Shafa Ortho J. 2019 May; 6(2):e91166. doi: 10.5812/soj.91166.

Published online 2019 May 13. **Research Article**

Comparison of Proximal Femur Locking Compression Plate and Intramedullary Nailing in the Treatment of Sub-Trochanteric Fractures

Karim Pisoude [1], Omid Elahifar [1], Mohammad Bagher Sohrabi [2] and Javad Khajemozafari [1, *]

[1] Bone and Joint Reconstruction Research Center, Shafa Orthopaedic Hospital, Iran University of Medical Sciences, Tehran, Iran
[2] School of Medicine, Shahroud University of Medical Sciences, Shahroud, Iran

[*] *Corresponding author*: Bone and Joint Reconstruction Research Center, Shafa Orthopaedic Hospital, Iran University of Medical Sciences, Tehran, Iran. Email: khmozafari@shmu.ac.ir

Received 2019 March 02; **Revised** 2019 April 29; **Accepted** 2019 April 29.

Abstract

Background: The sub-trochanteric (ST) fracture is relatively common. It does not have a single treatment but it can be repaired in a variety of ways.
Objectives: The aim of this study was to compare the proximal femur locking compression plate (PFLCP) and intramedullary nailing in the treatment of ST fracture.
Methods: This cross-sectional study was performed on 56 patients with ST fracture who referred to Firoozgar Hospital, Tehran, Iran, between January 2014 and December 2018. The patients were equally divided into two groups, PFLCP group and nailing group. The recovery and postoperative complications were evaluated by the Harris hip score (HHS).
Results: Of the 56 eligible patients examined, 49 (87.5%) were male. The overall mean age was 42.7 ± 16.2 years. The status of the union was significantly better in the PFLCP group than in the nailing group (P = 0.038). The total mean HHS was 88.9 ± 14.1 with no significant difference between the two groups. The results of the logistic regression model showed that sex and age could significantly decrease the HHS. Thus, the HHS was influenced by female sex (OR = 0.851) and age of more than 60 (OR = 0.829).
Conclusions: PFLCP provides an appropriate union, expedites the operation, and yields a very good HHS. Therefore, it can work even better than intramedullary nailing in some parameters, such as pain after the operation.

Keywords: Proximal Femur Locking Compression Plate, Intramedullary Nailing, Subtrochanteric Fracture, Complications, Harris Hip Score

1. Background

Hip fractures, following a snap or a simple fall, are very common and costly, especially among older people. Patients with hip fractures occupy about 20% of the orthopedic beds in England. It is estimated that these fractures involve 1.2 million people per year in the world that is expected to reach 2.5 million in 2025 and 4.5 million in 2050 (1).

Based on the anatomical location, proximal femoral fractures are divided into femoral neck fractures, intertrochanteric (IT) region fractures, and sub-trochanteric (ST) fractures. Each type of fractures has its unique features, individual surgical treatments, and especial prognosis (1, 2).

Proximal femoral bone fractures, especially the fractures of the femoral neck and intertrochanteric region, are one of the most important fractures in orthopedic surgery (3). On the other hand, ST fractures, which are anatomically referred to as a part of the proximal femur bone located 5 cm below the lower edge of the lesser trochanter, are also very important due to very serious complications, poor management, and poor clinical outcome after treatment (4, 5).

The most important factors affecting these fractures include age, sex, smoking, dementia, psychological disorders, underlying diseases, and osteoporosis (6). The overall incidence of proximal femoral fractures is about 230 per 100000 population, of which approximately 5 to 10% are in the ST region. The total ST incidence is estimated to be approximately 15 - 20 per 100000. The ST fractures account for 10% to 35% of the total fractures of the peritrochanteric region (7, 8).

Concerning the age of patients, approximately two-thirds of all ST fractures occur in patients over the age

of 50 and 25% in patients aged 17 to 50 years. Regarding gender, many studies have shown that femoral fractures occur with equal distribution in both genders. However, some studies have shown that women are at higher risk of femoral bone fractures (about 33%) than men (9). In addition to age and sex, other risk factors can increase the risk of ST fractures, including total bone mineral deficiency, diabetes mellitus, and bisphosphonate medications (10).

In most cases, ST fractures occur after a low-energy traumatic event in older patients and following a high-energy trauma in young patients (1-3). In the elderly patients, gliding or falling leads to direct trauma to the lateral side of the hip as the most common mechanism of this fracture. Few studies have determined the prognosis and results of surgical treatment of ST fractures. It seems that young people who have femoral fractures due to severe traumas, usually associated with other injuries, have a worse prognosis for femoral disability (4, 5). In suspicious cases of ST fracture, full-length radiography of the femur is initially taken. The use of more advanced imaging techniques such as CT scan and MRI modalities is suggested in cases with the highly suspected examination and radiologic evidence (2).

The Russell-Taylor classification is the most reliable method for categorizing the fractures of the ST, which is based on the presence of lesser trochanter continuity and fracture extension to the piriformis fossa. In this classification, type 1 fractures do not involve the piriformis fossa. They are divided into two sub-categories including 1A (small fractures of the lesser trochanters) and 1B (fractures involving lesser trochanter). Type 2 fractures involve the piriformis fossa. They are also divided into two subcategories including 2A (with a stable medial buttress) and 2B (with the loss of the integrity of medial femoral cortex) (1-3).

Treatment of ST fractures is very challenging. Open reduction sometimes damages vascular nutrition, weakens bony components, and disturbs the surrounding soft tissues. It can also increase the risk of non-union and implant insufficiency (7, 8). Another technique includes closed reduction and biologic plating. A lateral femoral locking compression plate (PFLCP) can be used as a protective shield next to the trochanter's sidewall to prevent the displacement of proximal parts (9, 10).

2. Objectives

Due to the lack of sufficient information on the ST fracture repair by the PFLCP and the difficulty in the import of implants in Iran, which has limited access to various implants, this study was conducted to compare PFLCP and intramedullary nailing in the treatment of ST fractures in Firoozgar Hospital, Tehran, Iran, in 2014 - 2018.

3. Methods

This descriptive - analytic study was carried out to compare the results of PFLCP and intramedullary nailing among patients with ST fractures undergoing open reduction and internal fixation in Firoozgar Hospital in Tehran between January 2014 and December 2018.

The inclusion criteria included the patients' ability to present in the follow-up visits and consent for the study. The exclusion criteria were the patients' mental or physical disability, underlying diseases affecting the process of repair, fracture due to underlying disease or malignancy, and dissatisfaction with the study.

Eligible patients were first selected by reviewing their medical records. Then, the selected patients were re-evaluated and randomly divided into equal groups A and B. Group A included patients that had used PFLCP to treat the ST fracture and Group B included patients using intramedullary nailing to treat their ST fractures. For surgeries in group A, after prep and drep, the patients were placed in the lateral position and an incision was made from the greater trochanter to the caudal with the length of approximately 15 cm. After separating the origin of the vastus lateral's muscle, the plate was placed on the bone. Three proximal screws were fitted to fix the plate. The distal plaque was fixed with five screws to the bone. Then, the drain was used to evacuate blood and secretions. For group B patients, a standard intramedullary nailing surgery was performed. It should be noted that one reason for selecting the PFLCP for repairing ST fractures is the problems and limitations that exist in using the intramedullary nailing, including the need for a fracture bed, C-Arm imaging, much more X-ray exposure, the patient's more difficult position for surgery, and equipment and time intensiveness while the PFLCP fixation uses a regular operation bed with routine imaging and necessitates the patient to take a lateral position that is easier to operate.

A standard Harris hip score (HHS) questionnaire was used to re-evaluate the patients. In addition to the patient's demographic information, the HHS questionnaire collects data regarding pain, limping, the use of a cane or supportive tools, the distance that the patient can walk, the comfort of sitting on the chair, the ability to use public transport, the ability to climb stairs, and comfort in the wearing of socks and shoes that is a measure of deformity and joint motion range (11). A score is specified for each item and a total score is calculated for each patient by summing the single scores. In the HHS questionnaire, the total score ranges between zero and 100. Based on the HHS, the surgical outcome was divided into four categories: Excellent (90 - 100), Good (80 - 90), Fair (70 - 80), and Poor (< 69) (11, 12). After completing the HHS questionnaire, patients were evaluated for bone regeneration by pelvic X-ray. The X-ray was used to examine malunion and non-union.

Descriptive statistics including mean and standard deviation, as well as relative frequency, were used to describe the data. The chi-square test was used to examine the relationships and make comparisons between the two groups. Multivariate logistic regression was utilized to evaluate the odds of each of the variables. All analyses were performed using SPSS version 16 software at a significance level of $P < 0.05$. This study received ethical approval from the Research Deputy of Iran University of Medical Sciences (IR.IUMS. FMD.REC. 1396.9411242003). The essential information and the objectives of the study were explained to the patients and written consent was obtained for participation in the study.

4. Results

In this study, of the 56 eligible patients examined, 49 (87.5%) were male. The overall mean age of the patients was 42.7 ± 16.2 years (range: 16 - 85) with no significant difference between the groups. The average operating time was significantly lower in the PFLCP group than in the nailing group (P = 0.029). The demographic characteristics of the patients in the two groups are presented in Table 1.

Regarding the variables studied in the HHS questionnaire, the complaint of pain after operation was significantly less frequent in the PFLCP group than in the nailing group (P = 0.041). However, there was no significant difference between the two groups in terms of other variables. The HHS results of patients in the two groups are presented in Table 2.

The results of union status and repair of femoral bone fractures are shown in Table 3. As can be seen, the status of the union was significantly better in the PFLCP group than in the nailing group (P = 0.038).

The mean HHS was 90.1 ± 15.1 (range: 51 - 98) in the PFLCP group and 87.7 ± 13.7 (range: 53 - 95) in the nailing group, which showed no significant difference between the two groups (P = 0.081). The HHS results of the patients in the two groups are presented in Table 4.

In this study, the relationship of the independent variables with HHS was investigated by the multivariate regression model. As shown in Table 5, the results of logistic regression model showed that sex and age could significantly decrease the HHS (OR = 0.851; 95% CI: 0.525 - 1.083 for female gender and OR = 0.829; 95% CI: 0.0612 - 1.008 for age of more than 60). There was no significant relationship between the HHS and other variables. The results of the multivariate logistic regression model are presented in Table 5.

5. Discussion

The results of this study showed that PFLCP was almost similar to intramedullary nailing in the treatment of ST fractures and it significantly reduced the pain after the operation. In addition, PFLCP could significantly increase the amount and quality of the union. Multivariate logistic regression model also showed that age and sex could significantly correlate with the patients' recovery so that patients under the age of 30 and male patients had higher rates of recovery (higher HHS).

Due to biomechanical properties, the treatment of ST fractures, especially comminuted and unstable fractures, is very challenging and there is no single treatment of choice (13). Several methods are chosen based on the location of the fracture, the age of the patient, and the surgeon's experience, but with regard to complications, none of the methods is definitely superior to others (14, 15).

One of the new ways to repair the ST fracture is to use the PFLCP (16). The success of using PFLCP depends on the correct selection of the patient, the application of a suitable length of the plate, the presence of medial buttress at the fracture site, and the use of the kickstand screw (17). In Barquet et al. study of 3500 cases of proximal femoral fractures, the results of using extra and intra-medullary implants were compared. They reported that the mortality rate, infection, union, bleeding, and surgical duration were not significantly different between the two groups (18).

In a study by Glassner et al., it was shown that the PFLCP as a simple treatment with acceptable results could be an alternative to other methods, especially in cases with a fracture in the lateral wall because it could produce satisfactory stability in the hip. The special feature of this type of implant is that once the screw is locked on the plate, it acts as an external fixator and can hold the parts together without stress and excessive force on the large trochanter (19).

According to numerous studies, more than 20% of patients undergoing intra-medullary implants show a variety of complications. The protrusion of the screws from the lateral region and their migration into the joint can cause abnormal pain and reduce the extent of joint movement, accounting for some of the complications of this treatment. On the other hand, 20% of patients undergoing intramedullary fixation may need reoperation (20, 21). In this study, the mean age of the patients was 42.7 ± 16.2 years, which shows that most of the ST fractures were caused by high-energy traumas mostly occurring in young people.

D'Angelo et al. showed a significant relationship between ST fractures and the age of patients so that the incidence of the fractures decreased dramatically in people over the age of 80 years (22). Mackie and Leyshon in a study in South Korea found a strong correlation between ST fractures and age. They also showed no case of ST fractures at the age of above 80 years (23). These findings are consistent with the results of our study.

Table 1. The Demographic and Clinical Information of Patients in the Two Groups[a]

Characteristics	PFLCP Group	Nailing Group	Total	P Value
Age, y	42.1 ± 16.6	43.7 ± 15.3	42.7 ± 16.2	0.123
Sex				0.103
Male	25 (89.3)	24 (85.7)	49 (87.5)	
Female	3 (10.7)	4 (14.3)	7 (12.5)	
BMI				0.095
< 18 kg/m^2	4 (14.3)	5 (17.8)	9 (16.1)	
18 - 25 kg/m^2	19 (67.9)	20 (71.4)	39 (69.6)	
> 25 kg/m^2	5 (17.8)	3 (10.7)	8 (14.3)	
Cause of fracture				0.063
Traffic accidents	17 (60.7)	19 (67.9)	36 (64.2)	
Falls	6 (21.4)	4 (14.2)	10 (17.9)	
Others	5 (17.9)	5 (17.9)	10 (17.9)	
GCS				0.147
> 10	21 (75)	20 (71.4)	41 (73.2)	
≤ 10	7 (25)	8 (28.6)	15 (26.8)	
Number of traumatic sites				0.089
Just femur	12 (42.9)	14 (50)	26 (46.4)	
Multiple	16 (57.1)	14 (50)	30 (53.6)	
The first time of referral				0.078
Immediately after the event	13 (46.4)	15 (53.6)	28 (50)	
After one to seven days	11 (39.3)	10 (35.7)	21 (37.5)	
After eight days or more	4 (14.3)	3 (10.7)	7 (12.5)	
Patient's outcome				0.059
Recovery and discharge	22 (78.6)	23 (82.2)	45 (80.4)	
Complicated	5 (17.8)	5 (17.8)	10 (17.9)	
Decease	1 (3.6)	0 (0)	1 (1.7)	
Average operating time, h	1.55 ± 0.25	2.35 ± 0.35	2.18 ± 0.48	0.029

[a]Values are expressed as mean ± SD or No. (%).

Barquet et al. compared the results of the PFLCP fixation and intramedullary nailing, reporting no significant difference in the HHS between the two groups, which is quite similar to the present study (18). The only difference was the need for walking aids, which its frequency was significantly lower in patients who used the PFLCP, possibly due to the number and age of the patients recruited for the two studies.

Kakkar et al. compared the results of PFLCP and intramedullary implants and stated that the use of PFLCP can produce the same results as the use of intramedullary implants even with fewer complications; this is while most researchers recognize intramedullary nailing implants as the standard treatment (24). This finding is consistent with the results of the present study.

In the current study, a normal, suitable union was observed in 74.1% of the patients who underwent PFLCP for ST fracture, which was significantly greater than its rate in the intramedullary nailing group. In the study of Cuny et al., the complete union was reported in 100% of 35 cases with ST fractures treated with PFLCP. In these patients, the complete union was established in an average of 16 weeks and no implant failure or non-union was reported (25). In the study of Lahoud et al., after the use of PFLCP for ST fracture treatment, the union was reported in 87.5% of the cases (26). The difference between the results of these two studies and the findings of our study may be due to the difference in plate size, age of patients, postoperative care, or sample size.

In the current study, the total mean HHS was 88.9 ± 14.1 in a range of 51 - 98 with no significant difference between the two groups. In the study of Asselineau et al., which evaluated the pelvic function after the introduction of PFLCP with the same questionnaire, the total mean HHS was 74.34 in a range of 62 - 94 (27). Saini et al. examined the repair process and postoperative complications in 45 patients with ST fracture treated with PFLCP. They evaluated hip joint performance one year after the surgery using the HHS questionnaire and reported the total mean HHS as 86.5 ± 9.8 (range: 73 - 95) (15). The difference in the obtained scores between these two studies and our study may be due to the difference in sample size (16).

Table 2. The Results of HHS of Patients in the Two Groups[a]

Complaint	HHS		Total	P Value
	PFLCP Group	Nailing Group		
Pain				0.041
Without pain	17 (60.7)	15 (53.6)	32 (57.1)	
Sometimes	10 (35.7)	11 (39.2)	21 (37.5)	
Mild	1 (3.6)	1 (3.6)	2 (3.6)	
Moderate	0 (0)	1 (3.6)	1 (1.8)	
Lame				0.069
None	17 (60.7)	18 (64.3)	35 (62.5)	
Mild	7 (25)	7 (25)	14 (25)	
Moderate	4 (14.3)	3 (10.7)	7 (12.5)	
Needing aids				0.081
None	21 (75)	22 (78.6)	43 (76.8)	
Crutches for long walk	2 (7.1)	3 (10.7)	5 (8.9)	
Crutches for most of the time	4 (14.3)	3 (10.7)	7 (12.5)	
Crutches	1 (3.6)	0 (0)	1 (1.9)	
Two canes	0 (0)	0 (0)	0 (0)	
Inability to walk	0 (0)	0 (0)	0 (0)	
Walking distance				0.074
Unlimited	24 (85.8)	22 (78.6)	46 (82.1)	
Six alleys	2 (7.1)	3 (10.7)	5 (8.9)	
Two or three alleys	2 (7.1)	2 (7.1)	4 (7.1)	
Indoors	0 (0)	1 (3.6)	1 (1.9)	
Inability to leave the bed	0 (0)	0 (0)	0 (0)	
Siting				0.107
Sitting without problem for 1 h	25 (89.3)	26 (92.9)	51 (91.1)	
Sitting on the chair for 30 min	3 (10.7)	2 (7.1)	5 (8.9)	
Inability to sit on the chair	0 (0)	0 (0)	0 (0)	
Use of public transport				0.091
Positive	27 (96.4)	26 (92.9)	53 (94.6)	
Negative	1 (3.6)	2 (7.1)	3 (5.4)	
Climbing stairs				0.088
Climbing normally	24 (85.8)	23 (82.1)	47 (83.9)	
Normal climbing with the help of the railing	3 (10.7)	4 (14.3)	7 (12.5)	
Need more help of railing	1 (3.6)	1 (3.6)	2 (3.6)	
Inability to climbing stairs	0 (0)	0 (0)	0 (0)	
Wearing socks and shoes				0.059
Easy	23 (82.1)	25 (89.3)	48 (85.7)	
Hard	5 (17.9)	3 (10.7)	8 (14.3)	
Unable to wear	0 (0)	0 (0)	0 (0)	
Range of motion				0.061
Normal	8 (28.6)	10 (35.7)	18 (32.1)	
Limited to abduction and adduction	6 (21.4)	5 (17.9)	11 (19.6)	
Limited to external rotation	9 (32.1)	8 (28.5)	17 (30.5)	
Limited to internal rotation	5 (17.9)	5 (17.9)	10 (17.8)	
Deformity				0.109
Positive	11 (39.3)	10 (35.7)	21 (37.5)	
Negative	17 (60.7)	18 (64.3)	35 (62.5)	

[a]Values are expressed as No. (%).

Table 3. Condition of Repair and Bone Union of Patients in the Two Groups[a]

Fracture Repair	HHS		Total	P Value
	PFLCP Group	Nailing Group		
Union				0.038
Normal union	20 (71.4)	17 (60.7)	37 (66.1)	
Malunion varus	4 (14.3)	5 (17.6)	9 (16.1)	
Malunion valgus	1 (3.6)	3 (10.7)	4 (7.1)	
Non-union	3 (10.7)	3 (10.7)	6 (10.7)	

[a]Values are expressed as No. (%).

Table 4. The Total HHS of Patients in the Two Groups[a]

Complaint	HHS					P Value
	Excellent HHS	Good HHS	Fair HHS	Poor HHS	Total HHS	
PFLCP group (n = 28)	21 (75)	2 (7.1)	1 (3.6)	4 (14.3)	90.1 ± 15.1	0.081
Nailing group (n = 28)	20 (71.4)	3 (10.7)	3 (10.7)	2 (7.1)	87.7 ± 13.7	

[a]Values are expressed as mean ± SD or No. (%).

Table 5. Relationship Between Independent Variables and HHS in Multivariate Logistic Regression Model

Independent Variables	Odds Ratio	95% CI	P Value
Age category			
Less than 30 years	1.000		
30 to 60 years	0.905	1.055 - 0.0832	0.051
More than 60 years	0.829	1.008 - 0.0612	0.042
Sex			
Male	1.000		
Female	0.851	1.083 - 0.525	0.039
GCS			
> 10	1.000		
≤ 10	0.938	1.248 - 0.811	0.085
BMI			
18 - 25 kg/m^2	1.000		
< 18 kg/m^2	0.923	1.125 - 0.756	0.055
> 25 kg/m^2	0.875	1.035 - 0.612	0.051
The first time of referral			
Immediately after event	1.000		
After one to seven days	0.851	1.123 - 0.671	0.117
After eight days or more	0.723	0.957 - 0.671	0.088
Number of traumatic sites			
Just femur	1.000		
Multiple	0.867	1.142 - 0.509	0.052

5.1. Conclusions

The use of PFLCP to treat ST fractures could help patients return quickly to their lives and work and lead to a better HHS than the other conventional methods. Therefore, PFLCP is suggested for ST fractures, particularly in young people, to avoid serious complications. It is also highly proposed in cases of great trochanter involvement, lateral wall damage, and comminuted ST fractures.

5.2. Limitations

A limitation of the present study was a relatively small number of female patients; thus, the evaluation of gender difference was not possible. In addition, the patients' failure to present in follow-up visits and their inability to complete the HHS questionnaire were among the other limitations of the study.

Acknowledgments

The present study was supported by the Iran University of Medical Sciences as a medical doctor (MD) thesis. We hereby acknowledge the Research Deputy of the University. In addition, we would like to thank all the participating patients.

Footnotes

Authors' Contribution: Data collection: Karim Pisoude, Omid Elahifar and Javad Khajemozafari; manuscript writing: Omid Elahifar, Javad Khajemozafari and Mohammad Bagher Sohrabi; data analysis: Mohammad Bagher Sohrabi.

Conflict of Interests: The authors declare that they have no conflicts of interest.

Ethical Approval: This study received ethical approval (IR.IUMS.FMD.REC.1396.9411242003) from the Research Deputy of Iran University of Medical Sciences.

Funding/Support: This study received funding from the Research Deputy of Iran University of Medical Sciences.

Patient Consent: Informed consent was obtained from all participants in the study.

References

1. Berger RJ, Sultan AA, Cole C, Sodhi N, Khlopas A, Mont MA. Subtrochanteric hip fracture following core decompression for osteonecrosis in a patient with a pre-existing contralateral occult femoral neck fracture. *Surg Technol Int*. 2018;**32**:361–5. [PubMed: 29791709].
2. Palm H, Teixidor J. Proximal femoral fractures: Can we improve further surgical treatment pathways? *Injury*. 2015;**46 Suppl 5**:S47–51. doi: 10.1016/j.injury.2015.08.013. [PubMed: 26387035].
3. Behera P, Khurana A, Saibaba B, Aggarwal S. Dealing with subtrochanteric fracture in a child with osteopetrosis : A case report. *Acta Orthop Belg*. 2016;**82**(4):907–12. [PubMed: 29182138].
4. Tsang ST, Aitken SA, Golay SK, Silverwood RK, Biant LC. When does hip fracture surgery fail? *Injury*. 2014;**45**(7):1059–65. doi: 10.1016/j.injury.2014.03.019. [PubMed: 24794618].
5. Riehl JT, Koval KJ, Langford JR, Munro MW, Kupiszewski SJ, Haidukewych GJ. Intramedullary nailing of subtrochanteric fractures–does malreduction matter? *Bull Hosp Jt Dis (2013)*. 2014;**72**(2):159–63. [PubMed: 25150344].
6. Sidaginamale RP, Fadero P, Apostolopoulos AP, Zolcze L. Dynamic condylar screw as a solution to operative dilemma in early subtrochanteric fracture following cannulated screw fixation for slipped capital femoral epiphysis: A case report. *J Long Term Eff Med Implants*. 2012;**22**(1):17–20. [PubMed: 23016786].
7. Rijal KP, Manandhar RR, Pandey BK. Sub-trochanteric fractures of the femur: Results of ORIF at KMCTH. *Kathmandu Univ Med J (KUMJ)*. 2007;**5**(2):161–5. [PubMed: 18604012].
8. Duchesne R, Thivierge A, Abi Nader N. [Sub-trochanteric fractures of the femur in adults treated with the Richard screw-plate]. *Union Med Can*. 1985;**114**(11):934–7. French. [PubMed: 4090098].
9. Herrera A, Domingo J, Martinez A. Results of osteosynthesis with the ITST nail in fractures of the trochanteric region of the femur. *Int Orthop*. 2008;**32**(6):767–72. doi: 10.1007/s00264-007-0411-0. [PubMed: 17618438]. [PubMed Central: PMC2898960].
10. Ruedi T, Quinn B. [Results in the treatment of sub-trochanteric fractures]. *Z Unfallmed Berufskr*. 1977;**70**(1):28–30. French. [PubMed: 860607].
11. Nilsdotter A, Bremander A. Measures of hip function and symptoms: Harris hip score (HHS), hip disability and osteoarthritis outcome score (HOOS), Oxford hip score (OHS), lequesne index of severity for osteoarthritis of the hip (LISOH), and American Academy of Orthopedic Surgeons (AAOS) hip and knee questionnaire. *Arthritis Care Res (Hoboken)*. 2011;**63 Suppl 11**:S200–7. doi: 10.1002/acr.20549. [PubMed: 22588745].
12. Soderman P, Malchau H. Is the Harris hip score system useful to study the outcome of total hip replacement? *Clin Orthop Relat Res*. 2001;(384):189–97. [PubMed: 11249165].
13. Erturer E, Tekkesin M, Dirik Y, Aksoy B, Ozturk I. [Radiographic and functional results of osteosynthesis with locked intramedulary nailing of subtrochanteric fractures of the femur]. *Acta Orthop Traumatol Turc*. 2004;**38**(4):265–9. Turkish. [PubMed: 15618768].
14. Lee PC, Hsieh PH, Yu SW, Shiao CW, Kao HK, Wu CC. Biologic plating versus intramedullary nailing for comminuted subtrochanteric fractures in young adults: A prospective, randomized study of 66 cases. *J Trauma*. 2007;**63**(6):1283–91. doi: 10.1097/TA.0b013e3180f62f00. [PubMed: 18212651].
15. Saini P, Kumar R, Shekhawat V, Joshi N, Bansal M, Kumar S. Biological fixation of comminuted subtrochanteric fractures with proximal femur locking compression plate. *Injury*. 2013;**44**(2):226–31. doi: 10.1016/j.injury.2012.10.037. [PubMed: 23200761].
16. Luo Q, Fang C, Shen WY, Lau TW, Leung F. A lesson from the failure of intramedullary fixation of atypical subtrochanteric fractures: A report of two cases. *JBJS Case Connect*. 2013;**3**(1). e22. doi: 10.2106/JBJS.CC.L.00212. [PubMed: 29252327].
17. Haefeli M, Huber H, Dierauer S, Ramseier LE. Fixation of subtrochanteric extending/derotational femoral osteotomies with the locking compression plate in ambulatory neuro-orthopaedic patients. *J Child Orthop*. 2010;**4**(5):423–8. doi: 10.1007/s11832-010-0281-7. [PubMed: 21966306]. [PubMed Central: PMC2946536].
18. Barquet A, Mayora G, Fregeiro J, Lopez L, Rienzi D, Francescoli L. The treatment of subtrochanteric nonunions with the long gamma nail: Twenty-six patients with a minimum 2-year follow-up. *J Orthop Trauma*. 2004;**18**(6):346–53. [PubMed: 15213499].
19. Glassner PJ, Tejwani NC. Failure of proximal femoral locking compression plate: A case series. *J Orthop Trauma*. 2011;**25**(2):76–83. doi: 10.1097/BOT.0b013e3181e31ccc. [PubMed: 21245709].
20. Fischer J, Chee Y, Waseem M, Barnes K. IMHS in peritrochanteric fractures. *Hip Int*. 2005;**15**(1):27–32. doi: 10.5301/HIP.2008.3888. [PubMed: 28224579].
21. Hamilton RJ, Kelly IG. Evaluation of the long intra-medullary hip screw. *Injury*. 2004;**35**(12):1264–9. doi: 10.1016/j.injury.2003.12.011. [PubMed: 15561116].
22. D'Angelo F, Molina M, Zatti G. Complex fractures of the femur: Treatment with a long gamma nail: Short- and medium-term experience. *Chir Organi Mov*. 2000;**85**(3):215–23. [PubMed: 11569084].
23. Mackie IG, Leyshon RL. Sub-trochanteric fracture (after Garden-screw fixation of sub-capital fracture) treated with AO dynamic hip screw and plate. *Injury*. 1983;**15**(2):136–7. [PubMed: 6629489].
24. Kakkar R, Kumar S, Singh AK. Cephalomedullary nailing for proximal femoral fractures. *Int Orthop*. 2005;**29**(1):21–4. doi: 10.1007/s00264-004-0624-4. [PubMed: 15647914]. [PubMed Central: PMC3456955].
25. Cuny C, Scarlat M, Moreau P, Mainard D, Delagoutte JP. [The Staca nail-plate in the treatment of trochanteric fractures]. *Rev Chir Orthop Reparatrice Appar Mot*. 1996;**82**(5):410–6. French. [PubMed: 8991164].
26. Lahoud JC, Asselineau A, Salengro S, Molina V, Bombart M. [Subtrochanteric fractures. A comparative study between gamma nail and angular osteosynthesis with lateral cortical support]. *Rev Chir Orthop Reparatrice Appar Mot*. 1997;**83**(4):335–42. French. [PubMed: 9452807].
27. Asselineau A. [Correction of the article: "Nailing with a long gamma nail in sub-trochanteric and trochanteric-diaphyseal femoral fractures in adults"]. *Rev Chir Orthop Reparatrice Appar Mot*. 2002;**88**(6):638. French. [PubMed: 12484409].