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Comparison of Dynamic Hip Screw and Plate Fixation for Pauwels Type III Femoral Neck Fractures in Adults

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Abstract

Introduction: Femoral neck fractures constitute 3.6% of all body fractures and 57% of hip fractures, predominantly affecting the elderly due to low-energy falls. Pauwel's Type III fractures, common in young patients, present significant challenges due to high shear forces. This study compares Dynamic Hip Screw (DHS) and Proximal Femoral Locking Plate (PFLP) fixation for treating Pauwel's Type III femoral neck fractures in adults.

Materials and Methods: This prospective study included 16 adult patients with Pauwel's Type III femoral neck fractures. Patients were divided into Group A (PFLP fixation, n=7) and Group B (DHS fixation, n=6). The operative technique for PFLP involved fracture reduction, insertion of temporary pins, and placement of a locked plate with screws. For DHS, the procedure included the insertion of an anti-rotation screw, measuring for lag screw placement, and securing with a barrel plate.

Results: Our study revealed intriguing parallels. Operation times were similar between Group A (1.45 hours) and Group B (1.32 hours) (P=0.07). Intraoperative blood loss was slightly higher in Group A (375 ml) than Group B (341 ml) (P=0.08). Fluoroscopic screen use was slightly higher in Group A than Group B (P=0.06). Fracture healing times were comparable (12.2 weeks for Group A, 13.1 weeks for Group B) (P=0.87). Both groups achieved commendable Harris Hip Scores (P=0.13). Complications were minimal, with one case of fracture non-union and infection in Group-A, and one case of malunion in Group-B. No femoral head necrosis occurred in either group.

Discussion: Both DHS and PFLP fixation were effective, with high Harris Hip Scores, good bone healing, and minimal complications. Differences in intraoperative time, blood loss, and fluoroscopic imaging were statistically insignificant.

Conclusions: DHS and PFLP are viable treatments. Surgeon preference and patient-specific factors should guide the choice of fixation method. Future research should involve larger, multicenter studies and explore additional treatment modalities to improve clinical decision-making.

Keywords: Femoral Neck Fractures, Pauwel's Type III, Dynamic Hip Screw, Proximal Femoral Locking Plate, Internal Fixation Techniques

Introduction

Femoral neck fractures are among the most prevalent types of fractures encountered in clinical practice, constituting approximately 3.6% of all body fractures and 57% of hip fractures [(1)]. The incidence of these fractures is rising due to factors such as car accidents, trauma, and other causes. Consequently, femoral neck fractures are no longer confined to the elderly population; high-energy trauma can also result in these fractures in young adults [(2)].

Femoral neck fractures predominantly occur in the geriatric population following low-energy falls. Currently, hip fractures affect approximately 280,000 Americans annually, and this number is projected to rise to 500,000 annually over the next 40 years due to the increasing average age of the population [(3)]. Notably, there is a bimodal distribution of these fractures, with 2–3% occurring in patients younger than 50 years old as a result of high-energy trauma [(4)].

Pauwel's classification, the first biomechanical classification for categorizing femoral neck fractures, remains widely used today to guide treatment decisions and predict potential complications [(5)].

Femoral neck fractures resulting from high-energy trauma in young patients commonly exhibit a Pauwel's Type III fracture pattern [(6)]. Pauwel's Type III fractures, typically caused by high-energy injuries in young patients, are particularly challenging due to the high shear forces involved. These forces contribute to the relatively high rates of non-union and other clinical complications, such as hardware cutout and the need for revision surgery [(7)].

The therapeutic guideline for Pauwel's Type III fractures generally recommends arthroplasty as the best option for older adults who have sustained a displaced femoral neck fracture. In contrast, internal fixation is preferable for young adults, as they have a longer life expectancy and aim to maintain their activity level [(8)].

Anatomical reduction and stable internal fixation are fundamental in managing femoral neck fractures among non-elderly patients to preserve the femoral head [(9)]. The options for internal fixation are varied and include dynamic hip screws (DHS), proximal femoral locking plates (PFLP), cannulated screws, femoral neck systems, and cannulated screws with a medial buttress plate. Several studies have suggested that Pauwel's Type I and II fractures, where compressive forces are predominant, can be effectively managed with three parallel cannulated screws [(10)]. However, the ideal fixation method for Pauwel's Type III fractures remains a debatable topic.

This study aims to compare two treatment modalities, DHS and PFLP fixation, for patients with Pauwel's Type III femoral neck fractures in adults, focusing on intraoperative variables, clinical outcomes, functional results, and complication rates.

Methods

Study Design

The study comprised 16 adult patients with Pauwel's Type III femoral neck fractures who underwent surgery at Al-Kindy Teaching Hospital in Baghdad, Iraq, and met the inclusion criteria. Data collection was prospective and conducted over an 18-month period from February 2022 to September 2023. Patients were divided into two groups based on the treatment modality:

Group A: Eight patients with Pauwel's Type III fracture treated with the PFLPfixation.

Group B: Eight patients with Pauwel's Type III fracture treated with the DHS fixation and anti-rotation screw.

Inclusion Criteria

1. Patients with closed femoral Pauwel's Type III fractures.
2. Patients with no history of pathological femur fracture, ipsilateral femur fracture, or femoral neck fracture.
3. Patients with unrestricted hip movement preoperatively.
4. Age between 18 and 65.
5. Completion of follow-up with the researcher.

One patient from Group A was excluded from the study due to loss of follow-up, resulting in a total of seven patients. Similarly, two patients from Group B were lost during follow-up, leaving a total of six patients.

Preoperative Preparation

Upon admission to the orthopedic ward, patients underwent routine examinations and laboratory tests, including a complete blood count (CBC), virology screen, chest X-ray, electrocardiogram (ECG), blood glucose level, prothrombin time (PT), partial thromboplastin time (PTT), international normalized ratio (INR), renal function tests (RFT), and blood preparation. A preoperative anesthesiologist consultation was conducted to assess the patients' fitness for surgery. Imaging of the affected hip was performed to evaluate fracture displacement, without the application of preoperative traction.

Patients received preventive infection control measures with broad-spectrum antibiotics, routine analgesics, and symptomatic treatments as needed. They fasted for at least eight hours before surgery. Informed consent was obtained from the patients and/or their families after explaining the surgical approach and the purpose of the research.

Operative Technique

The operation involved administering either general or spinal anesthesia, with the patient positioned on a radiolucent orthopedic table and C-arm fluoroscopy for guidance. A Foley catheter was inserted, and the patient was placed in a supine position with the feet secured in fracture table boots. The contralateral leg was flexed and raised, and initial fluoroscopic images were taken to examine the femoral neck.

A lateral incision was made below the vastus ridge, followed by subperiosteal dissection to expose the bone. Blunt dissection was used to access the fracture site, and the fracture reduction was performed and confirmed using C-arm imaging.

PFLP Procedure

Following fracture reduction, two or three temporary 2mm pins were inserted to maintain the reduction. Subsequently, a locked plate was positioned using a K-wire to secure it onto the bone. A sleeve was used to facilitate the insertion of three or four screws into the femoral neck, followed by the insertion of shaft screws. Placement was verified through fluoroscopic screening. The wound was meticulously closed in layers, ensuring proper hemostasis and placement of drainage. Closure was completed with sutures, and a surgical dressing was applied.

DHS Procedure

An additional pin was inserted superior and parallel to the lower pin for anti-rotation. This was followed by the introduction of an anti-rotation screw and washer to prevent spinning of the proximal segment during lag screw insertion. A direct measuring device was slid over the guide pin to determine the insertion depth, providing a direct reading via device calibration. The reaming depth, tapping depth, and lag screw length were calculated, with 5mm subtracted from the total reading.

A triple reamer was then used to drill the cortex along the guide wire, followed by irrigation with normal saline to prevent thermal trauma. The lag screw and barrel plate were introduced, and shaft screws were inserted before compressing the lag screw. Hemostasis was confirmed, a drain was placed, and the wound was closed in layers, followed by suturing of the skin and application of a surgical dressing.

Postoperative follow up

After surgery, patients are discharged to the orthopedic ward with prescriptions for postoperative antibiotics, analgesics, and anticoagulants to prevent deep venous thrombosis of the lower limbs. Each patient receives verbal rehabilitation guidance, emphasizing avoidance of weight-bearing activities for 6-8 weeks, followed by partial weight-bearing for an additional month. Follow-up appointments are scheduled on Day 1, 7, and 14 for suture removal and in Month 1, 3, and 6 with radiological assessments at each visit.

The Harris Hip Score is utilized postoperatively to assess hip joint function. Incidence of complications in both groups is monitored during follow-up, including fracture non-union, malunion, post-surgical infection, and femoral head osteonecrosis. Non-union is defined as minimal callus formation at the fracture site, a gap between bone ends resembling a pseudo joint, and absence of trabecular formation, with smooth, atrophic bone ends and dense bone occluding the marrow cavity. Osteonecrosis of the femoral head manifests on imaging as subchondral sclerosis or segmental collapse.

Statistical Analysis

Data were initially recorded on paper forms for each patient, then transferred to Microsoft Excel for organization before undergoing statistical analysis. IBM SPSS version 27 (SPSS, Inc., Chicago, IL, USA) for Windows was utilized for analysis. Fracture non-union rate, malunion, postoperative infection, femoral head necrosis rate, and other count data were presented as frequencies and percentages (%) and analyzed using the Chi-square test. Operation time, intraoperative blood loss, fracture healing time, and Harris score were expressed as means and standard deviations and analyzed using paired samples t-tests. A p-value of <0.05 was considered statistically significant.

Results

Patients were subdivided into two groups. Group A consisted of seven patients treated with PFLP fixation. Their mean age was 33.7 years, ranging from 21 to 47 years. Of these patients, five (71.4%) were males and two (28.6%) were females. Group B comprised six patients treated with DHS fixation. Their mean age was 31.1 years, ranging from 20 to 44 years. In this group, four patients (66.7%) were males and two (33.3%) were females (Table 1).

Table 1: Demographic Characteristics of the Study Participants

Group		Group A (n = 7)	Group B (n = 6)
Age (years)	Mean ± SD	33.7 ± 11.3	31.1 ± 11.9
	Range	21-47	20-44
Gender n (%)	Male	5 (71.4)	4 (66.7)
	Female	2 (28.6)	2 (33.3)

SD: Standard Deviation

Road traffic accidents (RTA) were the main cause of injury for Group A patients (57.1%) and Group B patients (66.7%). Falls from height (FFH) were the other cause for 42.9% of Group A patients and 33.3% of Group B patients. The chi-square P-value was statistically not significant (P=0.784). In Group A, four patients (57.1%) had injuries on the left side, and three (42.9%) had injuries on the right side. In Group B, three patients (50%) had left femur neck fractures, and three patients (50%) had right femur neck fractures. The chi-square P-value for this distribution was also statistically not significant (P=0.226) (Table 2).

Table 2: Comparative Analysis of Injury Mechanisms and Body Sides Affected Between Group A and Group B

Group		Group A (n = 7)	Group B (n = 6)	P-value
Injury Mechanism n (%)	FFH	3 (42.9)	2 (33.3)	0.784
	RTA	4 (57.1)	4 (66.7)	
Side of Injury n (%)	Left	4 (57.1)	3 (50)	0.226
	Right	3 (42.9)	3 (50)	

FFH: Fall FromHight; RTA: Road Traffic Accident

The mean time for plate fixation operations (Group A) was 1.45 ± 0.7 hours. DHS operations (Group B) took slightly less time, with a mean of 1.32 ± 0.9 hours. This minor difference was statistically not significant (P = 0.071). Intraoperative blood loss was higher for Group A, with a mean of 375 ml, compared to 341 ml for Group B. This difference was also statistically not significant at the alpha level of 0.05 (P = 0.082) (Table 3).

The mean number of fluoroscopic screens required to complete the seven plate operations for Group A patients was 20 ± 5, which was slightly higher than the mean number of screens required to complete the six DHS operations for Group B patients (17 ± 5). This difference was statistically not significant (P = 0.0601) (Table 3).

Table 3: Comparative Analysis of Operation Time, Intraoperative Blood Loss, And Fluoroscopic Screens Between Group A and Group B

Group	Operation time (hours)	Intraoperative blood loss (ml)	Intraoperative fluoroscopic screens
Group A (n=7)	1.45 ± 0.7	375 ± 258	20 ± 5
Group B (n=6)	1.32 ± 0.9	341 ± 386	17 ± 5
P-value	0.071	0.082	0.0601

The mean time required for fracture healing for Group A patients was 12.2 ± 3.45 weeks after the operation, while for Group B patients, it was slightly longer with a mean of 13.1 ± 4.03 weeks. However, the difference between the two means was statistically not significant with a P-value of 0.879. Both groups yielded similar mean Harris Hip Scores at the postoperative assessment. Group A had a mean score of 91.2 ± 7.9, and Group B had a mean score of 95.4 ± 2.7. Again, the difference between the two means was statistically not significant with a P-value of 0.137 (Table 4).

Table 4: Comparative Analysis of Post-Operative Fracture Healing Time and Harris Hip Score between Group A and Group B

Group	Fracture healing time in weeks (Mean ± SD)	Harris hip score (Mean ± SD)
Group A (n=7)	12.2 ± 3.45	91.2 ± 7.9
Group B (n=6)	13.1 ± 4.03	95.4 ± 2.7
P-value	0.879	0.137

SD: Standard Deviation

In Group A, complications recorded included fracture non-union for one patient (14.28%), who also developed post-operative infection (Table 5). For Group B patients, only one patient (16.66%) developed malunion after DHS fixation. No cases of femoral head necrosis were recorded among the 13 patients from both groups. The differences in all recorded complications between the two groups were statistically not significant, with P-values above the significant level of 0.05. Specifically, for fracture non-union (P=0.077), fracture malunion (P=0.083), and post-operative infection (P=0.077). For femoral head necrosis, the P-value was not calculable due to null values (Table 5).

Table 5: Postoperative Complications Comparison between Group A and Group B

Group	Fracture non-union, n (%)	Malunion, n (%)	Infection, n (%)	Femoral head necrosis, n (%)
Group A (n=7)	1 (14.28)	0	1 (14.28)	0
Group B (n=6)	0	1 (16.66)	0	0
P-value	0.077	0.083	0.077	–

Discussion

Currently, the treatments for femoral neck fractures mainly include internal fixation and hip joint replacement. It is generally acknowledged that hip joint replacement is the preferred treatment for patients >80 years with severe osteoporosis, while for patients <65 years, anatomical reduction, rigid fixation, and preserving the hip joint are the major treatment targets, especially for patients with abundant daily activities (11). In addition to age, factors such as life expectancy, preoperative activity, systemic conditions, osteoporosis, and financial conditions should be considered when selecting the treatment method (12).

Closure reduction and internal fixation with multiple cannulated screws have several advantages, including being easy to operate, minimally invasive, effective, and cost-effective, and have become a commonly used method for the treatment of displaced femoral neck fractures (13). In addition, screw placement is performed according to the principle of “closely adjacent, in parallel, inverted triangle, and screwhead in circular sector distribution”, and the screw placement channel is optimized, which could increase the holding force of the screws to the cortical bone (14). Nevertheless, studies suggested that using three cannulated screws was unsuitable for the fixation and treatment of Pauwels III femoral neck fracture, as the fixation could not support the vertical shear force at the fracture end (15,16). It is generally acknowledged that anatomical reduction and stable and strong fracture fixation early after injury are important factors ensuring good treatment effects (17,18).

In our study, both DHS and PFLP fixation for adults with Pauwels type III femoral neck fracture resulted in high Harris function score, good bone healing and lower complications of femoral head necrosis, both modalities seem to be good and effective approaches for treatment of such fractures. Jiang X. et al. have conducted a study on different treatment approaches for Pauwels type III fractures and also concluded that both dynamic hip screw (DHS) with the anti-rotation screw and plate fixation can effectively reduce the movement of the fracture section and share the shear force, which is consistent with our study findings [19].

In our study, treatments by PFLP fixation had similar characteristics, including minimal invasiveness, small incision, small blood loss, and ease of operation, although group A patients required more mean intraoperative time and more fluoroscopic pictures (higher risk of radiation exposure) and more blood loss, but statistically all the intraoperative variables resulted in insignificant P values, this could be caused by the relatively small sample size. There have not been enough studies conducted to compare the intraoperative variables of DHS versus PFLP fixation for Pauwels type III fractures. Most studies focus on biomechanical forces and postoperative complications. However, studies like that of Asif et al. have demonstrated that DHS operations for unstable intertrochanteric fractures require less operative time and result in minimal blood loss compared to locked plate operations [20].

The reductions in all 13 patients were satisfactory. However, one of the 7 patients in group A (PFLP) showed evidence of postoperative infection, which was treated with antibiotics. No plate withdrawal was observed. Nevertheless, the sample size is not large enough to draw any definitive conclusions. Dhamangaonkar et al. found similar results when comparing PFLP and DHS for unstable intertrochanteric femoral fractures. They observed deep wound infections in 3 patients of the PFLP group and 2 patients of the DHS group [21].

When using cannulated screws for fixation, femoral neck fracture healing processes involve the resistance against fracture collapse. Such collapse could generally lead to the lateral withdrawal of the screws or even fixation failure and discomfort or pain in the thigh, this was not reported during the current study for the 6 patients that were treated with DHS, the risk of the lateral withdraw is less when Pauwels angle becomes higher (type III).

The fractures in the patients were all well healed, with only one patient experiencing malunion and four screws showing slight withdrawal. Özer et al. have conducted a study that aimed to evaluate the performance of four different fixation techniques for Pauwels type III femoral neck fractures considering the fracture morphology in the sagittal plane and they have conducted that the plate displayed less vertical and rotational displacement in the anterior and posterior fracture lines in the sagittal plane compared to the DHS [22].

The study has several limitations. Firstly, the small sample size could reduce the statistical power and limit the generalizability of the findings. Additionally, only patients with Pauwels III fractures were included, potentially impacting the study's outcomes as the severity of the fracture may vary. Moreover, no other fixation options for Pauwels type III fractures were compared with dynamic hip screw (DHS) and proximal femoral locking plate (PFLP) fixation, which limits the comprehensiveness of the analysis.

Conclusions

Both proximal femoral locking plate (PFLP) and dynamic hip screw (DHS) with anti-rotation screw are effective treatment modalities for Pauwels type III femoral neck fractures, offering timely fracture union with minimal complications. Surgeon preference often dictates the choice of internal fixation modality, taking into account factors such as hospital availability and financial considerations. It's important to recognize that individual cases may necessitate personalized approaches. However, using the plate may entail longer operative time, increased fluoroscopic imaging, and higher intraoperative blood loss compared to DHS operations. DHS procedures may also pose a higher risk of malunion. Despite these differences, both treatment groups exhibited comparable functional outcomes, as indicated by the Harris hip score at the postoperative assessment.

To enhance the robustness of future research and improve clinical decision-making, the following steps are suggested. Firstly, establishing a broader study with a larger sample size, involvement of multiple orthopedic hospitals, and an extended follow-up period is crucial to achieve higher statistical power and enhance external validity. Secondly, further studies should explore the effectiveness of alternative treatment modalities utilized globally for Pauwels type III femur neck fractures. Comparing these modalities with dynamic hip screw (DHS) and/or proximal femoral locking plate (PFLP), which are currently available, can provide valuable insights into the optimal management strategies for these fractures.

Consent of Patient

In adherence to ethical guidelines, verbal consent was obtained from each patient during the data collection after explaining the purpose of their participation in the study. Additionally, formal written consent for surgery was obtained from each patient prior to their surgical procedure.

Consent of Ethics

This study received approval from the Iraqi Council of Medical Specialties/Scientific Council of Orthopedic Surgery, ensuring compliance with regulatory standards. Permissions were also granted from Al-Kindy Teaching Hospital for conducting the research ethically and effectively.

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