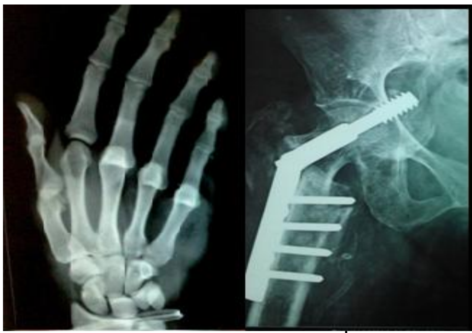

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Dr. PN Kulkarni
Professor & Head
Department of orthopaedics, KIMS, Karad, Maharashtra, India

Dr. Kiran Gaonkar
Professor, Department of orthopaedics, KIMS, Karad, Maharashtra, India

Dr. Nishant Gaonkar
Assist Professor, Department of orthopaedics, KIMS, Karad, Maharashtra, India

Dr. Ketan Gupta
Senior Resident, Department of orthopaedics, KIMS, Karad, Maharashtra, India

Dr. Gaurang Chanchpara
Resident, Department of orthopaedics, KIMS, Karad, Maharashtra, India

Dr. Prashant Pandey
Resident, Department of orthopaedics, KIMS, Karad, Maharashtra, India

Dr. Sushil Ankadavar
Resident, Department of orthopaedics, KIMS, Karad, Maharashtra, India

Correspondence
Dr. Prashant Pandey
Krishna Institute of Medical Sciences, Karad, Maharashtra, India

Bipolar Hemiarthroplasty for fracture of femoral Neck: Clinical review with special emphasis on prosthetic motion by Radiological evaluation

Dr. PN Kulkarni, Dr. Kiran Gaonkar, Dr. Nishant Gaonkar, Dr. Ketan Gupta, Dr. Gaurang Chanchpara, Dr. Prashant Pandey and Dr. Sushil Ankadavar

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Abstract
Introduction: Intracapsular femoral neck fractures are common in the elderly population. To avoid the poor outcome of internal fixation and for early mobilization, hemiarthroplasty is performed.
Aims & Objective: To study the management of fracture neck of femur by bipolar prosthesis and to study post-operative prosthetic components motion radiologically.
Materials & Methods: Thirty patients with fracture neck of femur were treated using fixed angle bipolar hip prosthesis. All patients were assessed post operatively radiologically at 1 ½, 3 and 6 months follow up. Patients with Avascular necrosis, Osteoarthritis and insufficient calcar size for implanting bipolar prosthesis were excluded. Radiologically prosthetic motions were evaluated in neutral position, 20° & 40° abduction and 20° adduction.
Results: Study shows that mean motion in the outer component & the acetabulum was higher than motion between inner component & the acetabulum in immediate, 1 ½, 3 and 6 months follow up. Main complaint of patients was pain in operated hip.
Conclusion: In a country like India, in rural population considering their economic status, the use of fixed angle bipolar prosthesis in fracture neck of femur was associated with more motion in outer component and acetabulum due to an impingement of the femoral neck on the liner and structural difference between the inner and outer joint.

Keywords: fracture neck of femur; hemiarthroplasty

Introduction

Fracture neck femur in elderly patient is one of the oldest in orthopaedics. Despite numerous technical advances the goal to return all patients to full function has remained elusive. The marked improvement in socioeconomic conditions and quality of life has resulted improvement in life expectancy and so increased incidence of fracture neck femur. It has been estimated that 1.66 million hip fractures occurred in 1990 worldwide a figure that is expected to double by 2025 and increase to 6.26 million by 2050. According to the Swedish National Hip Fracture Register, intra-capsular fractures of the femoral neck constitute 53% of all hip fractures with 33% undisplaced and 67% displaced [1].

Since the end of the 1960s, prostheses with an inner bearing have been used. The 1974, Sir J. E. Bateman, the pivot man, came with the idea of providing the desirable rotator movement in head of prosthesis to take care of pain and erosion seen in Austin-Moore hip replacement; and popularized it as 'BIPOLAR HIP PROSTHESIS'[2]. The underlying idea is that movements of the hip should occur mainly in the built-in bearing (because of the lower friction) rather than in the joint between the prosthetic head and the acetabulum, thus sparing the acetabulum.

A polyethylene bearing UHMWPE insert articulates with the head, and the insert is covered with a metal bearing surface that articulates with the acetabulum. This design is intended to distribute the forces at the site between the metal femoral head & the polyethylene insert and at the site between the outer metal surface of the insert & the acetabulum. Motion occurs at the inner bearing until the stem impinges on the polyethylene and then motion at the outer shell occurs.

The inner head is locked into the polyethylene insert [3].
Clinical results have demonstrated loss of outer bearing motion in some patients which include: surgeon over-sizing of the outer head, acetabular geometry, acetabular condition (quality and thickness of cartilage), use of acetabular reaming, underlying disease (fracture, rheumatoid arthritis, or osteoarthritis) and osteophyte formation.

Material and Methods: Thirty patients with fracture neck femur were included in this study and were treated using bipolar hip prosthesis [135˚]. All routine preoperative evaluation was done. Pre anaesthetic and physician check-up were done. Under appropriate anaesthesia surgery was done. Patients with insufficient calcar size, avascular necrosis and osteoarthritis were excluded. Prosthetic design [Fenestrated type] with fixed inner component diameter of 22 mm & with positive eccentric loadingwas used. Patients were mobilized full weight bearing on the 3^{rd} day of surgery and assessed post-operatively radiologically at 1 ½, 3 and 6 months follow up period. Indications for cementing were osteoporotic bones with wide medullary canal &as per Dorr's ratio. Dorr's CC ratio is the inner cortex diameter 10 cm below the most medial aspect of lesser trochanter is divide by the inner cortex diameter at the most medial aspect of lesser trochanter.

Radiological assessment of Prosthetic component motion: Radiological evaluation was made immediate post operatively (on 5^{th} to 7^{th} day when patient starts weight bearing by walker), 1 ½,3 and 6 months by taking X-Ray PBH AP view with movements at hip joint as follows:

- Neutral [Weight bearing]
- Abduction - 20 ^{0}, 40 ^{0}[Weight bearing, Fixed distance between the feet of 50 cm & 70 cm]
- Adduction - 20 ^{0} [Non weight bearing, maximum adduction]

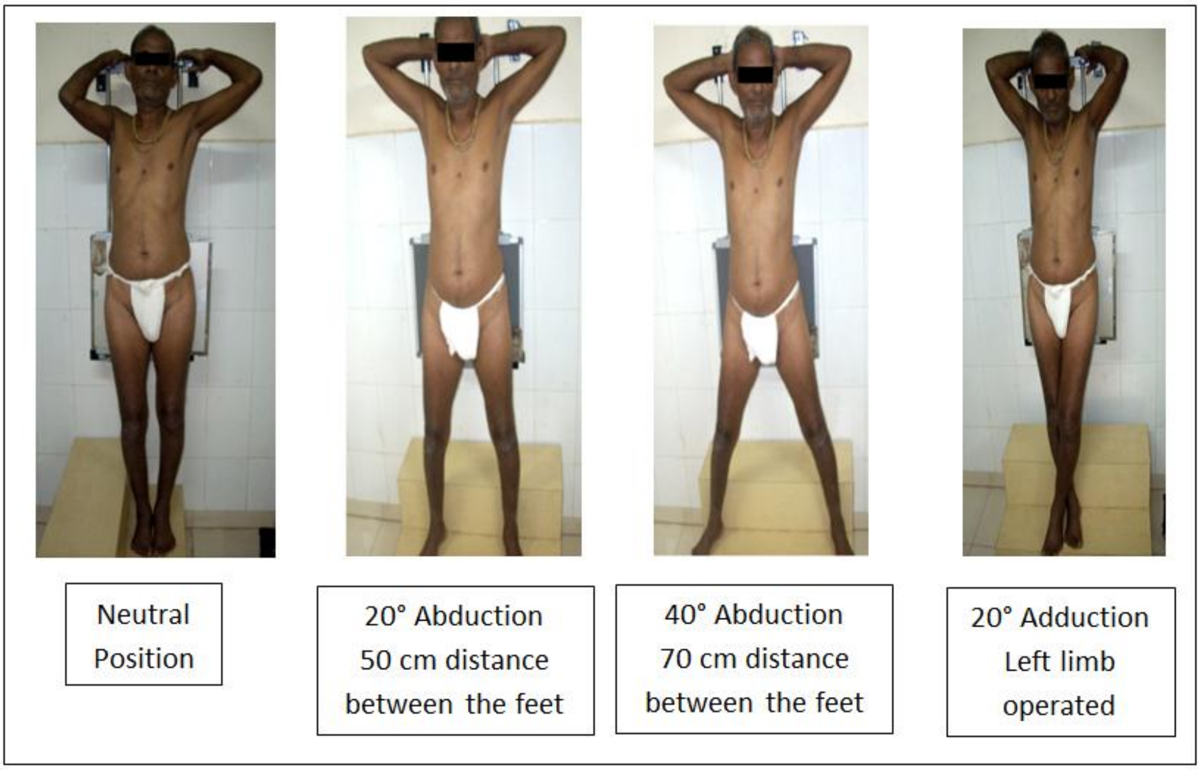

Fig 1: Lower Limb position while taking X-ray PBH AP view

Evaluation of component motion on X-ray film
The measurements of the angles between the two components were done as follows.

- **Line AD -** line passing through the superior and inferior lips of acetabulum
- **Line BD** - line passing through the base of the cup
- **Line CF -** line passing through center of neck stemexactly parallel &equidistant to superior and inferior borders of the stem.
- **Outer component& acetabulum angle -** Angle formed by points ADB evaluates motion of outer cup in acetabulum.
- **Inner & outer comp angle -** Angle formed by CEB evaluates the motion between inner cup & the outer cup.
- **In abduction -** Decrease in angle ADB & angle CEB
- **In adduction -** Increase in angle ADB & angle CEB

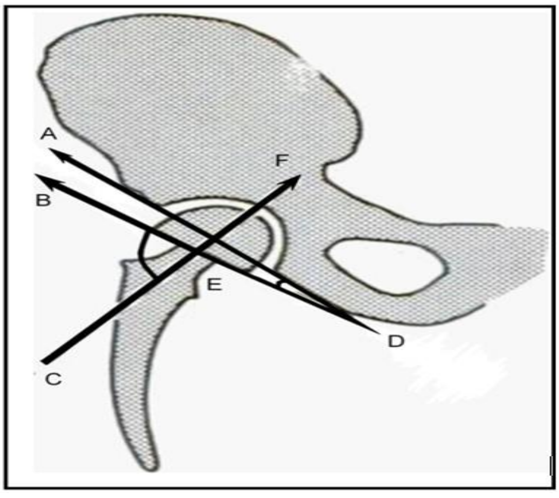

Fig 2: Evaluation of motion on x ray

For example - 65 years old male patient was operated by 49 mm Bipolar prosthesis and the angles of follow up x rays were as follows-

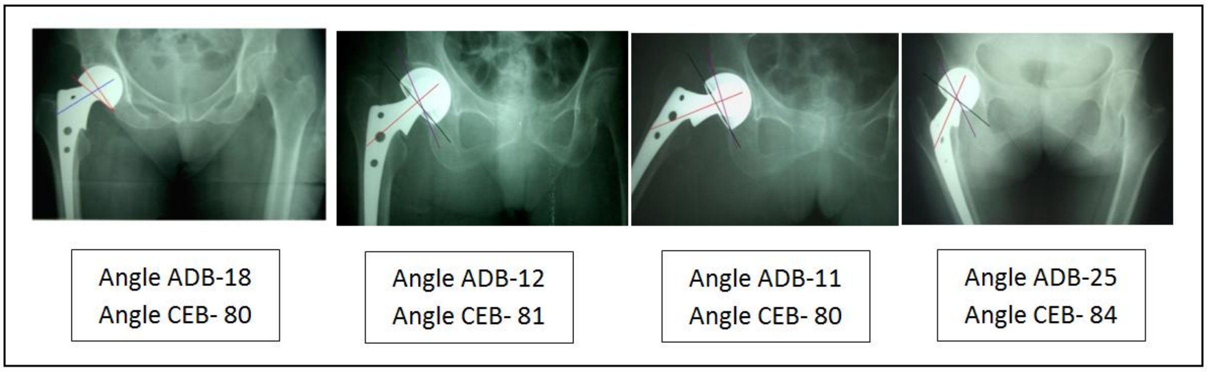

Fig 3: Immediate post-operative x rays

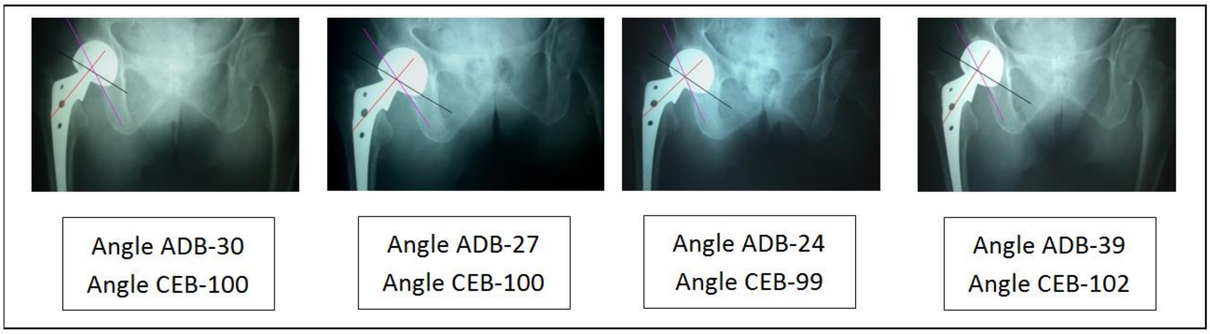

Fig 4.1: ½ month follow up x rays

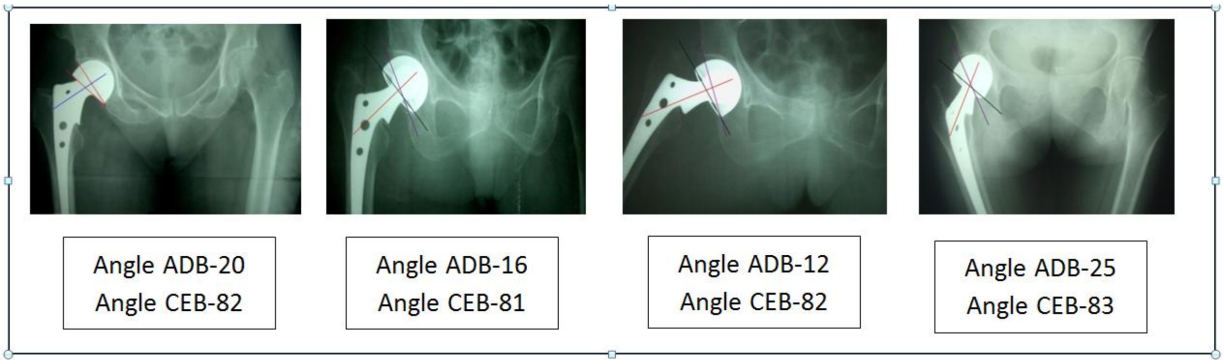

Fig 5.3: months follow up x rays

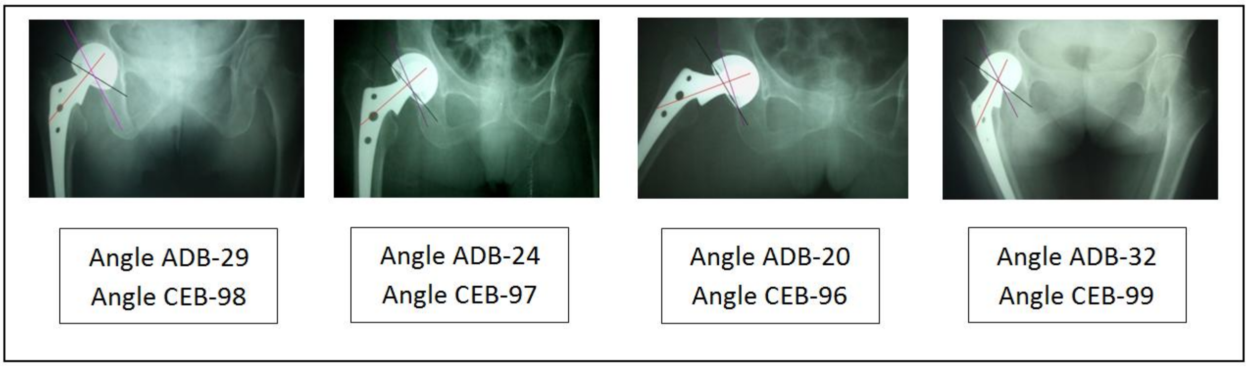

Fig 6.6: months follow up x rays

Observation and Results: In our study we used series of x-rays in neutral, 20° abduction, 40° abduction and 20° adduction. Results were graded by measuring the angles between inner & outer component and the outer component & acetabulum as described before. Maximum patients (24 cases) were from age group of 60 – 70 years. In our study out of 30 patients 10 were male and 20 were female. Right side was more commonly involved (19 cases)**.** There were 25 patients with transcervical fracture neck femur and 5 patients with sub capital fracture neck femur.Range of motion between two components and the outer component & acetabulum was as follows:

Table 1: Range Of Motion between Two Components and the Outer Component & Acetabulum

	Mean motion by paired T test			
Follow up →	**Immediate post-operative**	**1 ½ month**	**3 months**	**6 months**
Pair 1 Neutral position –inner & outer component v/s adduction 20° inner & outer component	2.5	2.6	2	1.7
Pair 2 Neutral position between inner & outer component v/s abduction 20° inner & outer component	3.4	1.7	.03	2.7
Pair 3 Neutral position between inner & outer component v/s abduction 40° inner & outer component	6.3	7.2	4.0	5.9
Pair 4 Neutral position between outer component & acetabulum v/s adduction 20° outer component & acetabulum	9.8	8.3	8	8.8
Pair 5 Neutral position between outer component & acetabulum v/s abduction 20° outer component & acetabulum	15.1	15.6	14.7	13.5
Pair 6 Neutral position between outer component & acetabulum v/s abduction 40° outer component & acetabulum	27.8	27.1	25.6	25.5

So when we compared both the tables (Table 1 & 2) we found increase in the degree of motion in outer component and acetabulum compared with neutral angles whereas decrease in the degree of motion in inner component and outer component compared with the neutral. We studied the frictional behaviour of bipolar prosthesis and the motion of the bipolar prosthesis for fracture neck femur in elderly patients above 60 years of age. It was seen that maximum motion occurs between the outer component and acetabulum even in extreme range of motions. It has been postulated that most hip motion occurs at the inner bearing in bipolar hip prosthesis. However, radiography analyses have shown that the inner bearing is not always the primary articulation [4]. Most of the motion during mid-abduction, full abduction and adduction occurred in the acetabulum and outer cup, during initial phase and also in the late phase. Motion between inner and outer component also occurred during initial and late phase but comparatively less than expected. Taking all these findings into consideration we have come to the conclusion that though theoretically it was expected that the motion between inner and outer component should be more than outer component and the acetabulum, in our study it was shown that motion between outer component and the acetabulum supersedes the motion between inner and outer component and this pattern was followed up to 6 months of postoperative period. Pit falls of the study were as follows: First is we have used only one fixed model of prosthesis and we have not tried different designs like broad outer cup, which over hangs the acetabulum [5] considering poor economic status of the patients as this study was conducted in rural areas. Second is we haven't assessed the motion during flexion and extension on weight bearing as it was difficult to measure and record radiologically which ideally the movements during walking are.

Discussion: The aim of this study was to study the component motion in bipolar prosthesis in elderly patients with intra-capsular fracture neck femur. Open reduction and internal fixation with pins and screws in elderly patients gave poor results mainly due to osteoporosis and vicarious blood supply of femoral neck. It produced complications like mal-union and avascular necrosis. Fenestrated bipolar prosthesis which had fixed size stem and variable head size from 37mm to 51mm with neck shaft angle of 135^0 were used in this study. All of our patients were from low or middle socio-economic status. The aim of the surgery was to restore the anatomy of proximal femur as regards to horizontal, vertical offset and neck shaft angle as close to normal as possible to lend as an almost normal hip functions. This study attempts to evaluate the motion between the acetabulum and the outer cup and between inner component and the outer cup. At an average up of 6 months of follow up, the motions were evaluated radiologically. Around 85% of patients were in their 5^{th} and 6^{th} decades. This was significant because of the relatively higher level of activities and greater functional demands of these patients as compared to 8^{th} and 9^{th}decade, who were not that active, were fragile and less demanding. The average age in our study was 65 years. This is comparable to population studied by other workers like Vezquez-vela *et al*, Cornell CN *et al*, McCorville *et al*. [6, 7, 8, 9].

The mean duration of hospitalization in our study was 11days. If patient was doing fine and no problem was anticipated, patient was discharged 10 days after surgery. Higher incidence of various hip pathologies including fracture neck femur in females may be due to social factors and osteoporosis, so exposed to higher risk of injury.[10]In our study right side predominates i.e various hip pathology are right sided in 19 patient and left sided in 11 patients with one patient was having bilateral hip affection. In our series, the rate of dislocation is 0.6 %, this rate is comparable with the rates of Bednarek *et al* and Bowmann A J *et al* series [9,11,12] This significantly lower rate of dislocation can be attributed to the inherent stability of the prosthesis and specific technique and post-operative protocol strictly followed. It has been shown that use of knee brace in post-operative period in patients in whom posterior approach is used has shown to reduce rate of dislocation probably the routine use of knee brace in this study has reduced the rate of dislocation. The post-operative morbidity rates for pressure sores were significantly lower in bipolar arthroplasty. Only one patient in our series had superficial bed sore which was treated by daily dressing twice and did not hamper the clinical outcome. This was probably because of earlier mobilization of these patients, started from 3^{rd} postoperative day. During hospital stay, post-operatively, patients were made to walk using walkers. Quadriceps and hip abduction exercises were also given extensively to strengthen lower limb musculature [13, 14].

Results of Component Motion was as follows

Table 1 A & B shows the maximum and minimum degrees of angle observed in the patients in neutral position in frequent follow ups, between inner and outer component and outer component and acetabulum. It also shows the mean degree of angle with the standard deviation.

Table 1: a) Neutral position between inner component and outer component

FOLLOW UP	Minimum	Maximum	Mean	Std. Deviation
Immediate	60.00	100.00	86.6	7.9
1 month	62.00	99.00	84.9	8.7
3 months	60.00	99.00	83.5	9.9
6 months	62.00	100.00	85.1	9.4
Total	60.00	100.00	84.10	8.10

Table 1: b) Neutral position between outer component and acetabulum

Follow UP	Minimum	Maximum	Mean	Std. Deviation
Immediate	.50	51.00	18.9	11.10
1 month	1.00	53.00	22.10	12.9
3 months	1.00	50.00	23.8	15.2
6 months	2.00	50.00	22.9	11.6
Total	.50	53.00	22.1	12.10

Table 2 A&B shows the maximum and minimum degrees of motion observed in the patients in 20° adduction in frequent follow ups, between inner and outer component and outer component and acetabulum. It also shows the mean degree of angle, with the standard deviation.

Table 2: a) 20° adduction - Motion between inner component and outer component

Follow UP	Minimum	Maximum	Mean	Std. Deviation
Immediate	63.00	105.00	89.1	8.6
1 month	62.00	100.00	87.5	9.1
3 months	60.00	100.00	85.5	10.1
6 months	62.00	100.00	86.8	9.2
Total	60.00	105.00	87.2	9.2

Above table reveals decreasing trend from immediate post-operative to 6 months post-operative.

Table 2: b) 20° adduction - Motion between outer component and acetabulum

Follow Up	Minimum	Maximum	Mean	Std. Deviation
Immediate	10.00	62.00	28.6	12.10
1 month	3.00	64.00	31.3	16.2
3 months	2.00	62.00	31.8	16.3
6 months	4.00	62.00	31.7	14.1
Total	2.00	64.00	30.8	14.8

Above reveals increasing trend from immediate post-operative to 6 months post-operative.

Table 3 A&B shows the maximum and minimum degrees of motion observed in the patients in abduction 20 degrees in frequent follow ups, between inner and outer component and outer component and acetabulum. It also shows the mean degree of angle with the standard deviation.

Table 3: a) 20° abduction – Motion between inner and outer component

Follow up	Minimum	Maximum	Mean	Std. Deviation
Immediate	52.00	100.00	83.2	9.6
1 month	50.00	98.00	83.1	10.7
3 months	51.00	98.00	83.4	10.5
6 months	50.00	100.00	82.3	10.8
Total	50.00	100.00	82.10	10.3

Above table shows decreasing trend from immediate post-operative to 6 months post-operative.

Table 3: b) 20° abduction – Motion between outer and acetabulum

Follow Up	Minimum	Maximum	Mean	Std. Deviation
Immediate	20.00	38.00	3.7	12.9
1 month	10.00	40.00	7.3	14.1
3 months	20.00	39.00	9	15.7
6 months	12.00	39.00	9.3	13.3
Total	20.00	40.00	7.3	14.1

Above table shows increasing trend from immediate post-operative to 6 months post-operative.

Table 4 A&B shows the maximum and minimum degrees of motion observed in the patients in abduction 20 degrees in frequent follow ups, between inner and outer component and outer component and acetabulum. It also shows the mean degree of anglewith the standard deviation.

Table 4: a) 40° abduction – Motion between inner and outer component

Follow Up	Minimum	Maximum	Mean	Std. Deviation
Immediate	50.00	100.00	80.2	10.9
1 month	10.00	100.00	77.6	16.3
3 months	50.00	100.00	79.4	10.6
6 months	9.00	100.00	79.1	16.4
Total	9.00	100.00	79.1	13.7

Above table shows decreasing trend from immediate post-operative to 6 months post-operative

Table 4: b) 20° abduction – Motion between outer and acetabular component

Follow Up	Minimum	Maximum	Mean	Std. Deviation
Immediate	40.00	20.00	8.9	13.4
1 month	25.00	22.00	4.2	13.8
3 months	40.00	29.00	1.9	14.4
6 months	22.00	22.00	2.6	13.8
Total	40.00	29.00	4.4	13.9

Above table shows increasing trend from immediate post-operative to 6 months post-operative.

Table 5: Significance of comparison of angles observed immediate post-operative follow up –

		Paired difference		T
		Mean	SD Deviation	
Pair 1	Neutral position –inner & outer component v/s adduction 20° inner & outer component	2.5	2.5	5.4**
Pair 2	Neutral position between inner & outer component v/s abduction 20° inner & outer component	3.4	5.7	3.2**
Pair 3	Neutral position between inner & outer component v/s abduction 40° inner & outer component	6.3	8.7	3.9**
Pair 4	Neutral position between outer component & acetabulum v/s adduction 20° outer component & acetabulum	9.8	4	13.3**
Pair 5	Neutral position between outer component & acetabulum v/s abduction 20° outer component & acetabulum	15.1	7.5	10.9**
Pair 6	Neutral position between outer component & acetabulum v/s abduction 40° outer component & acetabulum	27.8	9.9	15.3**

** = P < 0.01 Above table reveals that there is significant difference in specified pairs.

So in Table 5 as we compare the mean difference between the Pairs 1, 2 & 3 with the Pairs 4, 5 & 6 we can see that the mean motion in the outer component and the acetabulum is higher than the motion between inner component and acetabulum.So it shows that movement is more in outer component and acetabulum in immediate follow up.

Table 6: Significance of comparison of angles observed 1 month post-operative follow up

		Paired difference		T
		Mean	SD Deviation	
Pair 1	Neutral position –inner & outer component v/s adduction 20° inner & outer component	2.6	2.7	5.2**
Pair 2	Neutral position between inner & outer component v/s abduction 20° inner & outer component	1.7	3.7	2.5*
Pair 3	Neutral position between inner & outer component v/s abduction 40° inner & outer component	7.2	10.9	3.6**
Pair 4	Neutral position between outer component & acetabulum v/s adduction 20° outer component & acetabulum	8.3	5.8	7.7**
Pair 5	Neutral position between outer component& acetabulum v/s abduction 20° outer component & acetabulum	15.6	7.5	11.3**
Pair 6	Neutral position between outer component & acetabulum v/s abduction 40° outer component & acetabulum	27.1	11.4	13**

* = P < 0.05 **= P < 0.01 Above table reveals that there is significant difference in specified pairs.

In Table 6 as we compare the mean difference between the Pairs 1, 2, & 3 with the Pairs 4, 5 & 6 we can see that the mean motion in the outer component and the acetabulum is higher than the motion between inner component and acetabulum. So it shows that movement is more in outer component and acetabulum in 1 month follow up.

Table 7: Significance of comparison of angles observed 3 month post-operative follow up

		Paired difference		T
		Mean	SD Deviation	
Pair 1	Neutral position –inner & outer component v/s adduction 20° inner & outer component	2	2.0	5.2**
Pair 2	Neutral position between inner & outer component v/s abduction 20° inner & outer component	.03	5.9	.03
Pair 3	Neutral position between inner & outer component v/s abduction 40° inner & outer component	4.0	5.0	4.3**
Pair 4	Neutral position between outer component & acetabulum v/s adduction 20° outer component & acetabulum	8	9.4	4.6**

Pair 5	Neutral position between outer component & acetabulum v/s abduction 20° outer component & acetabulum	14.7	11.6	6.9**
Pair 6	Neutral position between outer component & acetabulum v/s abduction 40° outer component & acetabulum	25.6	15.1	9.2**

**= P <0.01 Above table reveals that there is significant difference in specified pairs.

In Table 7 as we compare the mean difference between the Pairs 1, 2& 3 with the Pairs 4, 5 & 6; we can see that the mean motion in the outer component and the acetabulum is higher than the motion between inner component and acetabulum. So it shows that movement is more in outer component and acetabulum in 3 months follow up.

Table 8: Significance of comparison of angles observed 6 month post-operative follow up

		Paired difference		T
		Mean	**SD Deviation**	
Pair 1	Neutral position –inner & outer component v/s adduction 20° inner & outer component	1.7	1.7	5.3**
Pair 2	Neutral position between inner & outer component v/s abduction 20° inner & outer component	2.7	3.1	4.8**
Pair 3	Neutral position between inner & outer component v/s abduction 40° inner & outer component	5.9	10.2	3.1**
Pair 4	Neutral position between outer component & acetabulum v/s adduction 20° outer component & acetabulum	8.8	4.3	11.1**
Pair 5	Neutral position between outer component & acetabulum v/s abduction 20° outer component & acetabulum	13.5	5.9	12.4**
Pair 6	Neutral position between outer component & acetabulum v/s abduction 40° outer component & acetabulum	25.5	8.9	15.6**

**= P < 0.01 Above table reveals that there is significant difference in specified pairs.

In Table 8 as we compare the mean difference between the Pairs 1, 2 & 3 with the Pairs 4, 5 & 6; we can see that the mean motion in the outer component and the acetabulum is higher than the motion between inner component and acetabulum. So it shows that movement is more in outer component and acetabulum in 6 months follow up.

Main complaints of operated patients were pain in operated hip. Other complications like infection and bedsore not encountered.

Summary and Conclusion: Today various treatment modalities are available for treatment of fracture neck femur in elderly patients with various designs of bipolar prosthesis available. But in a country like India, in a rural area where patients are not affordable for those higher designs, surgeons have to use fixed angle bipolar prosthesis. Therefore, in our study we used fixed 135^0bipolar prosthesis. We treated 30 patients with fracture neck of femur with maximum patients in 60-70 years of age group and female patient predominance. All patients were treated with either cemented or non-cemented technique. We found a relative preponderance of outer motion and the continuous co-existence of motion in the two joints in most patients. To our knowledge; the causative factors have not yet been clearly defined. Two factors can be suggested to cause the preponderance of outer motion. 1) Outer motion was induced by an impingement of the femoral neck on the liner. 2) Structural differences between the inner and outer joint also caused a preponderance of outer joint motion.

When weight is applied, the outer joint, which consists of a horseshoe-shaped acetabulum and a round acetabular cup, is not perfectly congruent and can contain some synovial fluid. Thus, the outer joint is more lubricated than the inner joint, and motion is more likely to occur at the outer joint.

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