

Assessment of Vascularity of Femoral Head after Post-traumatic Fracture Neck of Femur of Variable Period

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Abstract

Background: Fracture neck of femur always poses a big challenge to surgeons. In our country, the majority of them come from low socio-economic status and have to do hard field labor to maintain a household. So, preservation of femoral head should be given the priority during their treatment.

Objectives: It is presumptive to have some idea about the vascular status of the femoral head as they often present late. Our objective is to study the histopathology of femoral head sacrificed during operation so that we can have an idea regarding the vascular supply of femoral head and to determine up to which extent we can conserve the femoral head.

Materials and Methods: This is an institutional based longitudinal observation study conducted at IPGMER and SSKM Hospital Kolkata from May 2013 to April 2014 comprising 32 patients aged 55 years and above having fresh post-traumatic fracture neck of femur admitted for hemiarthroplasty. All sacrificed heads were studied histopathologically from different quadrants for vascularity changes for a variable period up to 4 weeks.

Results: All data are statistically evaluated. There is a gradual decrease in viability and vascularity of different quadrants of the femoral head with increasing time except foveal areas. There were no statistical sex differences of vascularity changes. The significant difference found in displaced and undisplaced fractures.

Conclusions: As there is a proportional relationship between time elapsed after trauma and avascular necrosis change, assessment of vascularity of femoral head should be done before sacrificing it routinely.

Key words: Avascular necrosis, Femoral head vascularity, Fracture neck femur, Viability

INTRODUCTION

Post-traumatic osteonecrosis is a major complication of fracture neck of the femur due to its characteristic blood supply. It is estimated to be 10-30%. It is an injustice to sacrifice femoral head in the form of hemiarthroplasty, which is expensive and a major procedure rather than head preserving surgery without knowing its vascular status.

So, some idea of vascularity of femoral head needs to be known according to their age, sex, duration, and type of fracture. Many studies of femoral head vascularization have assessed the lesion of impact on head viability.¹⁻⁵ Vascular input to the femoral head is threatened by fracture since the epiphysis, and most of the neck is intracapsular. Trueta and Harrison⁶ provide the reference here, completing the work of Howe *et al.*⁷ and Judet *et al.*⁸ In an anatomic study of 15 injected samples, Trueta and Harrison determined the essential vascular elements of the femoral head as being the retinacular vessels originating from the medial circumflex artery; intra-osseous cervical vessels play a minor role and those originating downstream of the neck do not feed anything more than the lateral quarter of the head. These findings were confirmed by Sevitt and Thompson.⁹ The

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lateral circumflex artery supplies few ant retinacular vessels. The medial circumflex artery is extracapsular, with branches penetrating the capsule to become the inferior, posterior, and superior retinacular vessels. The retinacular arteries lie medially to the femoral head and mainly comprise the superior and inferior retinacular vessels. The anterior and posterior vessels are of less importance. Taken together, these arteries form Hunter's arterial circle.¹⁰ There are between four and six superior retinacular vessels, which have the largest diameters, at a mean 0.8 mm. They penetrate the head at the superomedial and terminal part of the neck, at the cervicocephalic junction, to form the cervical branches: the superior metaphyseal and lateral epiphyseal arteries, of which the latter is the main artery, feeding 70-80% of the femoral head. It runs along the old growth plate, anastomosing with the ligament teres vessels, and lies near the retinacular reflection area of the femoral neck. The ligament teres artery branches from the obturator artery when passes the fovea; it anastomoses with the terminal branches of the lateral epiphyseal artery.⁷ The role played by this anastomosis would seem from the literature to be controversial. Sevitt and Thompson¹⁰ do not consider the ligament teres vessels to be essential to the survival of the head: After sectioning the neck, only a small part of the fovea was injected in two-thirds of their anatomic specimens, feeding only a very small part of the head. Catto,¹¹ Chandler *et al.*,¹² and Crock,¹³ on the other hand, consider the anastomosis system between the ligament teres and lateral epiphyseal arteries to be essential to revascularization of the femoral head after neck fracture. In our study, we have assessed histologically the vascularity of femoral head of variable period after intracapsular fracture neck of the femur.

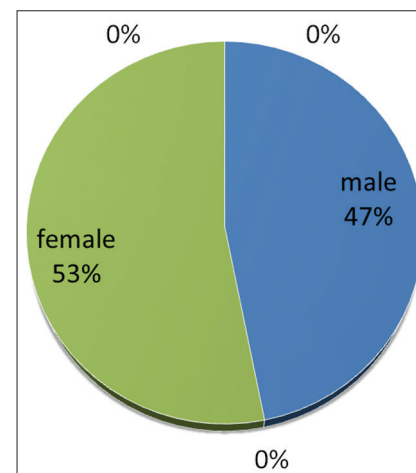
MATERIALS AND METHODS

We have conducted a longitudinal observational study comprising 32 patients of 55 years and above from May 2013 to April 2014, all having fresh post-traumatic intracapsular fracture neck of the femur (Figure 1). Those having age less than 55 years, pathological fracture, neglected fracture, and fracture having a radiological sign of avascular necrosis (AVN) are excluded from our study. We collected all sacrificed femoral head after hemiarthroplasty. The depressed area in the head where the ligamentum teres is attached marked as foveal/apex area, the junctional area with the neck marked as a base. Rest of the head was divided by two lines into four quadrants, i.e., superoanterior, superoposterior, infero-anterior, and infero-posterior. Total six areas denoted by dots like one dot, two dot, and three dots and so on one for each area (Figure 2). After cutting each quadrant into small pieces and putting them into 10 × 10 separate polythene bags with 10% formal saline send to the

pathology department (Figure 3). Next day again, the pieces were put into HNO₃/H₂SO₄ solution to decalcify. After staining with eosin-hematoxylin, we examined different quadrants under a microscope for vascularity changes and tissue necrosis. The earliest microscopic signs^{11,14,15} indicative of bone ischemia are seen in the marrow space starting from the 2nd day there is loss of nuclear staining of marrow cells and large round and ovoid spaces filled with fat appears. The fatty and hematopoietic marrow become then ghosted, and the small vessels show evidence of ischemia (Figure 4). After 15 days, the osteocytic lacunae are empty, and the trabecular surface is devoid of cells. At the border of the necrotic zone, there is a proliferation of capillaries accompanied by fibroblasts and foamy histiocytes, which are responsible for the breakdown of necrotic fatty marrow while dead bone is partly removed by osteoclasts and substituted by newly formed trabeculae; alternatively, woven bone is laid down on the surface of dead trabeculae. So, by observing such changes, the duration and amount of avascular changes have been determined (Figures 5 and 6).

RESULTS

This study includes 32 patients (male - 15, female - 17); left side was more common than the right side and mostly of garden type 3 or 4 variety of fractures (Pie Diagram 1).



Pie Diagram 1: Distribution of sex

Maximum number of cases found in 55-70 years of age group. 25 cases were displaced, and 7 cases were undisplaced fracture neck of the femur. Of the 32 femoral heads, 10 heads were found in the 1st week, 14 in 2nd, 6 in 3rd, and 2 in 4th weeks. Time duration represents the date of injury until the date of surgery (Tables 1-3).

1st week, 10 cases showing 8-10% of necrosis and viability of femoral head around 90%. 2nd week 14 cases and its

Table 1: Relationship between duration of fracture and % of necrosis of different quadrant of the femoral head

Duration of fracture (week)	Number of case	Base (%)	Foveal (%)	Sup-anterior (%)	Sup-posterior (%)	Inf-anterior (%)	Inf-posterior (%)	Average % of necrosis
1 st	10	8.76	8.2	8.4	8	8	7	8
2 nd	14	22.9	7.8	18.9	14.5	16	14	15
3 rd	6	28	7.8	25	25.3	24	21.67	22
4 th	2	46.3	11	37	37	35.5	29	32

Table 2: Average percentage of avascular changes according to displacement

Displacement /type	Average % of avascular change irrespective of time and zone
Undisplaced	7.82
Displaced	18.35

Table 3: Average percentage of avascular changes according to age

Gender	Average % of avascular changes
Male	17
Female	15



Figure 1: X-ray showing fresh undisplaced fracture neck femur of 65 years old woman



Figure 2: After removal of femoral head and 4 quadrants marked by diathermy



Figure 3: Femoral head kept in 10% formalin in sterile polythene and level the bag

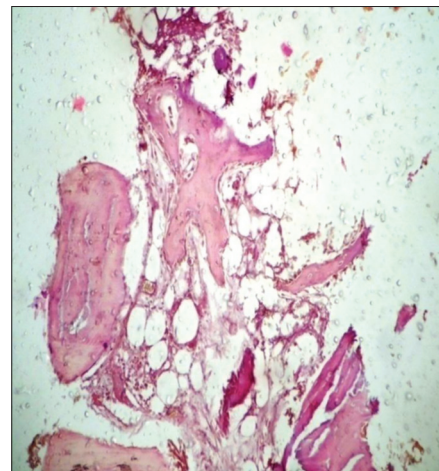


Figure 4: Living lamellar bone lined by osteoblasts with presence of osteocytes in the lacunae (H and E, x100)

necrosis of femoral head around 15%. The viability of femoral head remains half of the femoral head. 3rd week 6 cases and its necrosis and viability accordingly 21-25% and 70-75%. The 4th week has only two cases and necrosis of femoral head is highest (31-35%) and viability (60-65%).

All data were statistically evaluated. We use Statistical version 6 (Tulsa, Oklahoma: Stat Soft Inc., 2001) and

Table 4: Necrosis of different quadrant of femoral heads of all patients

Total number of case	Male/ female	Displaced	Base (%)	Apex (%)	Superoanterior (%)	Superoposterior (%)	Infero-anterior (%)	Infero-posterior (%)	OT days
1	M	Lateral	20	9	17	13	18	13	13
2	F	Superior lateral	24	10	19	14	20	13	12
3	F	Lateral	12	11	13	12	13	14	6
4	M	Lateral	24	9	20	21	19	16	13
5	F	Undisplaced	12	6	14	7	5	6	7
6	F	Lateral	60	11	35	33	37	29	26
7	M	Lateral	11	21	12	18	17	18	6
8	M	Lateral	20	9	19	20	14	20	11
9	F	Lateral	29	11	25	22	24	19	18
10	M	Undisplaced	10	8	10	5	9	6	7
11	M	Lateral	25	10	17	16	19	18	13
12	M	Lateral	37	9	29	28	29	25	20
13	F	Undisplaced	12	6	11	8	11	7	7
14	F	Lateral	24	9	19	8	19	14	13
15	F	Lateral	34	10	26	23	26	26	19
16	M	Lateral	28	8	26	20	25	20	12
17	M	Superior	11	13	10	12	10	13	7
18	F	Lateral	65	11	39	33	34	29	27
19	F	Lateral	27	8	25	16	18	16	13
20	M	Lateral	29	7	26	17	20	16	14
21	F	Superior lateral	19	8	16	11	13	13	10
22	F	Undisplaced	10	7	9	5	6	6	5
23	M	Lat	28	9	30	26	29	25	20
24	F	Undisplaced	5	9	4				7
25	F	Lateral	18	3	15	10	10	10	12
26	M	Lateral	30	7	22	18	18	15	17
27	M	Lateral	28	7	20	20	18	17	16
28	F	Undisplaced	4	7	8	6	4	6	6
29	M	Lateral	22	7	18	15	15	12	13
30	F	Lateral	6	6	5	7	5	6	7
31	F	Lateral	25	5	15	10	10	12	14
32	M	Undisplaced	25	8	12	15	10	10	12

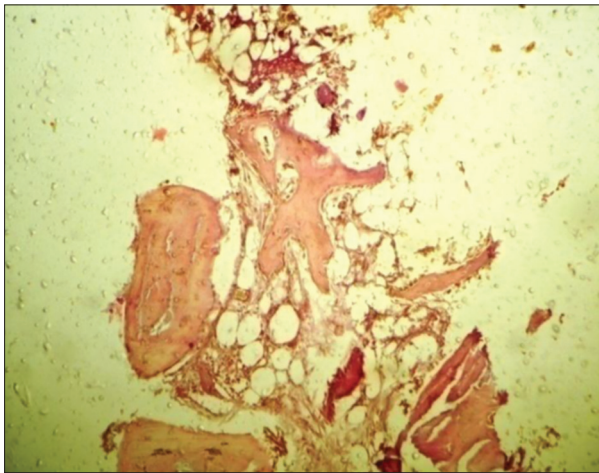


Figure 5: In the right lower corner dead woven bone with loss of osteoblastic rimming and osteocytes. The color of dead bone is more eosinophilic than alive bone (H and E, ×100)

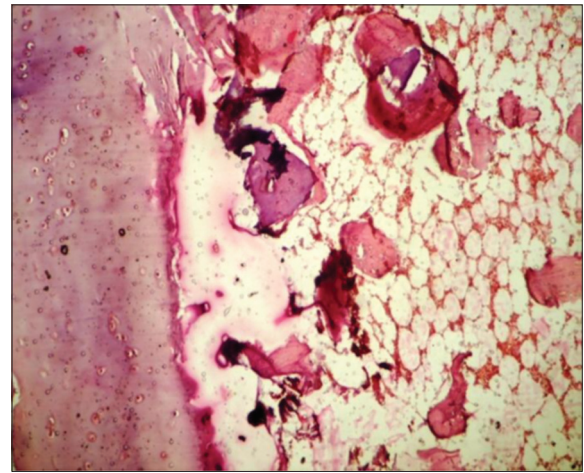


Figure 6: Dead bones and cartilage with loss of vascularity, areas of hemorrhage and increased fat spaces (H and E, ×400)

Pearson's Chi-squared test (χ^2) to test a null hypothesis (Table 4).

In our statistical calculation, decrease in vascularity of all quadrants of the femoral head is comparable with

increasing time after fractures except foveal zone. There is strong correlation between displaced fracture and loss of vascularity. No significant difference observed between sexes regarding viability changes. The highest amount of avascular changes observed was 35.16% in a female patient who was operated 27 days after injury, while the least

avascular changes, that is, 3% observed also in a female patient who was operated just 7 days from injury.

DISCUSSION

Fracture neck of femur usually affects elderly population, though this is not an emergency but treatment should begin as early as possible because chances of non-union, AVN changes increases with time duration. We usually do hemiarthroplasty or total hip replacement surgery in elderly patients. If we know about the vascularity and viability status of the femoral head after fracture, we can properly plan our management regarding whether femoral head can be preserved or not.

We have selected patients of 55 years or more of recent post-traumatic fractures because there is often a bias toward doing head sacrificing surgeries because of their age and they often come 2-3 weeks later. However, this type of surgery is more costly and do not match their lifestyle.

We took fresh fractures up to 4 weeks of duration and excluded old neglected ones and also those having pathological fractures, fractures having osteoarthritic changes to eliminate confounding factors.

In our study after histological and statistical analysis of 32 heads, we have not found any significant age and sex differences in vascularity changes. Age and sex are not a dependent factor in our study.

Defining displaced and undisplaced fractures we use gardens classification system, as this is more familiar to us and reproducible. The process of histopathological examination like tissue preservation, staining and high and low power microscopical slide examination was also very simple and standardized; results are reproducible. There is no other study that clearly mentioned about the displaced and undisplaced fracture vascularity. Our Study shows a significant difference of vascularity changes of displaced and undisplaced fractures probably more damage to retinacular vessels and more tamponade effects of the intact capsule.

The study also shows the viability of femoral head gradually decreases with increasing of fracture duration. More the fracture duration, there is less vascularity. We observe that in 1st week 8-10% of necrosis and viability of femoral head around 90-92%, whereas in 4th-week necrosis of femoral head is highest 32-35% and viability lowest.

Sherman and Phemister 1947,¹⁶ Phemister 1948¹⁷ studied histology of femoral head and showed slow osteocyte loss; the bone is dead shortly after the vascular injury. However,

our study did not find rapid bone dead in spite slow loss of vascularity and viability.

After studying different quadrants of the femoral head only, apex part survived till late may be due to intact blood supply through ligamentum teres, which was damaged less than retinacular and ascending cervical vessels.

We have lots of study regarding the assessment of femoral head vascularity, but most of them used radiological assessment, very few of them used histological assessment, and we do not have that data even in Indian patients. The result we are getting from this study will help us to have an idea that in whom we can predict that femoral head is still viable, and we can go for radiological assessment of vascularity by MRI, which is a must before head preserving surgery. Thus, we can avoid doing MRI in all patients, specially in those cases in whom we do not expect the head to be viable so can reduce the cost of treatment. As India being a developing country and more than 50% of its population still living in villages, we must give it a chance to preserve the femoral heads of such patients and it will be really helpful if we have some guidelines in choosing the right candidate.

So, from the above discussion head preservation surgeries (such as compression hip screw, dynamic hip screw with or without bone grafting) for fracture neck of femur are very justified in middle and old aged active group, in minimally displaced fractures within 4 weeks instead of head sacrificing to take a chance of revascularization and union with the remaining viability.

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