

# **A PROSPECTIVE STUDY ON RADIOLOGICAL EVALUATION OF INTRA-PROSTHETIC MOVEMENT IN BIPOLAR HEMI ARTHROPLASTY FOR FRACTURE NECK OF FEMUR AT BENGALURU URBAN, KARNATAKA, INDIA**

**Dr. Mahesh Kumar NB<sup>1</sup>, Dr. Suhas, D<sup>2</sup> , Dr. Adinarayana Roy.Gandi<sup>3</sup>, Dr. Sandeep  
KM\*<sup>4</sup>, Dr. Deepak. V.Kurian<sup>5</sup>**

<sup>1,2,4</sup>Associate Professor, Department of Orthopaedics, Rajarajeswari Medical College and  
Hospital, Bengaluru, Karnataka, India.

<sup>3</sup>Junior Resident, Department of Orthopaedics, Rajarajeswari Medical College and Hospital,  
Bengaluru, Karnataka, India.

<sup>5</sup> Junior Resident, Department of Orthopaedics, Rajarajeswari Medical College and Hospital,  
Bengaluru, Karnataka, India.

## **Abstract**

### **BACKGROUND**

Fracture neck of femur is a common orthopaedic problem in old age. Hip fractures are common and comprise 20% of the operative workload of an orthopaedic trauma unit. Intra-capsular femoral neck fractures account for 50% of all hip fractures. The lifetime risk of sustaining a hip fracture is high and lies within the range of 40% to 50% in women and 13% to 22% in men. Bipolar prosthesis was invented mainly to prevent the complications of acetabular erosions and prosthetic loosening as in the unipolar hemiarthroplasty. Certain authors believed that in normal acetabulum, the cartilage – prosthesis junction has low coefficient of friction (in contrast to arthritic joint) and therefore even Bipolar prosthesis may work as unipolar arthroplasty, with movements occurring between Acetabulum and outer cup of bipolar prosthesis.

### **OBJECTIVES**

Assessment of Intra– prosthetic movement in Bipolar prosthesis by radiological means and co-relating the intra-prosthetic movement with Bipolar prosthesis. This study represents the assessment of the intra-prosthetic joint movement in bipolar prosthesis done for fracture neck of femur, at 6 months and mid-term follow-up by radiological means. By this study we will be able to assess whether Bipolar prosthesis really functions as its name suggests or vice versa as the literature suggests.

### **METHODS**

A prospective study with 30 patients who had fracture neck of femur were operated with bipolar hemiarthroplasty were assessed radiologically as described by Bochner et al, at immediate

## RESULTS

The average immediate intra-prosthetic movement at immediate follow up was 54%, 42 % at 6 weeks, 30% at 6 months and 24% one year. The results were in line with recent studies and better than older studies published by Verbene et al. There was significant correlation with IPJ movement

## CONCLUSION

In this study we have radiologically assessed the intraprosthetic movements in a bipolar hemiarthroplasty done for fracture neck of femur. Intraprosthetic movement is maintained at all intervals of follow up with 24% at one year follow up. The functional outcome of subjects is proportional to the moments at intraprosthetic joint.

**KEYWORDS;** intraprosthetic movement; bipolar hemiarthroplasty; fracture neck of femur

## INTRODUCTION

Hip fractures are common and comprise 20% of the operative workload of an orthopaedic trauma unit. Despite the ubiquitous nature of these fractures, there is still a surprising degree of variation in treatment. Options include reduction and fixation, unipolar arthroplasty, bipolar hemiarthroplasty, and total hip arthroplasty (THA). Any of the arthroplasty options may be cemented or uncemented. As a generalization many trials have suggested that for the majority of old age patients with a displaced fracture an arthroplasty is the best choice, and a modern design of arthroplasty is better than older designs of unipolar hemiarthroplasties. Surgical treatment has been established as the gold standard. A successful operation at hip joint should provide painless, stable hip with wide range of movements. Since early 1950's prosthetic replacement was introduced for solving the problems of fracture neck of femur and vitallium intramedullary prosthesis received a hearty welcome, thus preventing Non-union and avascular necrosis. The Austin – Moore and Thompson prostheses have been successful implants in treating fracture neck of femur. Disabling pain and acetabular erosions are frequent complications after the use of Moore prosthesis. So in an attempt to retard the acetabular wear, prolong the life of the implant and delay the need for revision surgery the bipolar prosthesis was developed by James E Bateman in Toronto in 1974, which had the great advantage of second joint, below the acetabulum. It was named bipolar prosthesis, since it had an outer head of metal which articulates with acetabulum and a

second inner metallic head which articulates with High Density Poly-Ethylene (HDPE), lining

the inner surface of outer head. So theoretically hip motion is to occur at 2 interfaces – primarily at the prosthetic interface and secondarily at the metal – cartilage interface, thus minimising the articular wear. This prosthesis was found to be very useful and results were encouraging. But studies attempting to demonstrate the relative movements at the interfaces have yielded conflicting results. It's known that a friction produces particulate debris from the polyethylene liner and this was thought to be the cause of foreign body reaction causing stiffening up of the inter-prosthetic joint and also osteolysis and aseptic loosening of the implant. Recent studies have shown that over a variable period of time the bipolar prosthesis will become unipolar functionally due to stiffening up of the intra-prosthetic joint (IPJ). This

study represents the assessment of the inter-prosthetic joint movement in bipolar prosthesis done for fracture neck of femur at 6months and mid-term follow-up by radiological means. By this study we will be able to assess whether Bipolar prosthesis really functions as its name suggests or vice versa as the literature suggests

## **AIMS AND OBJECTIVES**

### **Aim**

Radiological evaluation of intra-prosthetic movement and functional outcome in correlation to intra-prosthetic movement in Bipolar hemiarthroplasty for fracture neck of femur.

### **Objectives**

Assessment of Intra–prosthetic movement in Bipolar prosthesis by radiological means and co-relating the intra-prosthetic movement with functional outcome of Bipolar prosthesis.

## **ANTOMY OF HIP JIONT**

The hip joint is a multi axial ball and socket joint (spheroidal joint). The femoral head articulates with cup shaped acetabulum 43 . The articular surfaces are reciprocally curved and are neither co-existent nor completely congruent. The surfaces are considered spheroid or ovoid rather than spherical. The femoral cartilage is covered by articular cartilage except for a rough pit for the ligament of the head (ligament of teres). In front, the cartilage extends laterally over a small area on the adjoining neck. The cartilage is thickest centrally. Maximum thickness is in the acetabulum's anterosuperior quadrant and the antero-lateral part of femoral head. The acetabular articular surface is anincomplete ring, the lunate surface, broadest above where the pressure of the body weight fall in erect posture. It is deficient below, opposite to the acetabular notch . The acetabular fossa within it is devoid cartilage, but contains fibroelastic fat largely covered by synovial membrane.

1)**Acetabular labrum-** It's a fibrocartilagenous rim attached to the acetabular margin, deepening the cup. It's triangular in cross section and its base is attached to the acetabular rim with the apex as the free margin. It bridges the acetabular notch as the transverse acetabular ligament, under which vessels and nerves enter the joint.

2) **Fibrous capsule:** It's a strong and dense attached above to the acetabular margin 5 to 6 mm beyond the labrum,in front near the acetabular notch to the transverse acetabular ligament and the adjacent rim of obturator fossa. Behind, it's attached about 1 cm above the inter-trochanteric crest. Below its attached to the femoral neck near the lesser trochanter. Anteriorly, many fibres ascend along the femoral neck as longitudinal retinaculae containing blood vessels for both the femoral head and neck. The capsule is thicker antero-superiorly, where maximal stress occurs, especially in standing. Postero- inferiorly it's thin and loosely attached. The capsule has 2 layers – inner circular, forming the zona orbicularis around the femoral neck and blending with pubofemoral and ischiofemoral ligaments, and outer longitudinal layer. The circular layer is not directly attached to bone.

3) **Synovial membrane:** Starting from the femoral articular surface, it covers the intra-capsular part of femoral neck, then passes to the capsule's inner surface to cover the labrum, ligament of the head and the fat in the acetabular fossa. It's thin on the deep surface of the iliofemoral ligament, where it is compressed against the femoral head. It communicates with the subtendinous iliac (psoas) bursa by a cicular aperture between

the pubofemoral and the vertical band of the iliofemoral ligament.

4) **Iliofemoral Ligament**- It's also known as bigelow 'ligament. Triangular or inverted 'Y' shaped. It's one of the strongest ligaments in the body. Its apex is attached between the anterior inferior iliac spine and the acetabular rim and it's base to inter- trochanteric line anteriorly.

5) **Pubofemoral ligament** - It's triangular with the base attached to the ilio-pubic eminence, superior pubic ramus, obturator crest and membrane. Distally it blends with the capsule and deep surface of the medial part of iliofemoral ligament.

6) **Ischiofemoral ligament**: it consists of superior ischiofemoral ligaments and the lateral and medial inferior ischiofemoral ligaments, extending from the ischium to the base of the femoral neck on the posterior aspect of the joint. Intra-capsular part of femoral neck, then passes to the capsule's inner surface to cover the labrum, ligament of the head and the fat in the acetabular fossa. It's thin on the deep surface of the iliofemoral ligament, where it is compressed against the femoral head. It communicates with the subtendinous iliac (psoas) bursa by a circular aperture between the pubofemoral and the vertical band of the iliofemoral ligament.

7) **Ligamentum teres** : It's a triangular flat band with apex attached to the pit on the femoral head and base on either side of the acetabular notch. It varies in length and sometimes being represented only by synovial sheath

## **BIOMECHANICS OF HIP JOINT**

The hip is a ball and socket joint and thus has inherent structural bony stability relying less on the ligaments and muscles than in other joints. A ball and socket provides multi-axial freedom of movement which in some measure provides protection from sudden stresses. However, that force will be transmitted directly to the skeleton thus producing a variety of injury patterns. The advantage of the bony constraint is stability gained for walking and transferring from a standing to a sitting posture. A fracture disrupts the supporting structure and therefore eliminates the functional performance of the hip joint. So the aim of the treatment is to provide support and anatomical realignment of bone fragments during healing to restore the function. Bone has a vital role in providing the essential supporting framework and locations for muscle attachments. It consists of cortical and cancellous parts with their respective distinct mechanical properties. The cortical bone is more solid and rigid structure and it's anisotropic, a feature which makes the analysis of physical properties difficult. In 1867 Von Meyer and Culmann, an anatomist and an engineer, compared the trabecular arrangement of the cancellous bone within neck of femur to fairbarin crane and from this developed the stress trajectory theory of bone formation. There differing proportions of cortical and cancellous bone in the trochanteric region compared with neck region. It's generally regarded that 95 % of bone tissue in the neck is cortical variety, whereas the ratio is reversed in trochanteric region. The work of Paul on the calculations of direction and magnitude of the forces passing through the femoral during walking using standard gait analysis techniques and more direct measurement of an instrumented Austin Moore prosthesis by Rydell, produced similar figures, determined for the first time, that the trabecular pattern within head and neck of femur did correspond to the calculated loadings. The medial trabecular

system has always been regarded as compression system in response to the maximum resultant compressive load. The Lateral trabecular system was originally thought to have

been laid down in accordance with Wolff's law (1870) as a result of tensile stresses. However the more recent work shows that the cortical shell of femoral neck is in fact entirely in compression, the maximum compression being on the medial aspect with tapering low compressive stresses on the lateral aspect of the femoral neck (Frankel 1960). Under normal physiological conditions, there is no tension in the femoral neck and the original neutral axis of the neck of femur is proposed by Koch (1917) does not exist. Only loading of the head and neck is in unphysiological position. Eg varus, is an element of tension occurring in lateral and superior aspect of femoral neck. Thus compression is major loading configuration of the bone of upper end femur with tension only in abnormal situations. Because of the multi-axial freedom in a low friction system within joint, torsion of the femoral neck is negligible.

**Hip Joint Forces:** There are 2 forces acting on the hip joint, ie, the body weight on the hip itself and the muscles acting across the joint. The movements produced by the muscle action during normal activities such as walking are quite considerable and provide a large magnification factor to the body weight applied directly on the joint. It's seen that in level of walking peak loads as much as 5 to 6 times the body weight are occurring in the hip. This high level of loading accounts for many problems associated with fractures. When the weight of the body above the lower extremities rests equally on two normal hip joints, the static forces on each hip is one half of, or less than one third, the total body weight. For example, the right lower extremity is lifted as in the swing phase of walking, the weight of the right lower extremity is added to the body weight, and the centre of body gravity, normally in median sagittal plane, is displaced to the right. The abductor muscles exert a counter – balancing force to maintain equilibrium. The pressure exerted on the head of femur is the sum of these forces. Each force is related to relative length of levers. If abductor lever is one third that of the lever arm from the head to the centre of gravity, so the downward pull of the abductors must be 3 times the force of gravity to maintain balance. Therefore the total pressure on the head is 4 times the superimposed weight. The longer abductor lever (i.e., the more laterally placed insertion of the abductors), the less the ratio between the levers, the less the abduction force required to maintain the balance and less pressure force exerted on the femoral head. The estimated load on the femoral head in the stance phase of the gait and during straight leg raising is about 3 times the body weight. Crowninshield et al calculated the peak contact forces across the hip during gait as ranging from 3.5 to 5 times the body weight. When lifting, running or jumping the load may be upto 10 times the body weight.

## **MATERIALS & METHODS**

**Source of data:** Patients presenting with fracture neck of femur and operated with bipolar hemiarthroplasty at Rajarajeswari medical college and Hospital during the period of October 2018 to November 2019 and one year follow up till November 2020 will be included.

### **Sample Size Estimation:**

The Sample Size is 30 and is calculated based on previous studies as well as approximate availability of number of cases in the above mentioned duration satisfying inclusion and exclusion criteria. Methods of collection of data (including sampling procedures if any) All cases meeting the inclusion criteria of both sex presenting with fracture neck of femur in Hospital attached to Rajarajeshwari Medical College And Hospital , Bengaluru

### **Inclusion Criteria:**

Patients with fracture neck of femur operated with bipolar hemiarthroplasty.

**Exclusion Criteria:**

- 1)patients who have had post-operative infection
- 2)Patients who have had Peri-prosthetic fractures, prosthetic stem loosening
- 3)Polytrauma
- 4)Bilateral femur neck fractures

**Implant used:**

Bipolar prosthesis made in india

No funding was received from the Implant company for the purpose of this study.

**X-ray Technique:**

Two A.P x-rays of pelvis were taken. One with limbs in neutral position and neutral rotation and the other x-ray with affected limb in Maximum abduction are taken.

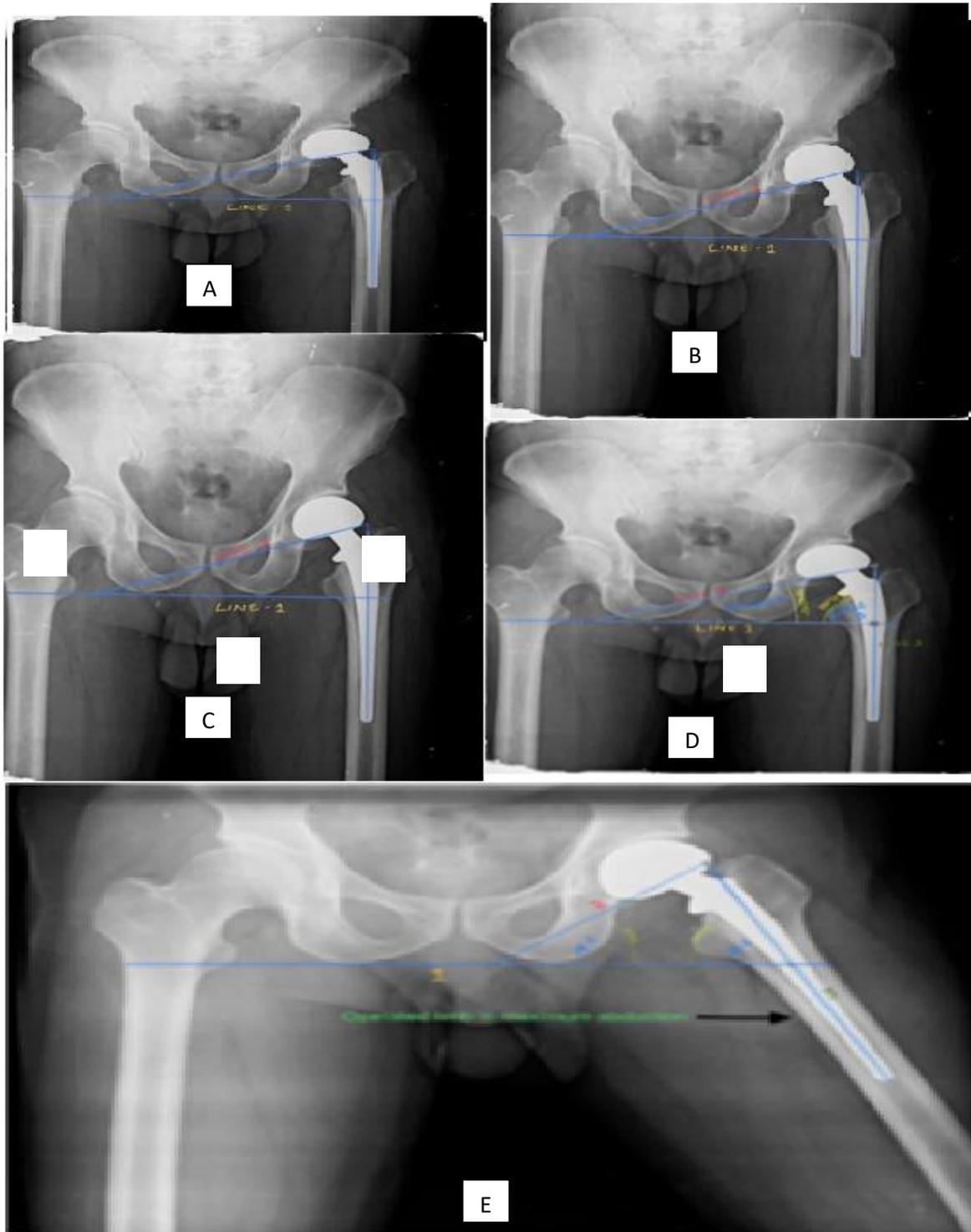
**Radiological Assessment:**

We followed the method of plain radiographs, as described by Bochner et al . On the X-ray in the neutral position, 3 lines are drawn as follows.

**Line 1:** a line drawn tangential to the most inferior aspects of the ischial tuberosities which is used as a reference line.

**Line 2:** drawn along the Inferior margin of acetabular component

**Line 3:** Drawn along the centre of the long axis of femoral stem.



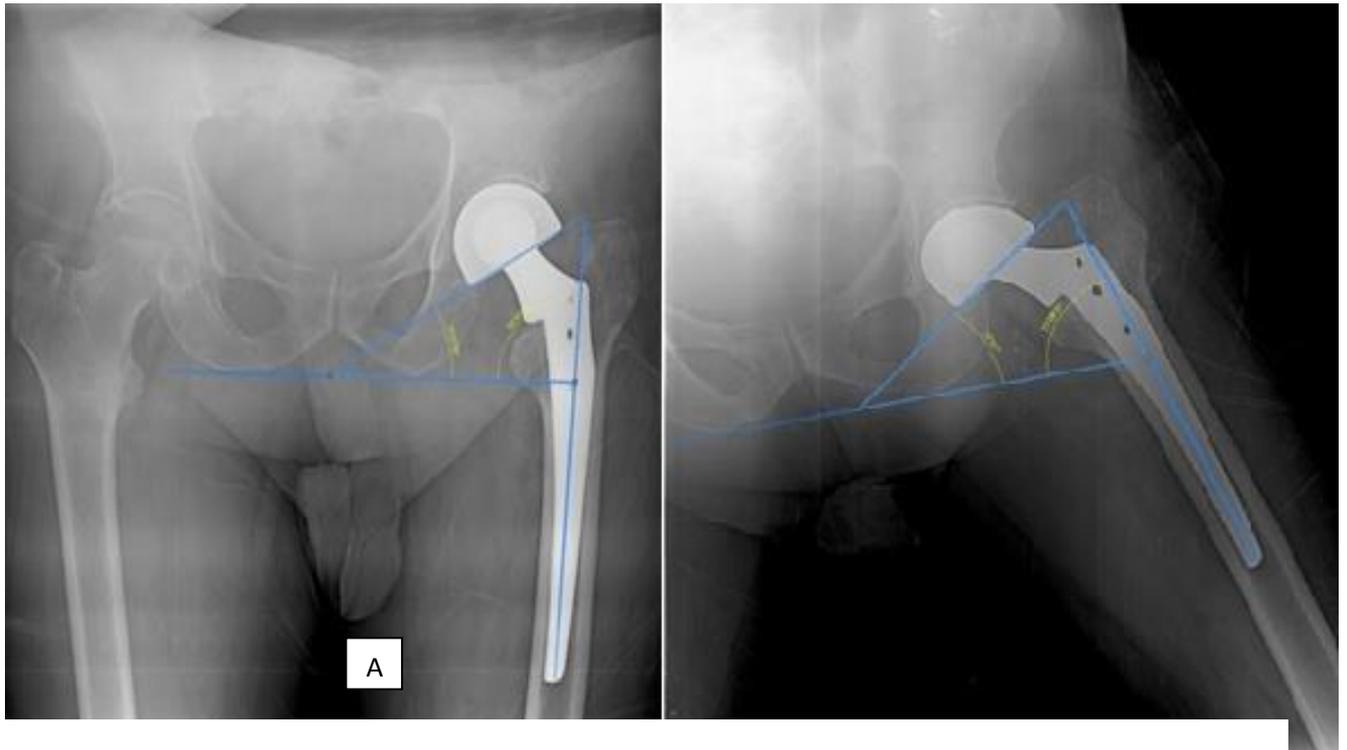
A)Line 1 on radiograph ,B)Line 2 on radiograph C)Line 3 on radiograph D) Radiological assessment of pelvis with implant in neural position E) Radiological assessment of pelvis with implant in abduction

**Angle A** was defined as the intersection of the line drawn from the inferior margin of acetabular component and the reference line.

**Angle B** was formed by the intersection of the ischial reference line with a line drawn along the center of the long axis of the femoral stem.

The same exercise was repeated on the maximum abduction anteroposterior radiograph also and the angles are marked as A1 and B1.

**Example:**



*A) Radiological assesment of pelvis with implant in neural position- model X-ray,B)Pelvis with implant in abduction position-model X-ray*

X-ray of pelvis with both hips (neutral position) with Bipolar prosthesis on right side showing

Angle A – 31.2degrees

Angle B – 92.4degrees

X-ray of pelvis with both hips (Abduction of operated hip) with Bipolar prosthesis on left side showing Angle

A1 – 38.3 and Angle B1 – 77.3 degrees.

A = 31.2, B = 92.4, A1 = 38.3 , B1 = 77.3 (DEGREES )

B2= 15.1 DEGREES (TOTAL ABDUCTION)

A2 = 7.1DEGREES (MOTION @ OUTER CUP)

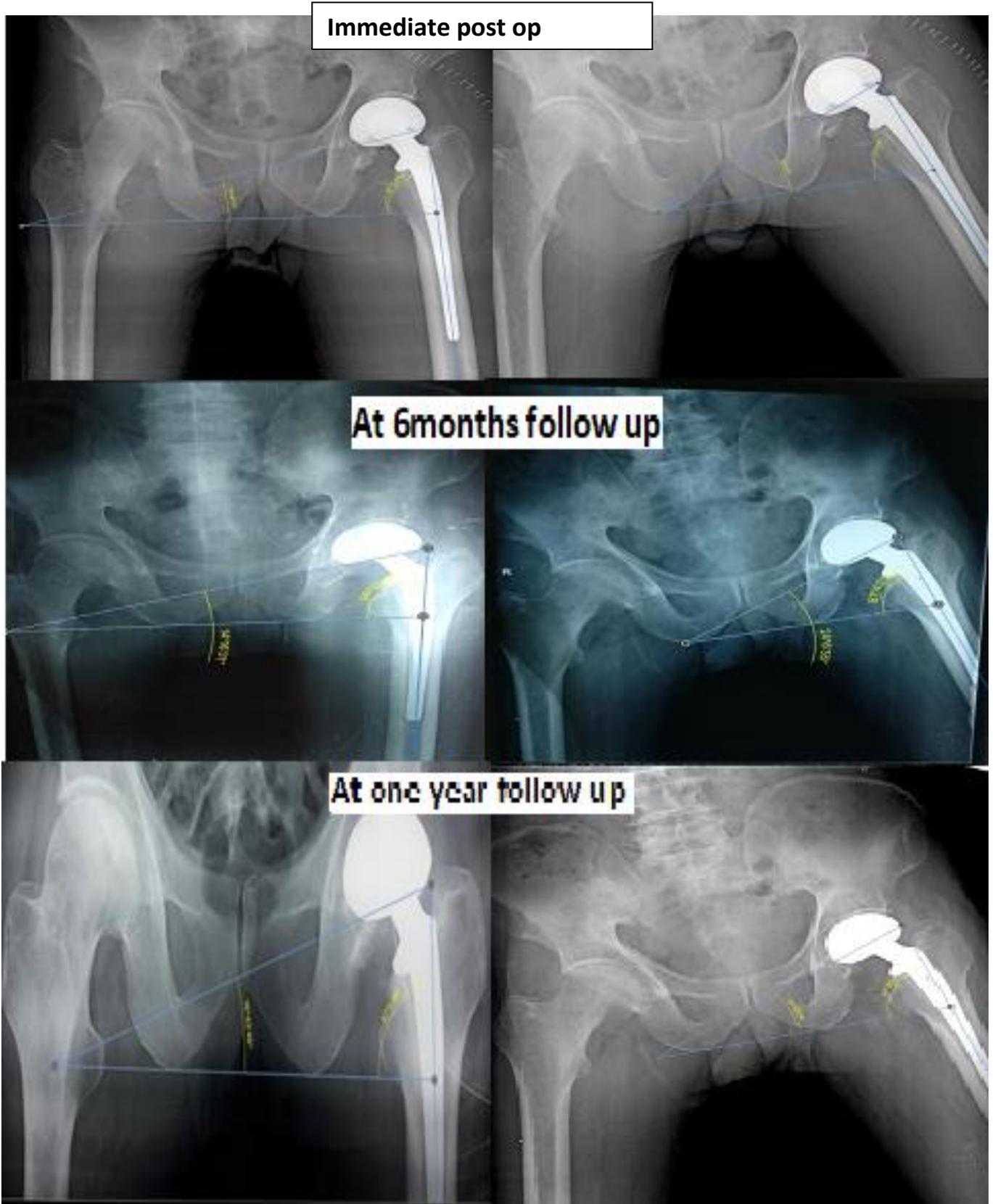
B2-A2 = 8 DEGREES ( INTRA-PROSTHETIC JOINT MOTION)

A2 = 20 % (MOTION @ OUTER CUP)

B2 - A2 = 80 % ( INTRA-PROSTHETIC JOINT MOTION) .

B

**CASE**



**STATICAL ANALYSIS**

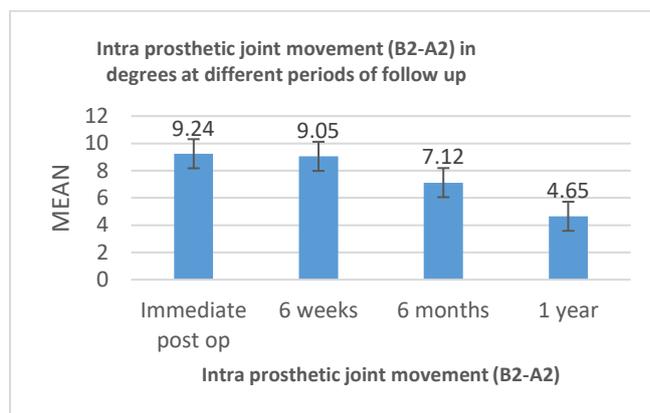
Data was entered in MICROSOFT EXCEL sheet and analysed using SPSS 22 version software categorical data was represented in form of frequencies and proportions. Continuous data was represented in form of mean and standard deviation.

## RESULT

### B2-A2 Motion at intraprosthetic joint (in degree) at different period of followup

In the study there was significant decrease in mean B2-A2 Motion at intraprosthetic joint at 1 year compared to immediate post op value.

		Mean	SD	Minimum	Median	Maximum	P value
B2-A2-Motion at intraprosthetic joint	Immediate Post Op	9.24	6.26	1.00	8.60	21.90	
	6 weeks	9.05	3.50	2.00	8.20	15.00	0.558
	6 months	7.12	2.12	2.20	7.60	10.70	0.055
	1 year	4.65	2.04	1.09	4.35	9.00	<0.001*



### Intra prosthetic joint movement (B2-A2) in degrees at different periods of follow up

During immediate post surgery the average intraprosthetic movement was 54.60 percent with one patient having maximum of 93% movement at intraprosthetic joint. At 6 weeks the average fell to 42.16 percent, at 6 months it was 30.28%

By one year, on average 24.02 percent of movements occurred at inter prosthetic joint and the rest of the movements occurring at outer cup and the acetabulum.

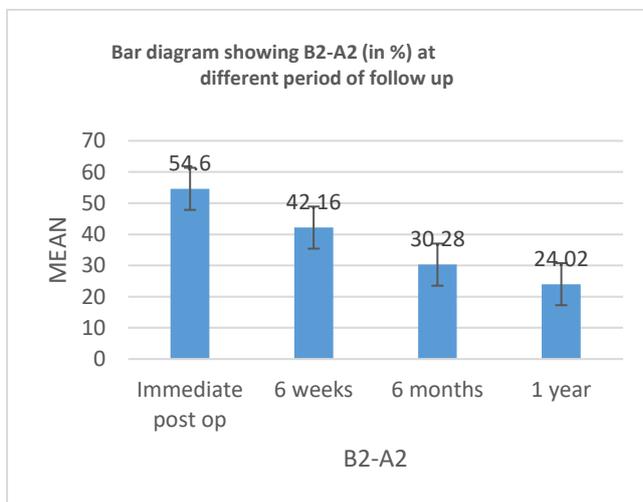
Over the period of one year the movements at inner cup gradually reduced to 24% of total movements occurring in bipolar hemiarthroplasty. With maximum being 45% and minimum being 11%.

In the study there was significant decrease in

mean B2-A2 at 6 weeks, 6 months and 1 year compared to immediate post op period.

**B2-A2 (in %) at different period of follow up**

		Mean	SD	Minimum	Median	Maximum	P value
B2-A2	Immediate Post Op	54.60	25.61	9.00	59.50	93.00	
	6 weeks	42.16	13.25	16.00	41.70	78.00	<0.001*
	6 months	30.28	7.13	14.00	30.50	46.00	<0.001*
	1 year	24.02	6.88	11.00	23.50	45.50	<0.001*



**Bar diagram showing B2-A2 (in %) at different period of follow up**

**DISCUSSION**

We did a study of radiological assessment of Intraprosthetic movement in bipolar hemiarthroplasty in 30 cases. The study was compared with relevant studies of other authors as well. Various aspects of the studies have been compared and discussed in detail.

The advantage of a Bipolar prosthesis over unipolar prosthesis is that the movement happens at the two interfaces

- 1.The prosthetic inner femoral head and inner polyethylene liner
- 2.Acetabulum and outer head

Various studies have proven that the incidence of protrusion of acetabulum has drastically come down with use of bipolar hemiarthroplasty compared to unipolar hemiarthroplasty .

A meta analysis involving 4511 patients reported that unipolar prosthesis tripled the risk of acetabular erosion compared to bipolar implant<sup>6</sup>.

Other complications like acetabular erosions would be delayed or prevented<sup>67</sup> by reducing wear due to sliding motion in acetabular socket. The high molecular weight polyethylene (HMWPE) also absorbs some of the impact forces during gait. The advantage of bipolar over unipolar have been accepted

by many studies <sup>67-69</sup>, but some reports cast doubt on the continuity of intraprosthetic movement in bipolar prosthesis.

In this context this study is conducted to radiologically evaluate intraprosthetic movement in Bipolar hemiarthroplasty immediately after surgery, at 6 weeks, at 6 months and at one year. The method followed was that of Bochner et al <sup>43</sup> for radiological assessment of IPJ motion.

In our study the amount of average intraprosthetic movement At immediate follow up was 54.6 %,

- a. 6 weeks was 42.16%
- b. 6 months was 30.3%
- c. 1 year was 24%

Philips TW(1987) had done a study on Bateman

Bipolar arthroplasty movements on fluoroscopy in 100 patients. Out of them 76 had arthritic hip and 24 had femur neck fracture. At the end of 4 years follow up 80% of arthritic group retained movements at inter prosthetic joint compared to 25 % of frequency neck fracture group.<sup>62</sup>

Verbene G.H.M (1983), did radiological study on movements in varikopf prosthesis in 20 patients with fracture neck of femur during immediate, one month and 3 months post operative period. He observed that interprosthetic joint lost mobility at 3 months and retained only 16.9% of mobility.<sup>63</sup>

Buchner RM, in a study on bateman's prosthesis assessed radiological IPJ movements and at the end of 4 years the bipolar function was retained and movements were shared between outer and inner cup.

The interprosthetic movements at 6 months was 19%.

Movement at IPJ (B2-A2) in %	Immediate	6 weeks	6 months	1 year
Anil Kumar Rai et al		36.5	33.74	27.92
Arvind Kumar SM et al	55	43	28	
Our study	54.6	42.16	30.28	24.02

**Movement at IPJ in various studies**

In a study conducted by Anil kumar rai<sup>70</sup> from Banaras Hindu university, Varanasi, India. During the period of 2003 to 2011 treated with BHU bicentric bipolar prosthesis showed that

in fracture neck of femur the IPJ movements were 33.74% at 3 months 25.66% at 1.5 years and remained stationary till 6 years at around 20 percent.

In a study conducted by Arvind Kumar et al<sup>71</sup>, the IPJ movements were at 55% at immediate post op which reduced to 43% and 28% at 6 weeks and 6 months respectively.

Higher IPJ movement was seen in arthritic group than fracture group possible due to friction at outer cup and acetabulum leading to better movements at IPJ

The results of our study at 6 months and one year was comparable to other studies and better than some of the earlier studies in preserving the intraprosthetic joint motion.

The results of our study at 6 months and one year was comparable to other studies and better than some of the earlier studies in preserving the intraprosthetic joint motion.

Factors affecting intraprosthetic prosthetic joint movement and variations in the study groups.

1.State of acetabular cartilage- in subjects with normal acetabular cartilage the outercup slides more compared to arthritic group leading to increased movement at outer cup. Here only at the terminal range of movements prosthetic femoral head impinges on the neck leading to movements of the outer cup.

2.The inner femoral head size used by Verbene et al was 32mm which decreased the polyethylene thickness and also the movements at IPJ.Bochner and Philips et al used charnley 22 mm inner femoral head and which successfully increased the UHMWPE/HDPE thickness.The rate of UHMWPE was 0.7mm/year<sup>70</sup>. The wear derbies from UHMWPE is much lower than HDPE and contributes to better IPJ movement.

This study used bipolar with smaller inner prosthetic head with UHMWPE liner our subjects had better intraprosthetic joint movement compared to Verbene et al and Bochner et al.

## CONCLUSION

Intraprosthetic movement in a bipolar implant is what sets it aside from a unipolar implant with reduced acetabular erosion giving better functional outcome.

In this study we have radiologically assessed the intraprosthetic movements in a bipolar hemi-arthroplasty done for fracture neck of femur.

We are of the conclusion that Intraprosthetic movement is maintained at all intervals of follow up with 24% at one year follow up unlike it was thought by older studies due to

- a) Improvement in implant design
- b) use of UHMWPE as polyethylene liner
- c) use of optimum size inner prosthetic head

2. The functional outcome of subject is proportional to the moments at intraprosthetic joint.

Further research and long term radiological assesment is needed to improve and preserve the intraprosthetic movement in a bipolar hemi arthroplasty.

### **LIMITATIONS OF THE STUDY**

- 1.Small sample size
2. Long term assessment needed
3. Radiological assessment was done in supine position and not in weight bearing position which might change the movements at IPJ.

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