



E-ISSN: 2395-1958
P-ISSN: 2706-6630
IJOS 2021; 7(2): 428-435
© 2021 IJOS
www.orthopaper.com
Received: 11-02-2021
Accepted: 18-03-2021

Amit J Patel
Department of Orthopedics,
Pramukhswami Medical College,
Karamsad, Gujarat, India

Mrudev V Gandhi
Department of Orthopedics,
Pramukhswami Medical College,
Karamsad, Gujarat, India

A radiological study of proximal femoral geometry and its relationship with hip fractures in Indian population

Amit J Patel and Mrudev V Gandhi

DOI: <https://doi.org/10.22271/ortho.2021.v7.i2f.2659>

Abstract

Context: In literature there is scarcity of documentation to test the relationship of radiological geometry of proximal femur with incidence and patterns of hip fractures especially in Indian population. In this study radiological parameters like Femoral Neck Length (FNL), Hip Axis Length (HAL), Neck Shaft Angle (NSA), Femoral Neck Diameter (FND) and Femoral Head Diameter (FHD) are measured in standardized digital pelvis radiograph of patients with hip fractures presented at a tertiary care hospital and efforts were made to establish a relationship of these parameters with the pattern of hip fractures in Indian population.

Aims: The objective of the study is to investigate as to whether a particular type of proximal femoral morphology (*viz.* Femoral Neck Length, Hip Axis Length, Neck Shaft Angle, Femur head diameter and Femoral Neck diameter) determines and predicts the anatomical location of various types of hip fractures (1. Intracapsular (femoral neck) fractures – subtypes – subcapital; transcervical and basicervical neck femur fractures, 2. Extracapsular – subtypes – intertrochanteric; intertrochanteric with subtrochanteric extension and subtrochanteric fractures).

Settings and Design: Cross sectional observational study

Methods and Material: A cross sectional analysis was made in our hospital of a population of 100 patients with hip fractures (Intracapsular and Extracapsular). Study was conducted during 18/10/2019 to 30/09/2020. FNL, HAL, FND, FHD and NSA were measured on standardized digital pelvis radiograph by using an advanced computer software.

Statistical analysis used: Independent sample t-test.

Results: The sample size was divided into two age groups a younger age group (31-60years) and older age group (61-90years). For both age groups, means and standard deviations for all five parameters were calculated. We observed that for older age group, HAL is higher for extracapsular fractures than for intracapsular fractures. FNAL is increased for extracapsular fractures for the whole sample size as well as for older group. There was no significance for FHD, FND and NSA for any of the age groups for any type of fracture.

Conclusions: In our study, we concluded that the HAL is significantly increased for extracapsular fractures than for intracapsular fractures in old age group of 61-90 years. FNAL is also found to be higher for extracapsular hip fractures in the same age group as well as the whole sample size. In our study, we could not establish any significant correlation between FHD, FND and NSA in any age group for any fracture type.

Keywords: Proximal femur, geometry, pelvis x-ray, hip fractures

Introduction

Fractures around Hip are common and comprise 20% of the operative workload of an orthopedic trauma unit globally [1]. The lifetime risk of a person of sustaining a hip fracture is high and lies within the range of 40% to 50% in women and 13% to 22% in men. Life expectancy is increasing worldwide, and these demographic changes can be expected to cause the number of hip fractures occurring worldwide to increase from 1.66 million in 1990 to 6.26 million in 2050 [2]. Hip fractures are common problem seen in orthopaedic department and are associated with high mortality rate in aged population [3]. Of all the hip fractures, neck of femur fracture constitutes approximately 50% and rest 50 % includes all extra-capsular fractures [3].

Corresponding Author:
Amit J Patel
Department of Orthopedics,
Pramukhswami Medical College,
Karamsad, Gujarat, India

There is paucity of literature available on hip fracture rates in India [5]. Hip fracture is an established health problem in the West and is increasingly recognized as a growing problem in Asia as per the Asian Audit Report, 2009 [4].

The available data on gender and race/ethnicity differences in hip fracture remain limited [5]. Most clinical trials and research on hip fracture outcomes have focused on women, particularly white women, as this is the demographic with the highest incidence of hip fracture [6].

Pertrochanteric proximal femoral fractures are of intense interest globally. They are the most frequently operated fracture type, have the highest postoperative fatality rate of surgically treated fractures, and have become a serious health resource issue due to the high cost of care required after injury. The reason for the high cost of care is primarily related to the poor recovery of functional independence after conventional fracture care in many patients.

Considering the above, a study was undertaken to understand and establish a relationship between proximal femur geometry and anatomical location of proximal femur fracture in Indian population and to find out whether the combination of the parameters - hip axis length, femoral neck axis length, neck shaft angle, femoral head diameter and femoral neck diameter is able to predict the occurrence of a specific type of proximal femoral fracture.

Material and methods

Study group

All those patients with proximal femur fractures who attended the out-patient department and the TEC of the Shree Krishna Hospital, Karamsad, between the periods of 18/10/2019 to 30/9/2020 were considered for the study.

Based on the initial X-rays presented they were classified into two distinct groups according to the pattern of fracture they have sustained. Thus the two groups are (1) Intracapsular (neck of femur) fractures with subtypes – (a) subcapital, (b) trans cervical and (c) basi-cervical and the (2) Extracapsular fractures with subtypes (a) intertrochanteric fractures, intertrochanteric fractures with subtrochanteric extension and (c) subtrochanteric fracture.

Those patients who were skeletally immature (<18yrs) are not accounted for the study. The individuals on steroids treatment for any medical elements were excluded. In some patients who are suffering from the congenital anomalies and the paralytic disorders like polio were not included further for the study. All those patients who presented to the trauma ward were evaluated for associated injuries. Those patients who had head injury/ pneumo or hemothorax or pelvic fractures or the fractures involving the skeletal extremities are not included.

Now all the remaining patients who were screened out were considered for the rest of the study. These patients were subjected to digital X ray pelvis with both hips antero-posterior view with traction and internal rotation of limbs by 15 degree.

The digital X rays taken have been standard in initial series with Conn's method [7] of placing a marker of known diameter beside the thigh at the level of the femur in which here a standard size universal coin was used.

Measurement protocol

Once the film has been taken, the hip fracture was classified according to its anatomical location i.e. Fracture neck of femur, Intertrochanteric fracture. Then measurement of FNL, HAL, NSA, FHD and FND was done for every patient from

the opposite uninvolved limb, in the central radiology console in PACS software of the Radiology Department of Shree Krishna Hospital, Karamsad.

For measurements, a line was drawn that was perpendicular to a line drawn at the narrowest portion of neck and medially passes through the center of head. This was considered femoral neck axis [8]. This line was extended medially up to a point on inner pelvic table and laterally up to outer cortex. The distance is measured in cm and was called as HAL. FNAL is a component of HAL and it is measured on the line drawn for HAL as the linear distance from the base of the greater trochanter to the apex of the femoral head [9]. The NSA is the angle between a line along the anatomical axis of the shaft of femur and anatomical axis of neck.

FND is measured on the line drawn for HAL as the shortest distance between the outer-superior edge of the femoral neck and the lateral cortex of the medial-inferior margin and FHD by superimposing a circle of particular diameter over head of femur on the X-ray and measuring its diameter.

Statistical analysis

Descriptive statistics Mean (SD), Median [IQR] and frequency (%) were calculated to portray the demographic and clinical characteristics of the study population. Independent sample t test, was used to compare radiological parameter (HAL, FNAL, HD, ND and NSA) for fracture types.

Results

The calculated frequency of the fracture suggests high incidents of hip fractures in female population. As been stated in literature hip fractures are old age fractures. Age group of 71-80 is found to be the group with highest incidence of hip fractures. More than 2/3rd fractures are extracapsular. In extracapsular fracture, intertrochanteric fracture was found to be most common which 57 out of 100 candidates is. In intracapsular fracture subcapital neck femur fractures are more common. We observed, in both sex groups extracapsular fractures are much more common than intracapsular fractures and intracapsular fractures are more common in female population.

We calculated the mean value and standard deviation to the mean for each variable for both extracapsular as well as intracapsular fractures. Using t test we carried out the p-value for each parameter and observed that for the whole sample size FNAL only with the p- value of 0.005 was significant. The mean FNAL for intracapsular fractures was 10.07 with standard deviation of 0.67 and for extracapsular fractures was 10.59 with standard deviation of 0.89 suggesting that FNAL is higher for extracapsular fractures than for intracapsular fractures in whole population. Rest of the parameters did not have any significance.

We extended the study by dividing the whole sample size into two age groups, younger age group (31-60years) and older age group (61-90years) and did the same calculations again for both young and old population. We observed that in young age group, p-value for none of the parameters was less than 0.05 and so we found no parameter to be significantly associated with any of the fracture type.

For the older age group, p-value for HAL was 0.04 which was significant. For this age group mean HAL for intracapsular fractures was 11.98 with standard deviation of 0.99 and for extracapsular fractures was 12.51 with standard deviation of 1.05. Thus in our study we observed that HAL is increased in patients with extracapsular hip fractures in old age group.

Similarly the p-value for FNAL for older age group was 0.007 which was also significant. Mean FNAL for this age group for intracapsular fractures was 10.05 with standard deviation of 0.72 and for extracapsular fractures was 10.64 with standard deviation of 0.89. And so we can state that FNAL is also increased in patients with extracapsular hip fractures than intracapsular hip fractures in old age group. Since FNAL is a part of HAL we can relate this significance.

For FHD, FND and NSA no significance was found for the older age group also same as for younger age group.

Considering all these we can say that in this study we found significance for FNAL for the whole population and HAL and FNAL for the old population.

Discussion

Geometry of proximal femur has been shown to be important for the evaluation of risk of fractures in literature. The mechanical properties of bone at tissue level are determined by structure of the bone and quality of the bone. It is necessary to evaluate the structural anatomy of the bone to predict the fracture pattern and incidence.

It has been well established that a significant role is played by the geometrical configuration and the bio-material characteristics in providing strength to a structure. To evaluate a fracture completely it is mandatory to evaluate the construct of the bone in terms of the geometry as well as the material the bone is made of. The calcified matrix within the bone determine the bone density.

In selecting the parameters, we regarded the proximal femur as a cantilever and assumed that the angle, length and diameters are of most importance in determining fracture patterns. Of these; HAL, FNAL and NSA were considered to be the most reliable measures to be determined in our study. While studying these parameters we also studied the significance of diameter of femur head and neck in determining the pattern of fracture.

With a large sample size in our study we tried to find out the mean values for five different radiological parameters for all fracture types and tried to find if there is a significance for all these parameters with a specific type of fracture.

In our study some simpler calculations to find out the incidence of hip fractures suggested increased incidence of hip fractures in females. We calculated incidence of each type and subtypes of fracture. We observed extracapsular fractures to be more common and in it intertrochanteric fracture was the commonest of all. We also carried out the cross relation between both male and sex groups and the incidence of each fracture type. We observed that in both the age groups extracapsular fractures are more common. According to the analysis intercapsular fractures are relatively more common in females (62%) than in males (38%). This is supported in a study by Pulkkinen *et al.* [10], where intra capsular fractures were significantly higher in women (74%), than in men (49%).

We took the whole sample size and classified the fracture type into two major types extra and intracapsular fractures. We then calculated the mean value of each of the five radiological parameters i.e. HAL, FNAL, FHD, FND and NSA with their respective standard deviations. We applied independent sample t-test for all parameters and calculated the p-values.

We observed that for FNAL the p-value was significant which suggested that FNAL is a parameter which has some association with the type of fracture and a positive relationship could be established between hip fractures and FNAL which was supported by other studies also [11]. In 1999, Yang and Wang SS *et al.*, in their work "Proximal femoral dimension in the elderly Chinese women with hip fractures in Taiwan" [11], concluded that in their study that individuals with increased femoral neck length (FNL) are predisposed to proximal hip fractures on comparison with the normal subjects. A meta-analysis of literature by Fajar *et al.* in 2017 found out six articles evaluating the association between FNAL and femoral neck fractures [12]. Two of them found positive correlation [13, 14] and rest four stated otherwise.

For a more extensive analysis we divided the sample size into two age groups, one had relatively younger patients from age 31 to 60 years and another with older patients from age 61-90. We then recalculated the mean values of each parameter for both intracapsular and extracapsular fractures for both young and old age groups. Again applying independent sample t-test we calculated p-values for each parameters. We observed that for younger population none of the parameter is found significantly associated with any of the fracture pattern. The significance we got with the whole sample size for FNAL must be due to its' significance in old population. So the hip fractures occurring in young age could not be significantly associated with the geometry.

For the age group 61-90 years, HAL was found significantly increased in extracapsular type of hip fractures than in intracapsular hip fractures. In hip geometry, HAL is defined as the distance from the pelvic rim to the outer margin of greater trochanter along the neck axis [15]. In literature we found around 10 articles evaluating the correlation between HAL and proximal femur fractures. Of these ten, four retrospective studies [14, 16-18], two cross-sectional studies [19, 20] and one RCT study [13] showed that HAL was associated with femoral neck fractures However few studies also denied such relationship, two cross-sectional studies [15, 21] and one retrospective study [22] found that no significant association between hip geometry and femoral fractures existed. In our analysis also we found p-value of 0.05 which is significant to be associated with hip fractures in older Indian population with mean HAL increased for the extracapsular hip fractures particularly.

For the same age group, FNAL was also observed to be increased in extracapsular hip fractures. This has also been supported by the literature.

As in our study we did not find any significance for the rest of the three parameters in any population in for any fracture type.

There is an another study by Sievannen [10] *et al.* who suggested that, there have been remarkable alterations in the proximal femur macro anatomy within past 1000 years. In their study, they compared the medieval hip anatomy with contemporary hip anatomy and they suggested that femoral neck axis has become larger and its cross section has become proportionately smaller and oval shaped. All these changes remarkably increases the risk of hip fractures especially when osteoporosis coexists.

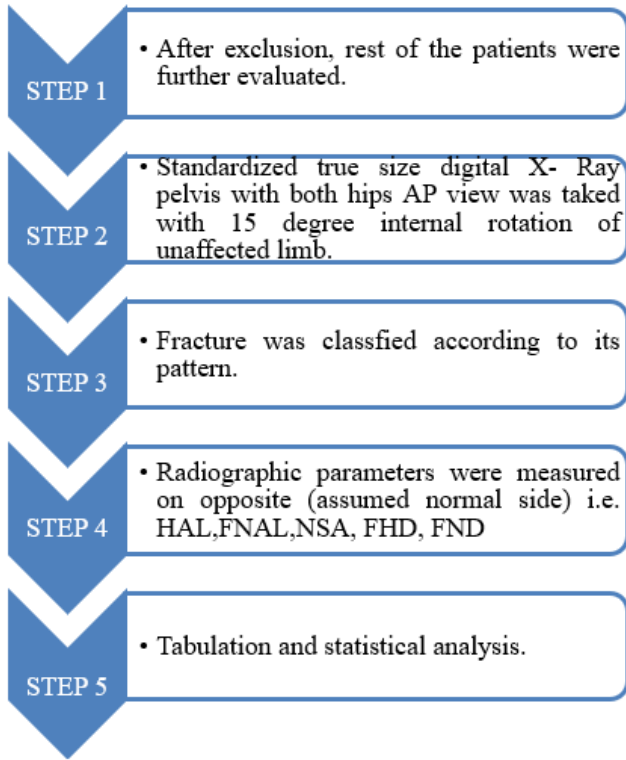


Fig 1: Process of patient selection



Fig 2: Patient positioning.



Fig 3: Drawing long axis of neck and measurement of HAL.



Fig 4: Measurement of FNAL



Fig 5: Measurement of NSA.



Fig 6: Measurement of Neck diameter



Fig 7: Measurement of Head diameter.

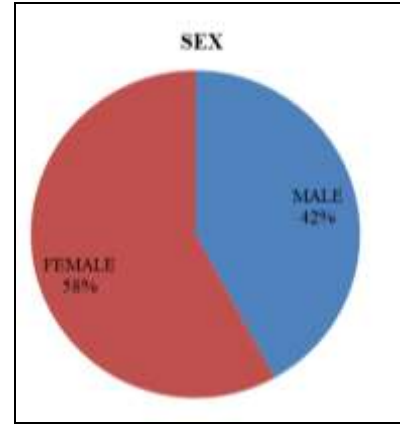


Fig 8: Pie chart of sex wise distributions of hip fractures

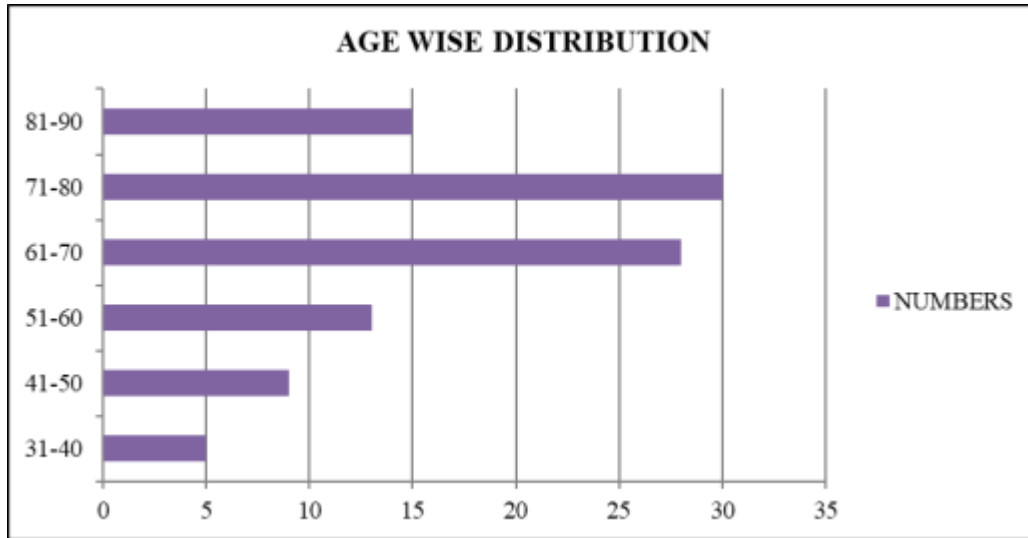


Fig 9: Bar chart of age group wise distributions of hip fractures

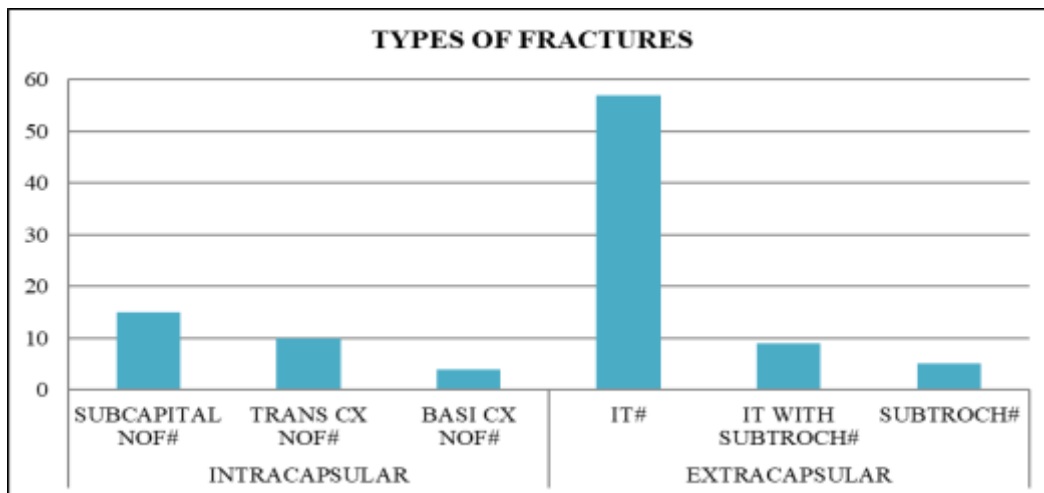


Fig 10: Column chart of type wise distributions of hip fractures

Tpi - 10-5-142

Table 1: Analysis of all HAL, FNAL, FHD, FND and NSA –Mean, SD and p-value (for whole sample size).

	I/C	E/C	p-value	Significance
	Mean(SD)	Mean(SD)		
HAL(mm)	119.2(9.30)	123.7(10.9)	0.06	Not Significant
FNL(mm)	100.7(6.70)	105.9(8.90)	0.005	Significant
HD(mm)	50.9(3.10)	50.7(7.70)	0.87	Not Significant
ND(mm)	31.9(3.00)	32.1(3.30)	0.80	Not Significant
NSA(degrees)	125.80(6.25)	125.45(7.41)	0.82	Not Significant

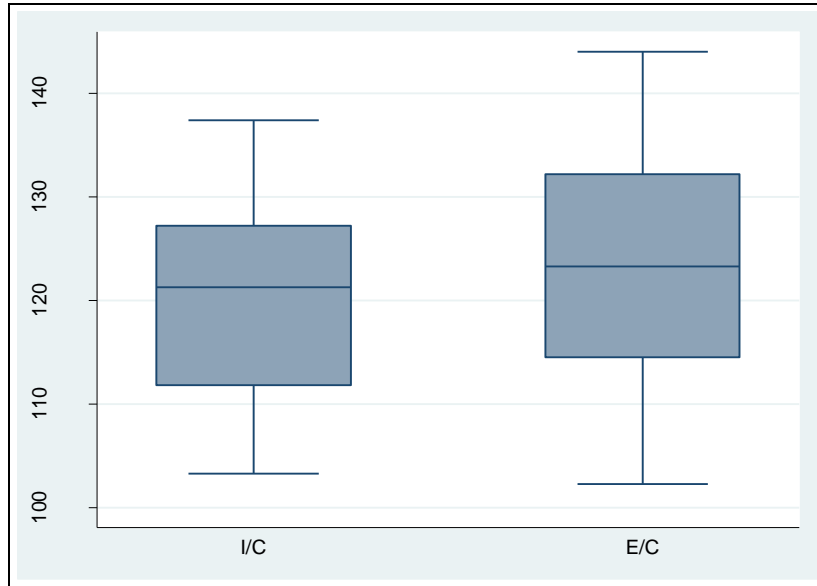


Fig 11: Box plot analysis of HAL for whole population

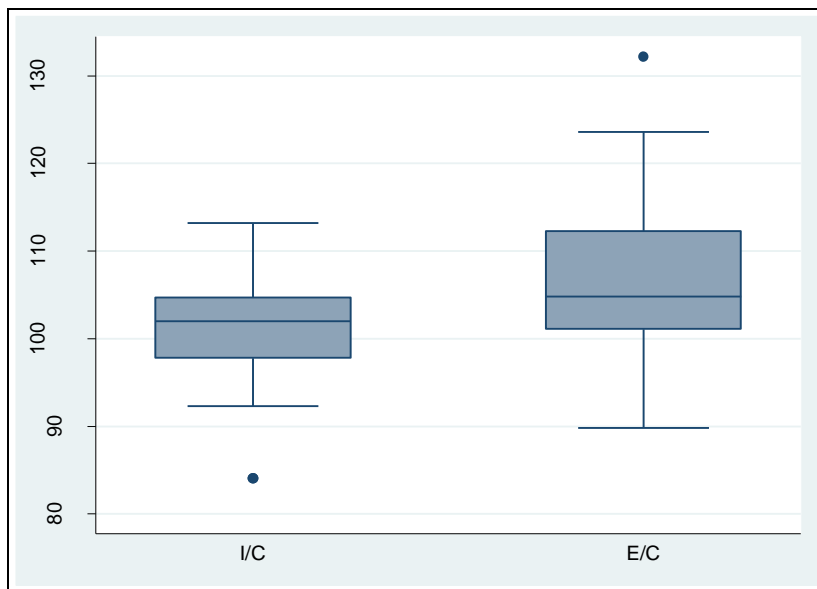


Fig 12: Box plot analysis of FNAL for whole population

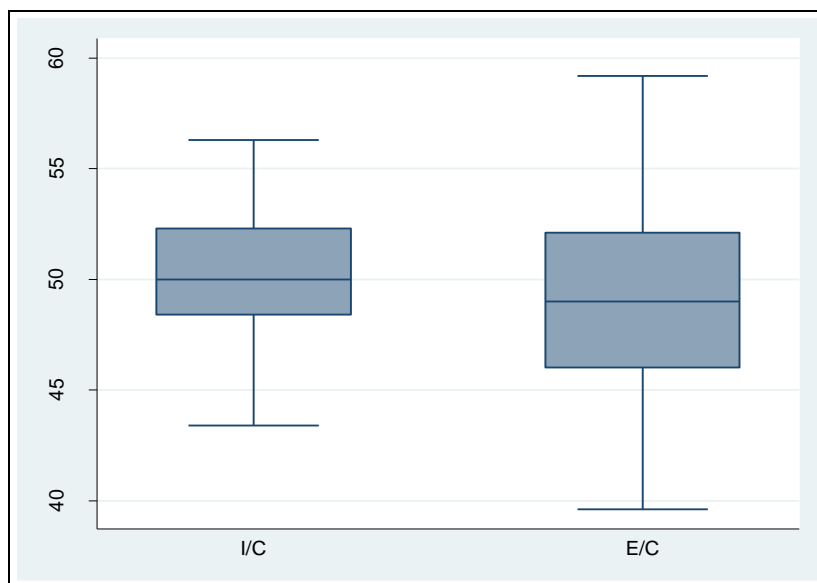


Fig 13: Box plot analysis of FHD for whole population

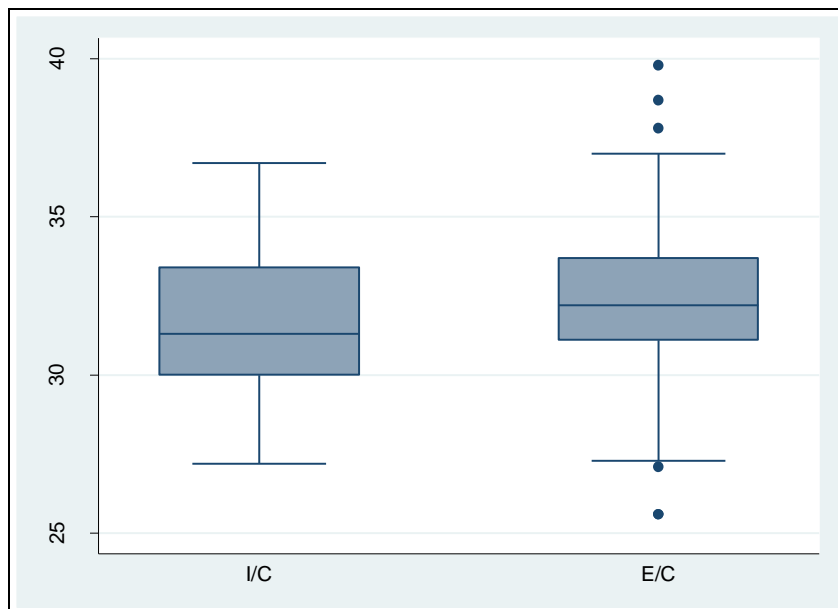


Fig 14: Box plot analysis of FND for whole population

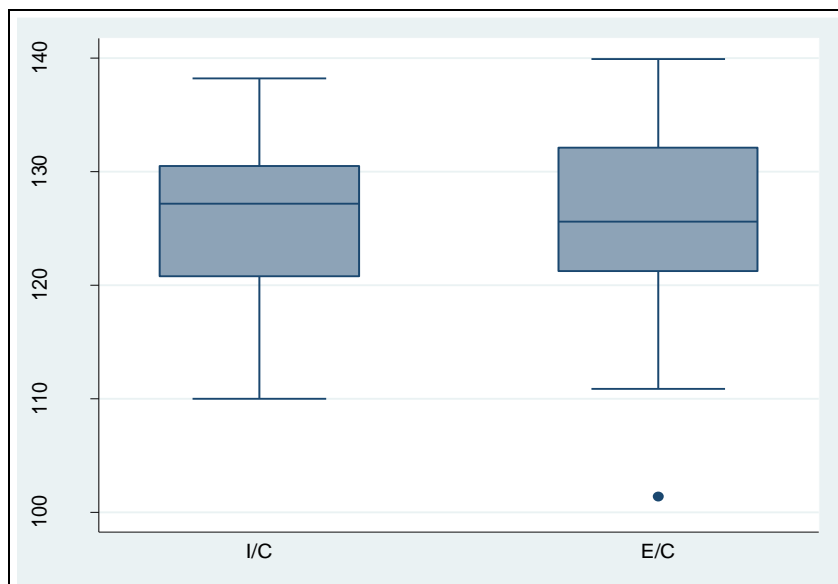


Fig 15: Box plot analysis of NSA for whole population

Table 2: Analysis of all HAL, FNAL, FHD, FND and NSA –Mean, SD and p-value (for younger age group 31-60 years).

	I/C	E/C		
	MEAN(SD)	MEAN(SD)	p-VALUE	SIGNIFICANCE
HAL(mm)	117.0(6.50)	120.1(11.20)	0.52	Not Significant
FNL(mm)	101.2(4.40)	104.6(8.90)	0.38	Not Significant
HD(mm)	50.8(2.60)	48.8(5.51)	0.41	Not Significant
ND(mm)	32.9(1.17)	31.6(2.90)	0.37	Not Significant
NSA(degrees)	127.47(4.42)	126.31(6.97)	0.70	Not Significant

Table 3: Analysis of all HAL, FNAL, FHD, FND and NSA –Mean, SD and p-value (for older age group 61-90 years)

	I/C	E/C		
	MEAN(SD)	MEAN(SD)	p-VALUE	Significance
HAL (mm)	119.8(9.90)	125.1(10.5)	0.04	Significant
FNL (mm)	100.5(7.20)	106.4(8.90)	0.007	Significant
HD (mm)	50.7(3.04)	48.8(3.92)	0.06	Not Significant
ND (mm)	31.2(2.30)	32.4(2.67)	0.08	Not Significant
NSA (degrees)	125.37(6.67)	125.25(7.16)	0.95	Not Significant

Conclusion

In our study, we concluded that the HAL is significantly increased for extracapsular fractures than for intracapsular

fractures in old age group of 61-90 years. FNAL is also found to be higher for extracapsular hip fractures in the same age group as well as the whole sample size. In our study, we could

not establish any significant correlation between FHD, FND and NSA in any age group for any fracture type.

References

- Singer BR, McLauchlan GJ, Robinson CM, *et al.* Epidemiology of fractures in 15,000 adults: The influence of age and gender. *J Bone Joint Surg Br.* 1998;80(2):243–248.
- Dennison E, Mohamed MA, Cooper C. Epidemiology of osteoporosis. *Rheum Dis Clin North Am.* 2006;32(4):617–629.
- Kazley JM, Banerjee S, Abousayed MM, Rosenbaum AJ. Classifications in Brief: Garden Classification of Femoral Neck Fractures. *Clinical orthopaedics and related research* 2018;476(2):441–445. doi:10.1007/s11999.0000000000000066
- Mithal A, Dhingra V, Lau E. Beijing, China: An International Osteoporosis Foundation (IOF) publication. The asian audit: Epidemiology, costs and burden of osteoporosis in Asia 2009.
- Sterling RS. Gender and race/ethnicity differences in hip fracture incidence, morbidity, mortality, and function. *Clinical orthopaedics and related research* 2011;469(7):1913–1918. Doi:10.1007/s11999-010-1736-3.
- Farmer ME, White LR, Brody JA, Bailey KR. Race and sex differences in hip fracture incidence. *Am J Public Health* 1984;74:1374–1380. Doi: 10.2105/AJPH.74.12.1374.
- Andjelkovic, Vladimir, Andjelković, Zoran. Femoral Neck Axis Drawing with Two Parallel Lines in Asymptomatic Adults 2018;1:22–30.
- Thompson RN, Phillips JR, McCauley SH, *et al.* Atypical femoral fractures and bisphosphonate treatment: Experience in two large United Kingdom teaching hospitals. *J Bone Joint Surg Br* 2012;94(3):385–390.
- Faulkner KG, Mcclung M, Cummings SR. Automated evaluation of hip axis length for predicting hip fracture. *J Bone Miner Res* 1994;9:1065–1070.
- Pulkkinen P, Eckstein F, Lochmüller EM, Kuhn V, Jämsä T. Association of geometric factors and failure load level with the distribution of cervical vs. trochanteric hip fractures. *J Bone Miner Res* 2006;21(6):895–901.
- Yang RS, Wang SS, Liu TK. Proximal femoral dimension in the elderly Chinese women with hip fractures in Taiwan. *Osteoporos Int* 1999;10:109–114.
- Peacock M, Turner CH, Liu G, Manatunga AK, Timmerman L, Johnston Jr CC. Better discrimination of hip fracture using bone density, geometry and architecture. *Osteoporos Int* 1995;5(3):167e73.
- El-Kaissi S, Pasco JA, Henry MJ, Panahi S, Nicholson JG, Nicholson GC *et al.* Femoral neck geometry and hip fracture risk: the Geelong osteoporosis study. *Osteoporos Int* 2005;16:1299e303.
- Fajar JK, Rusydi R, Rahman S, Alam SIN, Azharuddin A. Hip geometry to predict femoral neck fracture: only neck width has significant association. *Apollo Med* 2016;13(4):213e9.
- Karlsson KM, Sernbo I, Obrant KJ, Redlund-Johnell I, Johnell O. Femoral neck geometry and radiographic signs of osteoporosis as predictors of hip fracture. *Bone* 1996;18(4):327e30.
- Leslie WD, Pahlavan PS, Tsang JF, Lix LM. Manitoba Bone Density Program. Prediction of hip and other osteoporotic fractures from hip geometry in a large clinical cohort. *Osteoporos Int* 2009;20(10):1767e74.
- Im GI, Lim MJ. Proximal hip geometry and hip fracture risk assessment in a Korean population. *Osteoporos Int* 2011;22: 803e7.
- Gnudi S, Ripamonti C, Gualtieri G, Malavolta N. Geometry of proximal femur in the prediction of hip fracture in osteoporotic women. *Br J Radiol* 1999;72(860):729e33.
- Crabtree NJ, Kroger H, Martin A, Pols HAP, Lorenc R, Nijs J *et al.* Improving risk assessment: hip geometry, bone mineral distribution and bone strength in hip fracture cases and controls. The EPOS study. *Osteoporos Int* 2002;13:48e54.
- Dincel VE, Sengelen M, Sepici V, Cavusoglu T, Sepici B. The association of proximal femur geometry with hip fracture risk. *Clin Anat* 2008;21:575e80.
- Han J, Hahn MH. Proximal femoral geometry as fracture risk factor in female patients with osteoporotic hip fracture. *J Bone Metab* 2016;23:175e82.
- Sievänen H, Jozsa L, Pap I, Järvinen M, Järvinen TA, Kannus P *et al.* Fragile external phenotype of modern human proximal femur in comparison with medieval bone. *J Bone Miner Res* 200;22(4):537–453.