Original Article

Does the Proximal Femur Geometry Predict Early Functional Outcome after Plate Fixation of Geriatric Pertrochanteric Fractures?

CO Uzuegbunam, AU Katchy[1], UE Anyaehie, CC Agu[2], O Ede, EC Iyidobi, CU Nwadinigwe, ON Muoghalu, CL Ngwangwa, U Essien-Adetula, SC Uzodimma

Departments of Orthopaedics and Trauma, [2]Radiology, National Orthopaedic Hospital, Enugu, [1]Department of Accident and Emergency, University of Nigeria Teaching Hospital, Ituku-Ozalla, Enugu State, Nigeria

Received: 11-Apr-2023;
Revision: 21-May-2023;
Accepted: 19-Jul-2023;
Published: 04-Dec-2023

Abstract

Background: The proximal femur geometry determines the hip force distribution. The femoral neck axis length (FNAL), the hip axis length (HAL), the femoral head diameter, and the femoral neck-shaft angle (FNSA) could influence the risk and outcome of pertrochanteric fractures. Restoring these parameters to their prefracture values could predict early hip function. **Aim:** To determine if the postoperative proximal femur geometry of geriatric patients with plating for pertrochanteric fractures predicts the early functional outcome. **Materials and Methods:** The study was a prospective study carried out at the National Orthopaedic Hospital Enugu for 18 months. Geriatric patients who had Proximal Femoral Locking fixation for pertrochanteric fractures were recruited. Radiological parameters of the proximal femur in the unaffected and fixed hips were measured and compared. The functional outcomes of the patients were measured at 3 months postoperative period using the Harris hip score (HHS). Multiple linear regression was conducted on the parameters to determine the HHS. **Results:** Thirty patients participated in the study, with a significant difference ($P < 0.001$) in the mean FNSA between unaffected (M = 128.69, standard deviation (SD) =2.93) and operated hips (M = 121.81, SD = 8.86). The FNSA was the only significant predictor of hip function, with a 1-degree increase improving the HHS by 1.30. **Conclusion:** There is a significant difference in the FNSA between the unaffected and the operated hips. The FNSA significantly predicts the early hip function and should be reconstructed to within normal range during surgery.

Keywords: *Fracture, geometry, outcome, prediction, proximal femur*

Introduction

Geriatric pertrochanteric fractures are common injuries that can lead to significant morbidity and mortality with rising incidences.[1-3] Surgical fixation and rapid mobilization are often recommended to allow early rehabilitation, but there is a need to identify predictors of early functional outcomes to optimize patient care.[2] Many studies have examined the relationship between proximal geometry and fracture risks,[4-7] but few have studied its influence on functional outcomes.[8,9] The conclusion was that poor prefracture proximal femoral geometry restoration adversely affected the functional result of surgery.

Thus, good outcomes require restoring a fractured hip's proximal femur geometric anatomy to its preinjury state. However, many proximal femur indices have been studied. This study focused on parameters altered by pertrochanteric fractures that can be restored during surgery. They include the hip axis length (HAL), femur neck axis length (FNAL), and neck-shaft angle (FNSA). These values are usually altered by fracture fragment

Address for correspondence: Dr. O Ede, Department of Orthopaedics and Trauma, National Orthopaedic Hospital, Enugu - 400 103, Nigeria.
E-mail: edeosita@yahoo.com

How to cite this article: Uzuegbunam CO, Katchy AU, Anyaehie UE, Agu CC, Ede O, Iyidobi EC, *et al.* Does the proximal femur geometry predict early functional outcome after plate fixation of geriatric pertrochanteric fractures? Niger J Clin Pract 2023;26:1647-51.

Access this article online

Quick Response Code:

Website: www.njcponline.com

DOI: 10.4103/njcp.njcp_282_23

impaction, varus, or valgus angulation of the fracture plane, and correcting such deformities is crucial to restoring normal anatomy. Therefore, this research seeks to answer whether the proximal femoral geometry predicts early hip function in geriatric patients with pertrochanteric fractures treated with a proximal femoral locking plate.

The Harris hip score (HHS) is a commonly used tool to assess the function and outcome of hip surgery.[10-13] It measures the pain, function, and mobility level of the hip joint and is often used to track patients' progress after hip surgeries.[10,11] The HHS consists of questions that evaluate various aspects of hip function, such as pain level, ability to walk, and range of motion. Scores range from 0 to 100 and are grouped into excellent (90-100), good (80-89), fair (70-79), and poor (<70). Although the HHS is a widely recognized and validated tool for assessing hip function and outcomes, it has limitations. It may not capture all aspects of hip function that are important to a patient.[13] It is also criticized for its ceiling effect, whereby it cannot fully assess those scoring at the highest functional end of the scale.[12]

Materials and Methods

This study included 30 geriatric patients with pertrochanteric (intertrochanteric and subtrochanteric) fractures prospectively recruited from the accident and emergency unit and surgical outpatient clinic of National Orthopaedic Hospital Enugu, South-East Nigeria. The inclusion criteria were patients aged 65 and above with acute (less than 4 weeks) unilateral intertrochanteric or subtrochanteric fractures undergoing surgery with proximal femoral locking plates. The exclusion criteria were pathological and neglected fractures (longer than 4 weeks), bilateral hip fractures, cognitive dysfunction, use of a walking aid before the injury, and refusal of consent. Informed consent was obtained from all patients and documented.

All patients received digital radiography using a standard protocol, including an anteroposterior (AP) view of the pelvis at a film-object distance of 100 cm. The pelvic AP views were taken with the patient supine, with the beam centered over the pubic symphysis, with the unaffected hip internally rotated 10–15 degrees to balance physiologic anteversion. A 30-millimeter radio-opaque ruler was taped to the pubic symphysis to serve as a reference. After the x-ray, an independent assessor measured the FNSA, FNAL, and HAL pre-and postoperatively 3 months after surgery. The HAL is the distance between the greater trochanter's lateral edge and the pelvis's inner table, while the FNAL is a component of the HAL. It is the distance between the greater trochanter's lateral edge and the femoral head's apex. The FNSA is the angle between the neck axis and the femur shaft [Figure 1].

The procedures were done by a consultant or a senior registrar under the supervision of a consultant. They all used a direct lateral hip approach and achieved fracture reduction under imaging before plating. The HHS was calculated at three months postsurgery. The patients were grouped based on these scores into poor (<70), fair (70-79), good (80-89), and excellent (90-100) groups. The mean values of the normal and operated proximal femur were compared with the paired samples *t*-test. At the same time, multiple linear regression was conducted to determine the significant predictors of HHS among the studied parameters. All analyses were two-tailed and done with the IBM SPSS version 26, and a *P*-value less than 0.05 was deemed significant.

Result

Thirty geriatric patients participated in the study with a mean age of 75.37 years (standard deviation (SD) =7.81). Table 1 summarizes the subjects' characteristics. Only the FNSA significantly differed between the normal

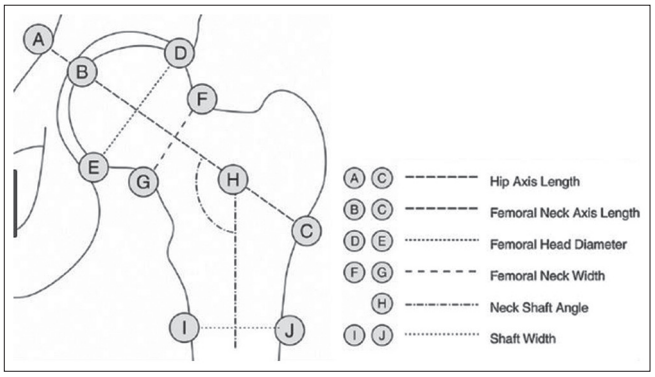

Figure 1: The proximal femoral parameters showing the HAL (AC), FNAL (BC), and FNSA (H)

Table 1: The patients' characteristics, *n*=30

Variable	Variable subgroup	*n*	%
Gender	Male	14	46.67
	Female	16	53.33
Age category (years)	65–74	14	46.67
	75–84	13	43.33
	85–94	3	10.00
Injury etiology	Ground Level Fall	15	50.00
	Road Traffic Accident	11	36.67
	Fall From Height	3	10.00
	Sports Injury	1	3.33
Fracture type	Intertrochanteric Fracture	16	53.33
	Subtrochanteric Fracture	12	40.00
	Pertrochanteric Fracture	2	6.67
Side affected	Right	19	63.33
	Left	11	36.67

and operated sides, with the operated side six degrees less than the normal side, implying a residual varus deformity. Table 2 shows the mean values of the proximal femoral parameters.

The three-month HHS was 63.17 (SD = 15.71) and correlated strongly with the FNSA, r = 0.785, $P < 0.001$. In contrast, it showed an insignificant, weak correlation with the HAL, r = 0.175, $P = 0.178$, and the FNAL, r = 0.086, $P = 0.327$. Figure 2 illustrates the scatterplot between the HHS and the FNSA. The multiple linear regression model was significant, with an r-squared of 0.622 and an adjusted r-squared of 0.578, implying that the predictor variables explain 62% of the variation in the HHS. This explanation falls to 58% after adjusting for the inclusion of nonsignificant variables. Table 3 is the coefficients table for the regression. Only the FNSA significantly predicts HHS at 3 months, with each degree increase in the FNSA improving HHS by 1.3.

Discussion

This study examined the proximal femoral parameters that predict early functional outcomes in geriatric patients with open reduction and internal fixation of pertrochanteric fractures with proximal femoral locking plates. It is hypothesized that biomechanical considerations can explain the relationship between proximal femur geometry and the early functional outcome.[8,9] Changes in the geometry of the proximal femur may affect the distribution of forces across the hip joint, leading to altered load transmission and potential complications, such as implant failure or impaired bone healing. Moreover, variations in proximal femur geometry may influence the stability of the fixation construct, impacting the overall mechanical integrity and functional recovery.[8,9] The documented patients' characteristics concurred with the findings of many authors. For example, females slightly predominated in this study which supports the results that hip fractures are commoner in females.[14,15] In addition, the mean age of the subjects was 75 years. Many studies reported a higher average age for extracapsular than intracapsular fractures in elderly individuals.[16] Also, the ground-level fall is the commonest etiology substantiating low energy injury being the most common mechanism in this group of people.[16]

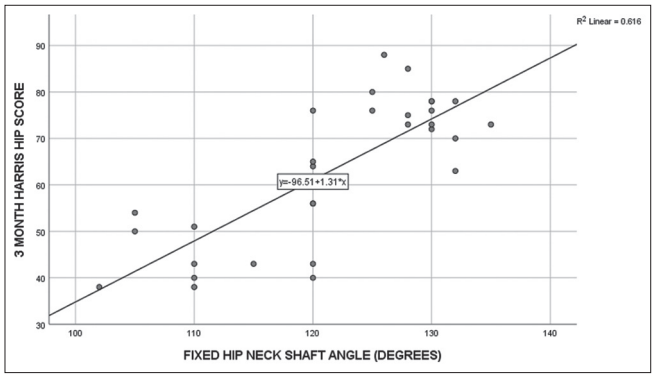

Figure 2: The scatterplot of the 3-month HHS and the FNSA showing a strong positive relationship

This study showed a significant difference in the mean FNSA between the normal and operated hip. Differences in the neck shaft angles between the two sides in the same individuals have been documented in many observational studies, with some significant[17,18] and others insignificant.[19-21] However, the 121.60^0 on the operated side lies below two SDs of the average value from other local studies on the proximal femoral geometry.[7,19,22] Therefore, this implies a varus position of the neck.

Only the neck shaft angle correlated significantly with the HHS at 3 months. The correlation was positive and

Table 2: The proximal femur parameters of the participants, *n*=30

Variable	Normal hip (mean±SD)	Operated hip (mean±SD)	Mean diff.	SE of the mean diff.	95% confidence interval of the difference		*t*	Sig.
					Lower	Upper		
Hip axis length (mm)	103.90±4.67	103.70±4.94	0.20	0.237	-0.284	0.684	0.844	0.405
Femur neck axis length (mm)	94.63±4.68	94.77±4.80	-0.13	0.351	-0.852	0.585	-0.379	0.707
Hip neck shaft angle (degrees)	128.53±2.74	121.60±9.39	6.93	1.801	3.250	10.617	3.850	0.001

Table 3: The regression coefficients for the proximal femoral parameters, *n*=30

Variable	*B*	SE	β	*t*-statistic	Sig.	95% confidence interval for b	
						Lower	Upper
HAL (mm)	0.207	0.571	0.065	0.362	0.720	-0.967	1.382
FNAL (mm)	0.042	0.582	0.013	0.072	0.943	-1.155	1.239
FNSA (degrees)	1.298	0.204	0.776	6.352	<0.001*	0.878	1.719

a. The outcome variable is the 3-month HHS. *significant at $P<0.005$. b. b is the unstandardized coefficient. c. SE is the standard error for b. d. β is the standardized coefficient

strong, meaning that a higher neck shaft angle improves the Haris hip score. However, because of the ceiling effect of the neck shaft angle in this study, 135^0 was the highest angle recorded; it is unclear if this relationship holds when the upper limit of the neck shaft angle is exceeded.

Similarly, only the neck shaft angle significantly predicted the Harris hip scores at three months, with a one-degree increase in the angle raising the HHS by 1.3 points. These findings correspond with works done by Pulkinene *et al*. and various other studies that found that the neck shaft angle was the most significant predictor of functional outcomes postoperatively.[9,23] These studies documented that shortening and varus collapse of the proximal fragment after hip fracture fixation is the most common malreduction regardless of the chosen implant. This loss of reduction might result in nonunion or malunion, which can affect hip function. By collapsing into varus, frequently associated with shortening, the abductor lever arm is shortened, affecting gait and quality of life. Pulkinene *et al*.[23] reported that varus collapse and shortening was the only significant predictor of quality of life after assessing 660 patients with hip fracture fixation.

Conclusion

Only the femoral neck shaft angle significantly predicted early hip function in this study. Therefore, surgeons must reduce the fracture to within normal ranges and avoid a varus malreduction.

Acknowledgment

The authors thank the management and staff that permitted the study to be conducted in their institutions.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Kanis JA, Odén A, McCloskey EV, Johansson H, Wahl DA, Cooper C, *et al*. A systematic review of hip fracture incidence and probability of fracture worldwide. Osteoporos Int 2012;23:2239-56.
2. Koval JK, Zuckerman JD. Hip fractures: A practical guide to management. 1st edition. New York: Springer- Verlag Inc. 2000. Chapter 4: Treatment Principles; p37-48. https://doi.org/10.1007/978-1-4757-4052-3.
3. Orimo H. Epidemiology of fractures in Asia. In: Christiansen C, Overgaard k, eds. Proceedings of the Third International Symposium on Osteoporosis. Copenhagen: Osteopress, 1990:66-70.
4. Kazemi SM, Qoreishy M, Keipourfard A, Sajjadi MM, Shokraneh S. Effects of hip geometry on fracture patterns of proximal femur. Arch Bone Jt Surg 2016;4:248-52.
5. Cummings SR, Cauley JA, Palermo L, Ross PD, Wasnich RD, Black D, *et al*. Racial differences in hip axis lengths might explain racial differences in rates of hip fracture. Study of Osteoporotic Fractures Research Group. Osteoporos Int 1994;4:226-9.
6. Ede O, Nwadinigwe CU, Eyichukwu GO, Madu K, Anyaehie U, Iyidobi EC, *et al*. Radiographic assessment of the proximal femoral anatomy in an indeginous adult african population. Int J Anat Res 2021;9:8034-39.
7. Obande BO, Iyidobi EC, Eyichukwu GO, Nwadinigwe CU, Ekwunife RT, Ede O. Is the femoral neck-shaft angle an independent risk factor for hip fractures? An observational study. Int J Res Orthop 2019;5:1032-36.
8. Aly T. Importance of restoration of proximal femur geometry in the management of intertrochanteric fractures using dynamic hip screw in Egyptian population. Orthoped Rheumatol Open Access J (OROAJ) 2017;8.
9. Pulkkinen P, Partanen J, Jalovaara P, Jämsä T. Combination of bone mineral density and upper femur geometry improves the prediction of hip fracture. Osteoporos Int 2004;15:274-80.
10. Azboy I, Demirtaş A, Gem M, Cakır IA, Tutak Y. A comparison of proximal femoral locking plate versus 95-degree angled blade plate in the treatment of reverse intertrochanteric fractures. Eklem Hastalik Cerrahisi 2014;25:15-20.
11. Ibrahim S, Meleppuram JJ. A retrospective analysis of surgically-treated complex proximal femur fractures with proximal femoral locking compression plate. Rev Bras Ortop 2017;52:644-50.
12. Wamper KE, Sierevelt IN, Poolman RW, Bhandari M, Haverkamp D. The Harris hip score: Do ceiling effects limit its usefulness in orthopedics? Acta Orthop 2010;81:703-7.
13. Reuling EM, Sierevelt IN, van den Bekerom MP, Hilverdink EF, Schnater JM, van Dijk CN, *et al*. Predictors of functional outcome following femoral neck fractures treated with an arthroplasty: Limitations of the Harris hip score. Arch Orthop Trauma Surg 2012;132:249-56.
14. Alpantaki K, Papadaki C, Raptis K, Dretakis K, Samonis G, Koutserimpas C. Gender and age differences in hip fracture types among elderly: A retrospective cohort study. Maedica (Bucur) 2020;15:185-90.
15. Brauer CA, Coca-Perraillon M, Cutler DM, Rosen AB. Incidence and mortality of hip fractures in the United States. JAMA 2009;302:1573-9.
16. Ahuja K, Sen S, Dhanwal D. Risk factors and epidemiological profile of hip fractures in Indian population: A case-control study. Osteoporos Sarcopenia 2017;3:138-48.
17. Adekoya-Cole TO, Akinmokun OI, Soyebi KO, Oguche OE. Femoral neck shaft angles: A radiological anthropometry study. Niger Postgrad Med J 2016;23:17-20.
18. Gilligan I, Chandraphak S, Mahakkanukrauh P. Femoral neck-shaft angle in humans: Variation relating to climate, clothing, lifestyle, sex, age and side. J Anat 2013;223:133-51.
19. Iyidobi EC, Obande BO, Eyichukwu GO, Nwadinigwe CU, Ekwunife RT, Ede O, *et al*. Assessment of the femoral neck-shaft angles of adults in Nigeria: Establishing an age and gender stratified reference values. Asian J Orthopaed Res 2020;3:80-6. Retrieved from https://journalajorr.com/index.php/AJORR/article/view/46. [Last accessed on 2023 Feb 20].
20. Nwoha PU. The collodiaphyseal angle of the femur in adult Nigerians. Afr J Med Med Sci 1991;20:143-7.
21. Jing G, Yia-wei S, Xiao S. Mechanical analysis and computer

simulation of the structure of femoral neck [online]; 2006. Available from: http://asbweb.org/conferences/2 006/pdfs/269.pdf. [Last accessed on 2014 Apr].

22. Ede O, Nwadinigwe CU, Eyichukwu GO, Madu K, Anyaehie U, Iyidobi EC, *et al*. Radiographic assessment of the proximal femoral anatomy in an indigenous african adult population. IJAR 2021;9:8034-9.
23. Zlowodzki M, Brink O, Switzer J, Wingerter S, Woodall J Jr, Petrisor BA, *et al*. The effect of shortening and varus collapse of the femoral neck on function after fixation of intracapsular fracture of the hip: A multi-center cohort study. J Bone Joint Surg Br 2008;90:1487-94.