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Radiological Differences Following Proximal Femoral Nail Antirotation (PFNA) Compared to the Contralateral Side and Its Correlation with Harris Hip Score (HHS) in Intertrochanteric Femoral Fracture After Three Months

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ABSTRACT

Introduction: The incidence of intertrochanteric femoral fractures, which account for 50% of all hip fractures, is increasing as a result of the aging population. While PFNA surgery typically enhances outcomes, certain individuals continue to have pain, stiffness, and difficulties with their gait. This study aims to determine whether there is a correlation between post-surgical complications and changes in hip joint angles assessed three months following PFNA to lead future advances in PFNA surgery for older persons by comparing impacted and unaffected hips and correlating angles with patients' hip ratings.

Methods: This study included 42 individuals who underwent surgery for intertrochanteric fractures aged 50 and above. Eligible participants must possess the ability to walk before to the study, have no history of previous leg fractures, and be capable of participating in rehabilitation. Individuals having comorbidities impacting these aspects or those unable to partake were not included.

Result : This study looked at hip angles in 42 people who had surgery intertrochanteric fracture. While the participants varied in age and gender, the surgery itself didn't seem to significantly change the angles of their hip bones or their ability to walk. This suggests that PFNA may not directly affect hip mechanics on its own.

Conclusion: This study indicates that attaining acceptable hip angles during the procedure could enhance patients' mobility and post-operative condition. Further investigation involving bigger cohorts and extended periods of observation is necessary to validate these findings and ascertain whether modifying these angles during surgery will result in improved outcomes following PFNA.

***Keywords*:** Intertrochanteric fracture; Hip fracture; PFNA

INTRODUCTION

The intertrochanteric femoral fracture is a common fracture among elderly, which accounts for almost 50% of all hip fractures. The prevalence of this fracture is rising as a result of the growing elderly population. Proximal femoral nail antirotation (PFNA)

is a frequently employed surgical procedure for managing intertrochanteric femoral fractures. Studies have demonstrated that PFNA is useful in mitigating the likelihood of sequelae and enhancing the functional results of patients with this specific fracture.(Karakus et al., 2018; Li et al., 2021)

Nevertheless, certain patients who undergo PFNA surgery for intertrochanteric femoral fracture may encounter symptoms such as discomfort, stiffness, and abnormalities in their walking pattern. These symptoms may be associated with alterations in the radiological characteristics of the hip joint. The femoral neck-shaft angle (NSA), femoral offset (FO), and quadriceps angle (Q-Angle) are significant radiological factors that might impact the functionality of the hip joint. The NSA refers to the angle formed between the axis of the femoral neck and the axis of the femoral shaft. A reduction in neck-shaft angle (coxa vara) can elevate the susceptibility to stress fractures in the femoral neck. An increased in NSA (coxa valga) can increase the susceptibility to knee joint osteoarthritis. A reduction in femoral offset (FO), which is the measurement from the center of the femoral head to the lateral edge of the femoral shaft may result in a decrease in the lever arm and muscular power of the abductor muscles, thus, increasing the likelihood of hip joint dislocation. The Q-Angle represents the angular measurement between the quadriceps muscle's line of action and the patellar tendon's line of action. An elevation in Q-Angle can heighten the vulnerability to patellar maltracking and patellofemoral pain syndrome.(Singh et al., 2019; Skouras et al., 2022)

This study aims to evaluate and compare the radiological measurements of NSA (neck-shaft angle), FO (femoral offset), and Q-Angle (quadriceps angle) between the affected and unaffected hips of patients who underwent PFNA (proximal femoral nail antirotation) surgery for intertrochanteric femoral fracture, specifically at the 3-month postoperative mark. We further examined the correlation between these radiological characteristics and the Harris Hip Score (HHS) three months following the PFNA procedure.

MATERIALS & METHODS

The study was approved by the institutional ethics review board of our institution. From March 2023 to December 2023, a total of 42 patients with intertrochanter fracture who were treated with Proximal Femoral Nail Antirotation (PFNA) in Prof. Dr. dr. I.G.N.G. Ngoerah General Hospital were compared radiographically with the unaffected side three months following the procedure. The intertrochanter fracture was defined as an extracapsular proximal femoral fracture, with a fracture line that passes through both the major and minor trochanter. The diagnosis was made by conducting a thorough physical examination and radiological assessment, employing the Boyd and Griffin classification criteria, which categorizes the condition into types 1-4. The inclusion criteria were as follows: (1) Patients over 50 years of age with intertrochanteric femoral fracture after Proximal Femoral Nail Antirotation (PFNA) procedure. (2) Patients with no history of other fractures in both lower extremities. (3) Patients who were able to walk unassisted prior to the trauma. The exclusion criteria were: (1) Patients who have undergone internal fixation with a concomitant diagnosis of pathological fracture due to bone cancer. (2) Patients who are unable to follow the post-operative rehabilitation protocol. (3) Patients who refuse to participate in the study. (4) Patients with bilateral intertrochanteric fracture. (5) Patients with conditions that affect the Femoral Neck–Shaft Angle (NSA), Femoral Offset (FO), and Quadriceps Angle (Q-Angle) such as congenital deformities, Perthes' disease and avascular necrosis (AVN) head of femur and malunion fracture. The Proximal Femoral

Nail Antirotation (PFNA) procedure was performed in all 42 patients using Depuy Synthes (DePuy Synthes, Raynham, Massachusetts, USA) with the standard length of 240 mm and neck-shaft angle of 130 degree. The spiral blade points to the femoral neck and a 4.5 mm cortical screw on the distal nail was used for rotational fixation.

All statistical analyses were performed using SPSS Statistics version 24 (IBM Corp., Armonk, NY, USA. The variables were analysed using independent T-test, Pearson test, and Spearman correlation test. The level of significance was set at $P < 0.05$ for all statistical analyses.

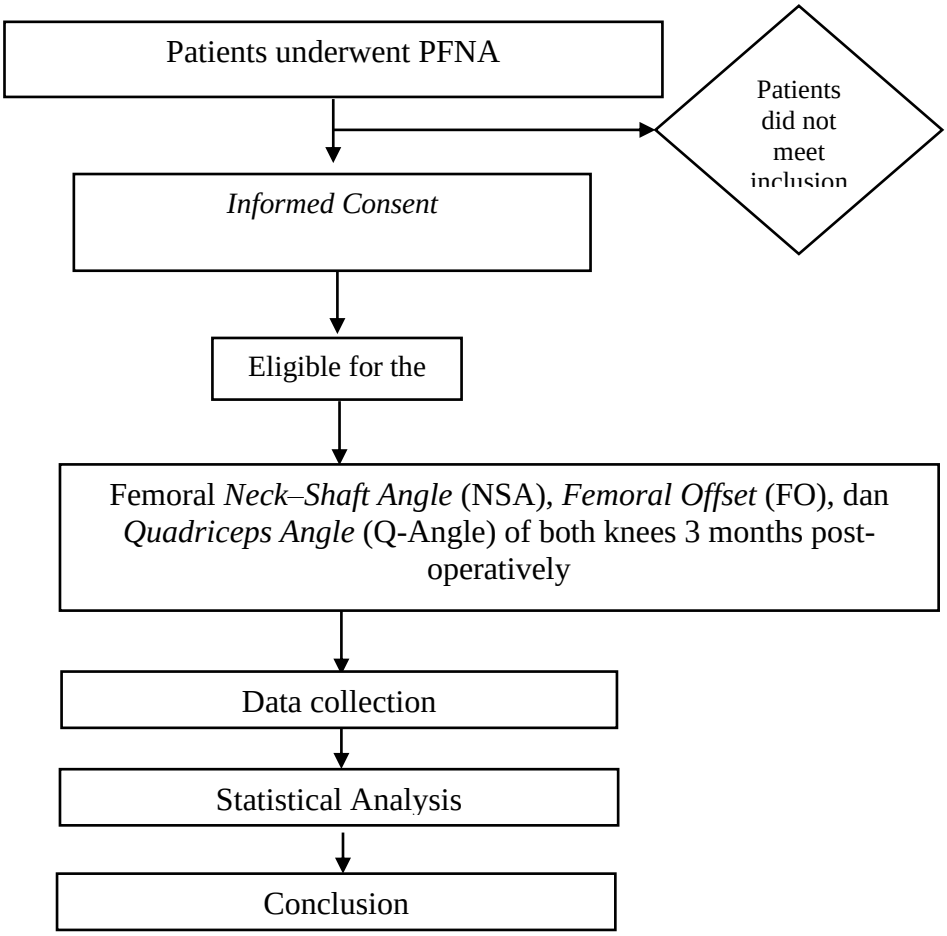

Figure 1. Flow Diagram Demonstrating Study Methods

RESULT

This study included 42 patients who underwent the Proximal Femoral Nail Antirotation (PFNA) operation as a treatment for intertrochanteric femoral fracture. The study participants show broad characteristics of patients. The mean age of the patients included in our study was 72.00 ± 12.3, indicating a variety of ages among our population. Furthermore, the research participants comprised both males and females, with a higher proportion of females of 28 individuals (49.4%).

Pearson correlation test was used to evaluate the relationship between Neck-Shaft Angle (NSA) and Harris Hip Score (HHS). The correlation coefficient is statistically significant with a p-value of less than 0.05. The study findings indicate that there was no statistically significant association between the Neck-Shaft Angle (NSA) variable and the Neck-Shaft Angle (NSA) itself, with a correlation coefficient of -

0.110 (indicating a very weak link) and a P value of 0.053. There is also no statistically significant distinction between the leg that underwent the PFNA procedure and the leg that did not undergo the PFNA procedure in terms of the Neck-Shaft Angle (NSA) with a p-value of 0.078, and in terms of the Quadriceps Angle (Q-Angle) with a p-value of 0.061. Similarly, for the Femoral Offset (FO), a p-value of 0.485 was obtained, suggesting no significant difference. The result between each functional outcome are shown in table 1 to table 3.

Functional Outcome		Correlation Coefficient	P Value
Neck-Shaft Angle (NSA)	Harris Hip Score (HHS)	-0,300	0,053

Table 1. Correlation Between Neck-Shaft Angle and Harris Hip Score

Functional Outcome		Correlation Coefficient	P-Value
Quadriceps Angle (Q-angle)	Harris Hip Score (HHS)	0,392	0,010

Table 2. Correlation Between Quadriceps Angle and Harris Hip Score

Functional Outcome		Correlation Coefficient	P Value
Femoral Offset (FO)	*Harris Hip Score* (HHS)	0,365	0,017

Table 3. Correlation Between Femoral Offset and Harris Hip Score

The independent t-test results indicated that the Neck-Shaft Angle (NSA) on the side that underwent the Proximal Femoral Nail Antirotation (PFNA) procedure had an average of 130.74 with a standard deviation of 4.905. In contrast, the normal side had an average NSA of 128.63 with a standard deviation of 5.923. The calculated P value was 0.078. Meanwhile, the study revealed that the Quadriceps Angle (Q-Angle) had an average of 15.49 ± 1.462 on the surgically treated side and 16.24 ± 20.82 on the healthy side, with a P value of 0.061.

DISCUSSION

This study evaluated the radiological measurement of both the damaged and healthy (contralateral) sides in patients who had undergone the Proximal Femoral Nail Antirotation (PFNA) operation for femoral intertrochanteric fracture. The measurements were taken 3 months following the procedure.

The study findings indicated that there was no statistically significant disparity in the Neck-Shaft Angle (NSA) (P = 0.078), Quadriceps Angle (Q-Angle) (P = 0.061), or Femoral Offset (FO) (P = 0.485) between the leg that received the PFNA operation and the leg that did not undergo the PFNA treatment. The study conducted by Ziabari et al. analyzed data from 80 patients with femoral fracture and compared it to a control group of 40 healthy persons. The study indicated that there was no statistically significant difference in the Neck-Shaft Angle (NSA) between patients with neck fracture and intertrochanteric fracture, and the control group (P>0.05). The average Neck-Shaft Angle (NSA) in patients with femoral neck fracture was 131.04±3.7°, whereas the average NSA in patients with intertrochanteric fracture was 132.07±4.1°. The average Neck-Shaft Angle (NSA) in the control group was 132.8±6.9°. This aligns with the current investigation conducted by Zia Ziabari et al. in 2020. Thus, it may be inferred that all the reduction outcomes in this study sample successfully attained a favorable Neck-Shaft Angle (NSA).(Kim et al., 2020; Singh et al., 2019; Zia Ziabari et al., 2020)

The study conducted by Chopra et al. examined patients with intertrochanteric fracture who received Dynamic Hip Screw (DHS) and Proximal Femoral Nail Antirotation (PFNA) fixation. The study focused on comparing the Neck-Shaft Angle (NSA) and Femoral Offset (FO) between the surgically treated side and the non-surgically treated side. The analysis data revealed a decrease of 3.9 ± 2.6 in the Neck-Shaft Angle (NSA) and a 5-degree increase in internal rotation in the Femoral Offset

(FO) on the side of the leg that received Proximal Femoral Nail Antirotation (PFNA) fixation, as compared to the side without PFNA fixation. The study demonstrated a disparity in the Neck-Shaft Angle (NSA) and Femoral Offset (FO) between intertrochanteric fracture patients who received Proximal Femoral Nail Antirotation (PFNA) fixation and the unaffected limb (Chopra et al., 2020). These findings align with the results of a study that compared the Femoral Offset (FO) of the side that received the Proximal Femoral Nail Antirotation (PFNA) surgery with the healthy side. It may be inferred that the reduction outcomes in this study group were satisfactory. (Cheng & Sheng, 2020; Chopra et al., 2020)

The Quadriceps Angle (Q-Angle) is the angle formed by the intersection of the center line of the patella and the center line of the tibial tuberosity. The Harris Hip Score (HHS) is a metric employed to assess the functionality and pain levels in individuals suffering from hip injury. The investigation revealed a significant correlation between the Quadriceps Angle (Q-Angle) and the Harris Hip Score (HHS) in patients who had undergone the PFNA operation for femoral intertrochanteric fracture. This correlation was shown after a 3-month period, with a p-value of less than 0.05. The Spearman correlation coefficient can be used to describe this relationship. A correlation coefficient approaching 1 shows a highly positive link between the Q-Angle and HHS. In contrast, when the coefficient value approaches -1, it signifies a robust negative correlation between the two variables. If the coefficient value tends towards 0, then the correlation between Quadriceps Angle (Q-Angle) and Harris Hip Score (HHS) might be considered weak or inconsequential. This study differs from the research conducted by Sanchez et al., as it specifically examined the variations in the Quadriceps Angle (Q-Angle) between two specific positions: external and internal rotation of the lower leg. The research employed a descriptive cross-sectional methodology, encompassing a sample of 62 participants, comprising 32 females and 30 males. The participants underwent evaluation in three specific positions: supine position with parallel legs, supine position with adduction (external rotation of the lower leg), and standing position with parallel legs and external rotation. All individuals had no previous record of sudden injury or any issues associated with the lower leg. The Quadriceps Angle (Q-Angle) was measured using the computerized biophotogrammetry method using the ALC image 2.1 (r) tool. The results of this investigation revealed notable disparities between standing with both feet aligned and assuming the orthostatic position with the feet elevated on the left side, for both males and females. There was a notable disparity observed between the supine position and the standing posture with the legs in abduction and parallel on the left side, particularly among women. These findings indicate that there is a notable disparity in the Quadriceps Angle (Q-Angle) when the legs are in abduction and parallel on the left side while standing. However, there is symmetry between the lower limbs regardless of leg rotation when in the supine position. This study presents empirical evidence investigating diagnostic tests for the Quadriceps Angle (Q-Angle) in various lower leg rotation postures (Sanchez et al., 2014). In 2022, Skouraz et al. conducted a study that revealed a moderate correlation between the two variables. Thus yet, there is a lack of studies that directly compare the two. (Gong et al., 2017; Skouras et al., 2022; You et al., 2023)

Present research is primarily centered around the Quadriceps Angle (Q-Angle) in the context of knee surgery. Nevertheless, the Quadriceps Angle (Q-Angle) is directly associated with the hip. The Q-Angle is a measure of the combined force exerted by the anterior thigh tendon and patella. The Quadriceps Angle (Q-Angle) is the angle produced by an imaginary line from the

anterior superior iliac spine (SIAS) of the pelvis to the midway of the patella, and a line projected from the tibial tubercle to the center of the patella. The Q-angle's size is affected by the positioning of pelvic rotation and foot placement. The Quadriceps Angle (Q-Angle) has clinical significance in various disorders and injuries, including patellofemoral pain (PFP), patellar subluxation and dislocation, chondromalacia patellae, knee osteoarthritis, overuse injuries, anterior ligament injuries, patellar instability, dynamic balance disorders, and ankle sprains. Chondromalacia, patellar instability, and PFP are all linked to a reduction in the Quadriceps Angle (Q-Angle). Contrarily, an alternative outcome is presented in a separate investigation. The study conducted by You et al. did not directly compare with HHS. However, their findings indicated that there was no statistically significant relationship ($p>0.10$) between the Quadriceps Angle (Q-Angle) and the assessment of knee pain using the SNAPPS questionnaire. The knee and hip are indirectly connected through the Quadriceps Angle (Q-Angle). The Quadriceps Angle (Q-Angle) is a measure of the combined force vector exerted by the anterior thigh tendon and patella.(Sanchez et al., 2014; You et al., 2023)

Femoral Offset (FO) is a quantitative measurement that characterizes the spatial separation between the central axis of the femoral head and the central axis of the femoral shaft. The Harris Hip Score (HHS) is a metric employed to assess the functional outcome and pain levels in the hip of individuals who have had hip injuries. Furthermore, it diverges from the research conducted by Cheng et al. The objective of this study was to assess the impact of Femoral Offset (FO) on the functional result following Proximal Femoral Nail Antirotation (PFNA) fixation in cases of femoral intertrochanteric fracture. An investigation was conducted on a cohort of 112 patients who underwent Proximal Femoral Nail Antirotation (PFNA) fixation surgery between May 2017 and June 2019. Prior to the surgery, the hip underwent X-Ray and CT scan procedures, and an additional X-Ray examination was conducted on the first day following the surgery. The patients were subsequently categorized into two groups according to the disparity in bilateral Femoral Offset (FO): group A with a Femoral Offset (FO) difference of < 5 mm, and group B with a Femoral Offset (FO) difference beyond 5 mm. There were no notable distinctions between the two groups for patient characteristics, including gender, age, operation side, and Harris Hip Score (HHS) prior to surgery. The Harris Hip Score (HHS) was evaluated at 6- and 12-months post-surgery for both groups. Additionally, the relationship between the difference in Femoral Offset (FO) and the Harris Hip Score (HHS) was examined. The findings indicated a considerable disparity in the Harris Hip Score (HHS) between the groups at 6- and 12-months post-surgery. Additionally, a negative connection was seen between the difference in bilateral Femoral Offset (FO) and the Harris Hip Score (HHS) at 6 and 12 months following the operation. Greater disparity in Femoral Offset (FO) between the two sides during the treatment of intertrochanteric fracture with Proximal Femoral Nail Antirotation (PFNA) is linked to poorer patient function following surgery. Hence, it is crucial to attain a precise Femoral Offset (FO) (with a maximum variation of 5 mm between the two sides) in order to enhance the patient's postoperative functional outcome. (Buecking et al., 2015; Cheng & Sheng, 2020)

The Femoral Offset (FO) exhibits a favorable correlation with the strength of the hip abductors, particularly the gluteus medius muscle. A study revealed that a Femoral Offset (FO) over 5 mm in comparison to the non-implanted side was linked to unfavorable functional improvement results, weakened hip abductor muscles, irregularities in gait, and

an increased reliance on assistive device. (Hu et al., 2021; Mahmood et al., 2016; Wamper et al., 2010) Furthermore, a further investigation conducted by Hu et al. in 2021 demonstrated that an increase in Femoral Offset (FO) resulted in heightened polyethylene wear, micro-motion on the implant surface, and a diminished 5-year success rate, ultimately leading to complaints of pain and reduced functionality. A study conducted by Mahmood et al in 2016 demonstrated that even slight changes in femoral lateralization, also known as Femoral Offset (FO), resulted in improved outcomes as measured by the Harris Hip Score (HHS). Hence, it is crucial to optimize the Femoral Offset (FO) in order to restore the physiological functioning of hip muscles during hip surgery. (Hu et al., 2021; Mahmood et al., 2016; Wamper et al., 2010) This study focuses on the radiological differences on both legs following PFNA procedure. Our study has the limitation of a small sample size due to its nature of single centre trial. Due to the short period of follow up (minimum nine months), long term follow-ups cannot be evaluated any further.

CONCLUSION

This study found the potential impact of PFNA on long-term hip function in patients with intertrochanteric fractures. While achieving perfect anatomical restoration may not always be possible, optimizing radiological parameters during surgery might be crucial for improving functional outcomes and patient quality of life. Further studies with larger sample sizes and longer follow-up periods are needed to confirm these findings and explore the potential benefits of optimizing radiological parameters to improve functional outcomes after PFNA surgery.

Declaration by Authors

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Conflict of Interest: The authors declare no conflict of interest.

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