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Original Research Article

Radiological study to determine the association of proximal femoral geometry in hip fractures

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ABSTRACT

Background: 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 (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.
Methods: Total of 72 patients attending orthopaedics outpatient clinic or admitted into the hospital with proximal femoral fractures were included in the study. Thorough history and clinical examination data were obtained. Radiographs and necessary investigations were done and FNL, HAL, NSA was calculated. Analysis was done using SPSS package version 26.
Results: Among the 72 patients included in the study, the mean age of the patients is 65 years with a SD of 13.64. The mean FNL was 2.452 cm with a SD of 0.471. The mean HAL was 11.1547cm and SD of 1.062. The mean NSA was 124.56degree with a SD of 3.339. The distribution of NSA is statistically insignificant at $p<0.05$. The mean NSA of extracapsular fracture and Intracapsular fracture in 51-60 years is 123.1956 and 125.7750 with SD of 2.58782 and 3.99555 is respectively. The $p=0.151$ and is statistically significant.
Conclusions: In our study, we concluded that the HAL is significantly increased for intracapsular fractures than for Extracapsular fractures in old age group of 51-60 years. In our study, we could not establish any significant correlation between FNL, HAL and NSA in any age group for any fracture type.

Keywords: Femoral geometry, Neck fracture, FNL, HAL, Extracapsular fractures, Intracapsular fractures

INTRODUCTION

Fracture is the most common outcome of an injury, with old aged individuals being the most common victims. Fractures can vary from a simple non-disabling fracture to a severe life-threatening death association. Hence, serious consideration with respect to the condition should be considered and be managed meticulously.[1]

A fracture is defined as “A break in the continuity of a bone, with or without displacement of fragment”-Duckworth and Blundell 2010.

Fracture is always accompanied by soft tissue damage-torn vessels, bruised muscles, lacerated periosteum, and contused nerves

As per NICE -2014-hip fractures “fractures occurring in the area between the edge of the femoral head and 5 cm below the lesser trochanter.”

Hip fractures are found to be the most dreadful fractures, which are most commonly observed amongst old-aged individuals (>60 years) with loss of life being the end-result in 33% of the subjects. There are many internal as well as external factors which have to be taken into consideration when the individual suffers from an injury.[2]

An astounding 1.66 million hip fractures were recorded in the year 1990 with a projection of 6.26 million hip fractures by the year 2050.

Data also states that individuals aged more than 80 years and above, have a fall probability of 50%, whereas those aged above 65 years have a 30% fall probability of once in a year.

Hip fractures account for 20% of the orthopaedic trauma care cases, on a global scale with twice the probability of the fracture in women (40-50%) in comparison to the male (13-22%) population. The incidence of fractures in women are high in comparison to males as they are more prone for osteoporosis and have reduced outdoor exposure, making them devoid of sunlight.[3]

There are intrinsic, extrinsic as well as environmental factors which are responsible for the fractures with fall being the key trigger of the fractures, as the bones are more spatially stabilized against the loading of the body and do not succumb to the weight and pressure.

The factors include cognitive impairment, insufficient muscle strength, reduced mobility, visually impaired, polypharmacy, reduced reflexes and stability.

The neck of the femur is the most susceptible/vulnerable anatomical position for fracture in comparison to the other areas of the hip, as the neck region constitutes for 50% of the fractures against the rest 50% of the fractures spread over the other areas.[4]

A quarter of the patients lose their lives within a year and a quarter of them are permanently disabled, with the others leading a compromised lifestyle, in comparison to the pre-fracture levels of the patient.

Hip fractures can be intracapsular or extracapsular type, which is the determining factor in the type and prognosis of the fracture, with or without the involvement of capsule.

Brownbill and Ilich in the year 2003 has focused on some of the most important components which plays an important part in determining the severity as well as the level of risk with three (3) important parameters being-hip axis length represents the lateral aspect of the greater trochanter passing through the femoral neck to the inner pelvic brim.

Femoral neck width (FNW) is defined as the shortest diameter of the femoral neck. The above-mentioned factors play a pivotal role in the type of fracture and determining the recovery period.

Figure 1: Hip axis length.

Figure 2: Femoral neck width.

NSA the angle between the longitudinal femoral shaft axis and the femoral head-neck axis is measured. The axis of the femoral neck is defined by a line bisecting the femoral neck through the centre of the femoral head. The longitudinal femoral shaft axis is determined by two bisections of the femoral shaft at different locations.

Figure 3: Neck shaft angle.

Hip fracture assessment is important to treat and manage the disease process. Assessment can be done by means of recording a detailed history, clinical examination (signs and symptoms) as well as radiological investigations. Radiological investigations ranging from a simple x-ray, and bone densitometry to computed tomography and magnetic resonance imaging are useful, indispensable tools to assess hip fractures and reach a diagnosis with the best prognosis.

METHODS

Study type

Study was of cross-sectional hospital-based study.

Source of data

Patients attending orthopaedics OPD at Rajarajeswari medical college and hospital in Bangalore, Karnataka with sustained proximal hip fractures.

Sample size

The 72 patients were included in the study.

Inclusion criteria

All the patients above the age of 18 years (attained skeletal maturity) who have sustained hip fractures were included in the study.

Exclusion criteria

Patients aged less than 18 years, patients with poly traumatic injuries, patients under medications which affects the bone metabolism, patients with malignant disease, patients with pathological fractures, serum calcium levels of <10 mg/dl were excluded from the study.

Study duration

The study was conducted over a period of 18 months from January 2021-June 2022 (18 months).

Method of collection of data

Subjects fulfilling inclusion criteria will be selected for the study. All patients sustaining hip fractures will be assessed by taking detailed history of trauma and general physical examination will be carried out. Digital radiographs will be taken with patient in supine position with arms adducted and forearm over their chest. X-rays will be taken with traction and internal rotation of limbs at 15 degrees. Radiological parameters will be measured.

Patients will be screened by clinical evaluation and subjected for exclusion criteria, basic investigations and general examination, radiological evaluation-digital x-ray of pelvis with bilateral hips in AP view.

Statistical tool used for analysis

IBM SPSS Statistics for windows, version 26.0. (Armonk, NY: IBM Corp)

RESULTS

In our study of 72 patients, majority of the patients were belonging to the age group of 61-70 years (20, 27.8%), followed by 15 patients (20.8%) in 51-60 years and 71-80 years group each. There were only 3 (4.2%) patients below the age of 40 years in our study.

In our study, among females 12 (34.3%) patients were of 61-70 years, followed by 8 (22.9%), 6 (17.1%) were of 71-80 years and 51-60 years respectively and only 1 patient was below 40 years. Among males 9 (24.3%) patients were of 51-60 years, followed by 8 (21.6%), 7 (18.9%) were of 61-70 years and 71-80 years respectively and only 2 patients were below 40 years. The chi-square statistic is 2.747 and the p=0.739. The distribution is statistically not significant at p<0.05.

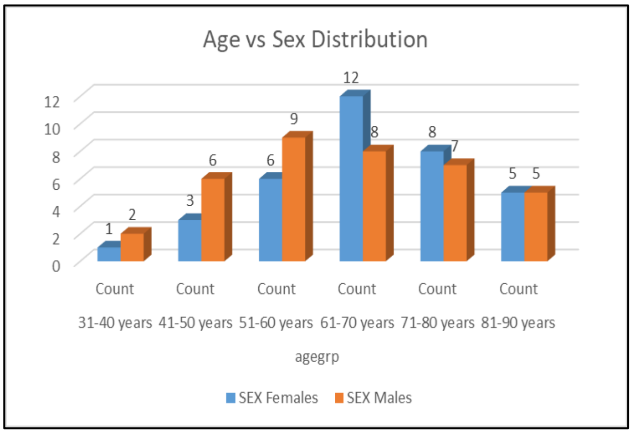

Figure 4: Age vesus sex distribution.

In our study, among patients with extracapsular fracture, 13 (27.7%) patients were of 61-70 years, followed by 11 (23.4%), 9 (19.1%) were of 71-80 years and 51-60 years respectively and only 1 patient was below 40 years. Among patients with Intracapsular fracture, 7 (28%) patients were of 61-70 years, followed by 6 (24%), 4 (16%) were of 51-60 years and 71-80 years respectively and only 2 patients were below 40 years. The chi-square statistic is 0.690 and the p=0.406. The distribution is statistically not significant at p<0.05.

In our study of 72 patients, 25 females had extracapsular and 10 females had intracapsular fracture whereas 22 males had extracapsular and 15 males had intracapsular fractures. The chi-square statistic is 1.137 and the p=0.286. The distribution is statistically not significant at p<0.05.

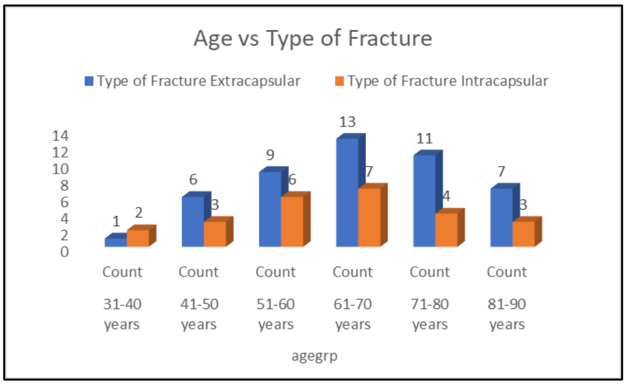

Figure 5: Age versus type of fracture.

The mean FNL of extracapsular fracture in 31-60 years is 2.315 with a SD=0.342 and in 61-90 years is 2.483 with a SD=0.342. The mean FNL of Intracapsular fracture in 31-36 years is 2.606 with a SD=0.358 and in 61-90 years is 2.417 with SD=0.48. The distribution of FNL is statistically insignificant at p<0.05.

The mean FNL of extracapsular fracture and intracapsular fracture in 31-40 years is 2.52000 and 2.74000 with SD=1 and 0. 282843 is respectively. The p=0.640 and is statistically not significant.

The mean FNL of extracapsular fracture and intracapsular fracture in 41-50 years is 2.31833 and 2.50833 with SD=0.355720 and 0.444644 is respectively. The p=0.506 and is statistically not significant.

The mean FNL of extracapsular fracture and intracapsular fracture in 51-60 years is 2.29000 and 2.61167 with SD=0.366572 and 0.365208 is respectively. The p=0.119 and is statistically not significant.

The mean FNL of extracapsular fracture and intracapsular fracture in 61-70 years is 2.43077 and 2.54429 with SD=0.6008 and 0.5837 is respectively. The p=0.689 and is statistically not significant.

The mean FNL of extracapsular fracture and intracapsular fracture in 71-80 years is 2.7100 and 2.3000 with SD=0.536321 and 0.303645 is respectively. P=0.117 and is statistically not significant. Mean FNL of extracapsular fracture and intracapsular fracture in 81-90 years is 2.22714 and 2.27667 with SD=0.387157 and 0.477214 is respectively. P=0.866 and is statistically not significant.

The mean HAL of extracapsular fracture in 31-60 years is 10.7038 with a SD=0.86701and in 61-90 years is 11.1426 with a SD=1.05844. Mean HAL of intracapsular fracture in 31-36 years is 12.2682 with a SD=0.77481 and in 61-90 years is 10.8221 with a SD=0.90998. Distribution of HAL is statistically insignificant at p<0.05.

The mean NSA of extracapsular fracture in 31-60 years is 123.4350 degree with a SD=2.64160 and in 61-90 years is 124.6629 degree with a SD=3.05679. The mean NSA of intracapsular fracture in 31-36 years is 125.1045 degree with a SD=3.1523 and in 61-90 years is 125.2071 degree with a SD=4.61985. The distribution of NSA is statistically insignificant at p<0.05.

The mean HAL of extracapsular fracture and intracapsular fracture in 31-40 years is 11.5000 and 12.6850 with SD=1 and .48790 is respectively. The p=0.640 and is statistically not significant.

The mean HAL of extracapsular fracture and intracapsular fracture in 41-50 years is 10.8333 and 11.7600 with SD=0.60222 and 0.87932 is respectively. The p=0.100 and is statistically not significant.

The mean HAL of extracapsular fracture and intracapsular fracture in 51-60 years is 10.5289 and 12.3833 with SD=1.02788 and 0.77681 is respectively. The p=0.002 and is statistically significant.

The mean HAL of extracapsular fracture and intracapsular fracture in 61-70 years is 10.9192 and 10.9629 with SD=1.00514 and 0.84433 is respectively. The p=0.923 and is statistically not significant.

The mean HAL of extracapsular fracture and intracapsular fracture in 71-80 years is 11.3582 and 10.4950 with SD=1.07288 and 1.00474 is respectively. The p=0.186 and is statistically not significant.

The mean HAL of extracapsular fracture and intracapsular fracture in 81-90 years is 11.2186 and 10.9300 with SD=1.20929 and 1.19528 is respectively. The p=0.738 and is statistically not significant.

Table 1: FNL versus type of fracture versus age.

Age (Years)	FNL (cm)						P value
	Extracapsular			Intracapsular			
	Mean	N	SD	Mean	N	SD	
31-40	2.52000	1	1	2.74000	2	0.282843	0.640
41-50	2.31833	6	0.355720	2.50833	3	0.444644	0.506
51-60	2.29000	9	0.366572	2.61167	6	0.365208	0.119
61-70	2.43077	13	0.600853	2.54429	7	0.583748	0.689
71-80	2.71000	11	0.536321	2.30000	4	0.303645	0.177
81-90	2.22714	7	0.387157	2.27667	3	0.477214	0.866
Total	2.42638	47	0.493983	2.50060	25	0.429754	0.528

Table 2: HAL versus type of fracture versus age.

Age (Years)	HAL (cm)						P value
	Extracapsular			Intracapsular			
	Mean	N	SD	Mean	N	SD	
31-40	11.5000	1		12.6850	2	0.48790	0.297
41-50	10.8333	6	0.60222	11.7600	3	0.87932	0.100
51-60	10.5289	9	1.02788	12.3833	6	0.77681	0.002
61-70	10.9192	13	1.00514	10.9629	7	0.84433	0.923
71-80	11.3582	11	1.07288	10.4950	4	1.00474	0.186
81-90	11.2186	7	1.20929	10.9300	3	1.19528	0.738
Total	10.9932	47	1.00992	11.4584	25	1.11147	0.077

Table 3: NSA versus type of fracture versus age.

Age (Years)	NSA (Deg)						P value
	Extracapsular			Intracapsular			
	Mean	N	SD	Mean	N	SD	
31-40	126.4000	1		123.5000	2	1.41421	0.343
41-50	123.3000	6	2.88721	124.8333	3	2.17792	0.449
51-60	123.1956	9	2.58782	125.7750	6	3.99555	0.151
61-70	123.3215	13	1.74596	123.3757	7	3.72522	0.965
71-80	125.8227	11	3.49253	126.7850	4	5.95334	0.700
81-90	125.3314	7	3.66160	127.3767	3	4.48950	0.467
Total	124.2449	47	2.95216	125.1620	25	3.96285	0.270

The mean NSA of extracapsular fracture and intracapsular fracture in 31-40 years is 126.4000 and 123.5000 with SD=1 and 1.41421 is respectively. The p=0.343 and is statistically not significant.

The mean NSA of extracapsular fracture and intracapsular fracture in 41-50 years is 123.3000 and 124.8333 with SD=2.88721 and 2.17792 is respectively. The p=0.449 and is statistically not significant.

The mean NSA of extracapsular fracture and intracapsular fracture in 51-60 years is 123.1956 and 125.7750 with SD=2.58782 and 3.99555 is respectively. The p=0.151 and is statistically significant.

The mean NSA of extracapsular fracture and intracapsular fracture in 61-70 years is 123.3215 and 123.3757 with SD=1.74596 and 3.72522 is respectively. The p=0.965 and is statistically not significant.

The mean NSA of extracapsular fracture and intracapsular fracture in 71-80 years is 125.8227 and 126.7850 with SD=3.49253 and 5.95334 is respectively. The p=0.700 and is statistically not significant.

The mean NSA of extracapsular fracture and intracapsular fracture in 81-90 years is 125.3314 and 127.3767 with SD=3.66160 and 4.48950 is respectively. The p=0.467 and is statistically not significant.

DISCUSSION

Bone geometry has a pivotal role in evaluation of proximal femoral fractures. Biomechanically, material quality and bone structure determine the mechanical properties of bone at the tissue level i.e., strength of bone is influenced by both the material of which the fracture is composed and also the distribution and organization of the material content.

Thus, a significant role is played by the geometrical configuration and the biomaterial characteristics in providing ample strength and stress. The calcified matrix within the bone determines the bone density.

The hip structure anatomy seems to be an important determinant in predicting the risk of hip fractures. It has been suggested that cervical fractures are much related to pelvic geometry/anatomy of hip joint and trochanteric fractures to the osteoporosis in the trabecular compartment of neck and trochanteric region.

The size, shape and structure of bone are the components of so called “bone quality”. In selecting the parameters, we regarded the proximal Femur as a cantilever and assumed that the angle, length is most critical. Of these, the HAL, FNL, NSA were the most reliable measures to be determined in our study.

The mean age in our study group is 65 years, which is in line with the studies by Partanen et al and Gnudi et al.[5,6]

In our study, 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. 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 intracapsular fractures are relatively more common in males than in females. This is in contrast to a study by Pulkinnen et al which shows female predominance in intracapsular fractures, where intra capsular fractures were significantly higher in women (74%), than in men (49%).[6]

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 3 radiological parameters i.e., HAL, FNL, and NSA with their respective standard deviations. We applied independent sample t test for all parameters and calculated the p values.

In 1999, Yang and Wang et al in their work "Proximal femoral dimension in the elderly Chinese women with hip fractures in Taiwan", concluded that in their study that individuals with increased FNL are predisposed to proximal hip fractures on comparison with the normal subjects.[7] A meta-analysis of literature by Fajar et al in 2017 found out six articles evaluating the association between FNAL and femoral neck fractures. Two of them found positive correlation 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 parameter, we observed that for younger population none of the parameter is found significantly associated with any of the fracture pattern. For the age group 51-60 years, HAL was found significantly increased in intracapsular type of hip fractures than in extracapsular hip fractures.

In literature we found around 10 articles evaluating the correlation between HAL and proximal femur fractures. Of these ten, four retrospective studies, two cross-sectional studies and one RCT study showed that HAL was associated with femoral neck fractures However few studies also denied such relationship, two cross-sectional studies and one retrospective study found that no significant association between hip geometry and femoral fractures existed. Our study emphasises the same. 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 another study by Sievannen et al who suggested that, there have been remarkable alterations in the proximal femur macro anatomy within the past 1000 years.[8] In their study, they compared medieval hip anatomy with contemporary hip anatomy and thy suggested that femoral neck axis has become larger and its cross section has become proportionately smaller and oval shaped. All these changes remarkably increase the risk of hip fractures especially when osteoporosis coexists.

Limitations

Bigger sample size, consideration of other factors of femoral geometry like FNW, longer duration of study.

CONCLUSION

It is concluded that HAL is significantly different between the intra capsular and extra capsular fractures especially more in individuals of 51-60 years. But in our study, we didn't find any significant differences in the FNL and the NSA of these fractures. The study draws results in a geographical population. Other patient factors like height, weight, race in relationship to the fractures were not evaluated. Consideration of more parameters like FNW, ratio of FNL to FNW, femoral head width, cortices thickness of the shaft at the level of trochanters will be much more productive. Thus, we conclude from our study that, the HAL, is an independent predictor of the risk of hip fractures. It can be used as a screening tool in the patients to predict and there by forewarn about their susceptibility to hip fractures and educating about the ways to avoid the risk factors predisposing the hip fractures. However, large population studies are required to stablish the same.

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