). Trokanter minor seviyesindeki ortalama femoral kanal çapı 29,2 ± 4,3 mm ve trokanter minörün 10 mm proksimalinde ise 39 ± 4,6 mm olarak ölçüldü. Fark istatistiksel olarak anlamlı bulundu(p=0,000).

Sonuç: Trokanter minor seviyesi, rölatif olarak proksimal femurun en dar yeri olması nedeni ile transvers proksimal kilitleme vidası için optimal seviye olarak saptandı. Ortopedik cerrahların femoral çivi seçerken çivinin tepesi ile proksimal kilitleme vidası arası mesafenin –üç nokta bükülme direncinin yüksek olması ve erken implant yetmezliği riskini azaltması nedeni ile- erkeklerde 61 mm ve kadınlarda 52 mm olmasına dikkat etmesinde fayda vardır.

Anahtar kelimeler: Femur Kırığı, İntramedüller Çivileme, Proksimal Kilitleme Vidası, Üç Nokta Bükülme Testi

Introduction

Intramedullary interlocking nailing is very common in trauma practice. Frequent proximal locking screws failure had been documented by many researchers (1-4). Failure of locking screws is known to cause loss of reduction and subsequent nonunion and mal union (2, 3). One of the most important factors of proximal locking screw failure in femoral nailing is the level of screw insertion and the wide canal medial-lateral diameter. Femoral medullary canal expands proximally to become conical in shape before reaching the trochanteric area. Some studies reported that, as the femoral medullary canal diameter expands proximally the proximal locking screws bending resistance decreases (5, 6).

Many studies reported the detailed anatomy of the trochanteric region and isthmus geometry (7-12). It is strange not to find any study in the literature documenting the appropriate proximal screw position in the interlocking intramedullary nailing systems in femoral fractures. In an Anthropometric work for Ericksen MF et al, measurements of femoral head, femoral neck and condyle level with medial and lateral cortex measurement of the proximal femoral diaphysis had been studied (13).

Many researchers advised placing the proximal locking screw as much proximal as possible in the narrowest medullary canal and also leaning upon the thick lateral cortex (5, 6).

We could not find any study about optimal level of proximal locking screw hole on femur interlocking nail. The distance between the top of the nail and proximal locking screw hole was not standardized and it was varied from manufacturer to manufacturer. Standardization of the level of the proximal nail hole on femur interlocking nail is required to decrease implant failures by increasing 3-point bending resistance of proximal locking screw.

The purpose of this study was to assess optimum proximal locking screw hole position on femur nails and femurs by measuring the distance between femur trochanteric fossa and lesser trochanter region of the anterior- posterior (AP) X-ray radiographies in different age groups and genders.

Material-Methods

Between October 2011 and September 2013, hips neutral AP X- ray radiographies of 208 patients were obtained from the orthopedic and traumatology clinic were included in this study. 98 male and 110 female (% 47.1- %52.9). X-ray radiographies were examined retrospectively. 36 of 98 male (% 35.7) were 20-39 age group, 32 of 98 male (% 30.6) were 40-59 age group and 32 of 98 men (%32.7) were older than 60 years. 36 of 110 female (% 32.7) were 20-39 age group, 45 of 110 female (% 41) were 40-59 age group and 29 of 110 female (%26.3) were older than 60 years. The youngest patient was 21 and oldest one was 89 years old. The mean age was 50 years. 111 right and 97 left femurs X- ray radiographies were evaluated.

Patients with bone pathology, previous hip surgery, fracture and metabolic bone diseases were excluded from this study. The X- ray radiographies that lesser trochanter was very evident or very small were also excluded from this study to extrude the radiographies in rotation intern and extern. Only patients with complete bone maturation were included in this study.

Radiological measurements were made with Siemens Axiom Aristos FX (Germany). X- rays were taken by 66 Kv, 125 mA and 10.0 mAs exposure values, anterior to posterior in neutral position (patella horizontally), from 108 cm and positioned to include the proximal femur diaphysis. 43X43 cm cassettes were used. For standardizing the measurements,

a metal ruler was put into to the some radiographies and positioned parallel to femur shaft in a foam material. Software measurements were made with Wizards (Siemens). Metal ruler measurements and software measurements were controlled to be the same. Similar to previous studies, the measurement of the proximal femur diaphysis was made from the level of the lesser trochanter (7,12,14).

A five different transvers marking were made vertical to the femoral shaft every 10 mm from the proximal 20 mm to the distal 20 mm of the lesser trochanter. The M-L medullary canal diameter and the medial and the lateral cortex thickness in all 5 marked levels were measured by the same researchers. The distance between lesser trochanter's midpoint and trochanteric fossa that exists in medial base of major trochanter was also measured (Figure 1). 16 different measurements were performed on every X-ray radiography. The measurement were performed by a single senior orthopaedic surgeon using standart measurement techniques. The measurements were evaluated for a piriformis fossa type intramedullary nail with two proximal locking screws. The proximal locking screw placement was evaluated.

The difference of the distance between lesser trochanter's midpoint and trochanteric fossa in male and female groups were statistically analyzed with independent samples T test, and different age groups were statistically analyzed with Kruskal-Wallis test. Medullary canal diameter and lateral cortex thickness measurements were analyzed with (paired comparison) Wilcoxon signed ranks test. $P<0.05$ values were accepted significant.

Results

The femoral canal diameter was noticed to vary about 4-5 mm between different levels below the lesser trochanter. The ML canal diameter was reported to increase between the lesser trochanter and 10 mm proximal to it (Table 1). A significant differences of the ML canal diameters and lateral cortex thicknesses was detected between femoral levels tested by Wilcoxon signed ranks paired comparison ($p=0.000$).

The average distance between the level of trochanteric fossa and lesser trochanter was recorded to be 60.87 ± 5.11 , range (59.85-61.90) mm (mean \pm SD, 95% confidential interval) in

Table 1. The medial-lateral canal diameters, lateral and medial cortex thickness of femur proximal diaphysis (mm, mean \pm SD, 95%CI)

(n=208)	M-L Canal diameter (mm, mean \pm SD, 95%CI)	Lateral cortex thickness (mm, mean \pm SD,95%CI)	Medial cortex thickness (mm, mean \pm SD,95%CI)
20 mm proximal to lesser trochanter	46.8 \pm 5.3 (46.1-47.5)	1.85 \pm 1.11 (1.7-2.01)	6.16 \pm 1.39 (5.97-6.35)
10 mm proximal to lesser trochanter	39 \pm 4.6 (37.4-38.7)	2.74 \pm 0.81 (2.63-2.85)	6.33 \pm 1.33 (6.15-6.51)
Lesser trochanter level	29.2 \pm 4.3 (28.6-29.8)	3.77 \pm 1.19 (3.61-3.94)	6.5 \pm 1.47 (6.3 -6.7)
10 mm distal to lesser trochanter	24 \pm 3.1 (23.6-24.4)	5.39 \pm 1.28 (5.21-5.56)	6.96 \pm 1.17 (6.8 -7.12)
20 mm distal to lesser trochanter	20.3 \pm 3.4 (19.9-20.8)	6.18 \pm 1.43 (5.98-6.38)	7.4 \pm 1.35 (7.22-7.59)

male population and 52.19 ± 6.11 , range (51.04-53.35) mm in female population. The difference was statistically significant according to the independent samples T test ($p=0.000$). According to Kruskal-Wallis test the length difference between the level of the trochanteric fossa and lesser trochanter was not found statistically significant between age groups ($P=0.808$).

Six different groups (both gender and age groups) were analyzed together with T-two-way Anova test. Only gender difference was detected to be significant ($p=0.000$). However there was no significant difference between age groups (20-39 ages, 40-59 ages, above 60 age) ($p=0.886$).

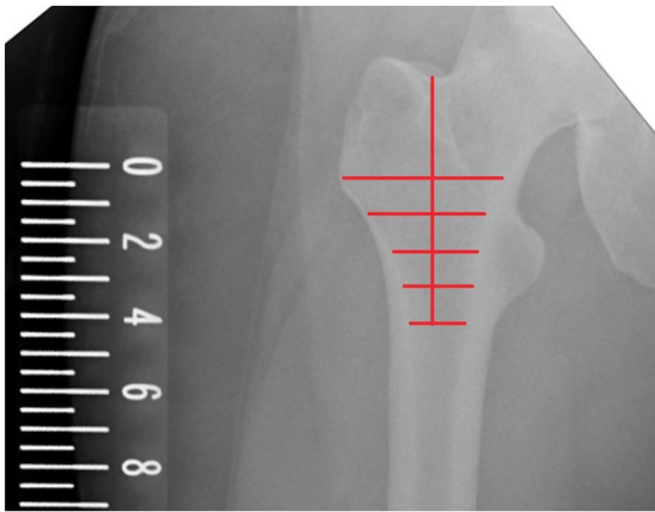


Figure 1. The intramedullary canal diameter measurement method and distance between the trochanteric fossa and lesser trochanter level on femur neutral AP radiogram.

Discussion

The aim of this study was to determine the proper ideal position of the proximal locking screws insertion in the intramedullary interlocking femoral nailing systems. This study revealed that, the most appropriate level of the proximal locking screws insertion is the level of the lesser trochanter, since this area has relatively the narrowest ML canal diameter and the thickest lateral cortex when compared to other parts of the proximal femur that were proximal to lesser trochanter. For the transverse proximal locking screws to be placed at the level of the lesser trochanter, proximal locking screw hole should be an average of 61 mm in male and 52 mm in female distal to the top of the nail.

The ML canal diameter was recorded to expand suddenly 10 mm in each 10 mm proximal to the lesser trochanter. The average medial- lateral diameter was 29.25 mm at the level of the lesser trochanter, however 10 mm proximal to the lesser trochanter a sudden increase with a mean of 39 mm was recorded. Measurements of ML canal diameter at the level of lesser trochanter were consistent with previous

publications (7, 10, 11, 14). It was reported that the level of lesser trochanter had relatively the second narrow femoral M-L canal diameter after isthmus area in proximal femur (7, 11, 14).

Together with the increase of the femoral canal diameter, the locking screw bending strength decreases rapidly (5, 6). Aper et al. applied the 3-point bending test of the screws in two aluminum tubes (19 mm and 31.8 mm inner diameter), with the increase of the inner diameter of the tube, less cyclic loading was needed in the fatigue test to obtain screw failure (6). At the proximal femur area higher bending resistance was reported with short transverse locking screws than the long screws (5). It was reported that the 3-point bending resistance of the 5 mm smooth locking screws in the line of the lesser trochanter (3190 N in 30 mm diameter) was 174 % more than the 3-point bending resistance of the screws 20 mm proximal to the lesser trochanter (1164 N in 45 mm diameter) (15).

The average of the lateral cortex thickness at the level of the lesser trochanter was found to be 3.77 mm, whereas it was 1.85 mm 20 mm proximal to the lesser trochanter. For this reason, the lesser trochanter level is a more appropriate level on account of lateral cortex thickness. Ericksen's study on skeletons showed that the lateral cortex thickness was 3.46 mm in male and 2.69 mm in female populations at the level of the lesser trochanter between 51-60 age group (13). At the level of 20 mm proximal to the lesser trochanter, the average lateral cortex thickness was 2.05 mm in male and 1.75 mm in female populations at the same study. Due to the sudden increase of the medial- lateral canal diameter and the thinner lateral cortical thickness, the levels that are proximal to the lesser trochanter are not suitable for proximal locking screws insertions.

However this study like other studies has some limitations, the lack of measurement with computerized tomography (CT). In CT scanning patients are exposed more to radiation and it is a more expensive imaging method than the traditional radiographies. It was reported that while the roentgen graphic method is more accurate, measurements in the CT method is technically easier to conduct (16). One other limitation of this study is to evaluate one transverse locking screw, the second screw may be placed 20 mm distal to the first screw because the mediolateral canal diameter was the narrowest part found in this study.

To obtain a stable firm intramedullary fixation, this study may increase the awareness of trauma surgeon to choose the intramedullary interlocking nails in femoral surgery which have that proximal locking holes about a 61 mm in the male and a 52 mm in female populations away distal to the top of the nail. Using these average values, the transverse proximal locking screws can be at the level of the lesser trochanter while the proximal end of nail is at the level of trochanteric fossa. If this distance is less than these values, in order to relevel the proximal locking screw at the level of the lesser trochanter, the nail proximal tip will be embedded in the bone of the trochanteric fossa, otherwise the screw will be too much proximal to the lesser trochanter when proximal end

of nail is at the level of trochanteric fossa. If the distance is larger than these values, when proximal locking screw hole of nail is at the level of lesser trochanter proximal end of the nail will be extruded from the trochanteric fossa causing pain and soft tissue complications.

Conclusion

Lesser trochanter level is the optimal level for transverse proximal locking screw insertion since it contains the relatively narrowest femur canal. Orthopedic surgeons should be aware of choosing the femoral nails with a proximal nail tip to proximal screw hole distance of a 61 mm in male and a 52 mm in female populations to increase three point bending resistance of proximal locking screw and to prevent early implant failure and loosening.

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