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Does Increasing Horizontal Offset lead to better Stability in Bipolar hemiarthroplasty for Fracture Neck Femur

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Abstract

Introduction: Bipolar hemiarthroplasty is one of the treatments of choice for femur neck fractures when the femoral head is unsalvageable, which has been collaborated in multiple registries. However, one of the main reasons for readmission is dislocation mainly due to poor muscular tone in the elderly age group. We have compared stability intraoperatively with and without higher offsets when other confounders like neck and broach size are neutralized.

Materials and Methods: A prospective study consisting of selective cohort of 25 elderly patients treated with Bipolar hemiarthroplasty for femur neck fractures. During each procedure, surgeon measured stability keeping 0º adduction of hip at 90 and 110 degrees of flexion and internally rotating the hip till it starts dislocating using trials of 2 stems one with high horizontal offset and other with low horizontal offset, keeping vertical offset the same. All readings were taken on goniometer.

Results: Significantly (p=<0.001) increased stability in internal rotation at 90º flexion and 0º adduction is seen by 40±7º in low offset to 63±11º in high offset. Similar extremely significant results (p=<0.001) of increased stability in internal rotation at 110º flexion and 0º adduction is seen by 31±7º in low offset and 52±12º in high offset using Mann- Whitney test.

Conclusion: Higher offset does allow almost extra 22° of internal rotation before critical angle of dislocation when compared with normal offset. Higher offset undoubtedly restores better tone in abductors, stretches lax nonarthritic capsule adding to stability and lesser readmission rates because of added stability.

Keywords: Bipolar arthroplasty, Femoral neck fractures, Hip dislocation, Offset, Range of motion.

Introduction

Femoral Horizontal offset is the distance from the Centre of rotation of the femoral head to a line bisecting the long axis of the femur. Offset (range, 41 to 44 mm) increases with the size of the femur showing a good correlation coefficient [1]. The work of Mac Grory et al. [2] statistically demonstrates a significant statistical correlation between femoral offset and abductor muscle lever arm and strength. The femoral neck-shaft angle also determines the size of the anatomical femoral offset [3]. The vertical offset is measured relative to the bi-ischial line or inter tear drop line. It determines the tension of the abductor muscles [4]. Pauwels has shown that during a single-leg standing position, the body weight was counterbalanced by the abductor muscles strength [3]. Previous studies have shown that increasing femoral offset will improve hip abductor strength [2,5], enhance range of motion [2,6], reduce limping and the need for crutches [7-10]. Offset restoration seems to decrease dislocation risks [2,3,11].

There has been controversy in optimal surgical treatment of the elderly patient with a displaced femoral neck fracture. Options being closed reduction with internal fixation, bipolar or unipolar hemiarthroplasty or total hip arthroplasty (THA). Rog mark et al recently published the results of a large multicenter prospective randomized study comparing internal fixation with arthroplasty in patients older than age70 years who had displaced femoral neck fracture. At 2-year follow-up, the failure rate was 43% in the internal fixation group versus 6% in the arthroplasty group [13].

In a meta-analysis examining the results of 14 prospective, randomized trials comparing internal fixation with arthroplasty, Bhandari et al [14] concluded that 17 conversion surgeries can be avoided for every 100 patients treated with arthroplasty rather than internal fixation [14]. Similarly, Keating et al [15] recently compared open reduction and internal fixation (ORIF) with hemi-arthroplasty and THA. Patients older than age 60 years with displaced femoral neck fractures were studied. At 2-yearfollow-up, a secondary surgery rate of 39% in the ORIF group was observed compared with 5% and 9% in the hemiarthroplasty and THA groups, respectively. Study by Iorio et al [16] also concluded arthroplasty to be better in patients above 65 years of age, poor bone quality and high degree of comminution.

For neck femur fractures Bipolar hip arthroplasty is one of the alternatives for less active, more than 70 years age and co morbid patients. Recent studies have reported that Bipolar hemiarthroplasty provides good outcomes for elderly patients with displaced femoral neck fractures. Bipolar hemiarthroplasty after femoral neck fracture has predictable and good medium- and long-term results, even when compared with internal fixation or unipolar hemiarthroplasty [17, 18, 19]. Bipolar hemi-arthroplasty offers extra range than unipolar hemiarthroplasty due to inbuilt narrower neck as in total hip arthroplasty. Hemi-replacements are thought to be best stabilizers as largest fitting head articulates with acetabulum. Compared with Unipolar hemi-replacement, Bipolar prosthesis with an additional inner articulation has the theoretical advantages of less acetabular erosion and less dislocation [20,21]. Information from national registries showed lower readmission rate with bipolar than with Total Hip Arthroplasty (Australian and Italian registries), lower revision and reoperation rates with cemented hemiarthroplasty (Australian, England and Wales, and Swedish registries), revision rates lower with increasing age (Australian, Italian and Swedish registries) [22-25].

Most distressing and early complication of Bipolar hip arthroplasty is postoperative hip dislocation which can be attributed to bony and prosthetic impingement. So we decided, on witnessing some dislocations – whether offset “stand alone” gives stability. Although a review of 560 primary and revision hip arthroplasties found no significant difference of mean offset in cases with and without postoperative dislocation [12]. The purpose was to see whether there is correlation of increasing offset with hip stability, as seen during intraoperative trial reduction and finding critical angle of dislocation at 90º and 110º flexion with two offsets, when operated by same surgeon.

Materials and Methods

Study design and sampling of participants

A prospective study consisting of selective cohort of 25 elderly patients 15(Females) and 10(Males) aged between 63 to 75 (69±3) years with neck of femur fracture from March 2021 to March 2022, operated with bipolar hip arthroplasty of two different offsets. Although there are equally comparable results achieved by other modalities, cumulative costing following femoral neck fractures favoured use of Bipolar hip arthroplasty in our setup(Table 1).As we are tertiary care Public government run hospital where admission, bed charges, pathology, operative charges are given free i.e. beared by Bombay municipal cooperation except implant costing which is partly sanctioned by poor box charity fund thus serving lower economic section of society, making cemented bipolar hemiarthroplasty our preferred choice.

Table 1: Cumulative cost for implants (As quotations accepted by hospitals of Mumbai Municipal Cooperation a government funded fully subsidised healthcare organization)

Procedure	Cost
Cemented Bipolar Hemi-arthroplasty	$311
Uncemented Bipolar Hemi-arthroplasty	$623
Cemented Total hip Arthroplasty	$467
Uncemented Total hip Arthroplasty	$935

All patients were explained about the procedure and increase time during surgery due to trials and measurement for which informed consent was taken. Study was approved by the institutional board.

Study instruments and surgical procedure

The surgical technique was identical for all cemented Bipolar hip arthroplasty. Standard lateral positioning, painting and draping is done. Taking standard posterior approach to hip taking a 12 cm. incision over skin and subcutaneous tissue, incising the tensor fascia lata in the line of incision and splitting the Gluteus maximus fibres. Trochanteric bursae is opened and limb is internally rotated simultaneously separating external rotators of hip flush to bone, finally opening the capsule and removing the head using cork screw. Pack the acetabulum with sponge, to preventing spillage of bony spicule, which may enter the joint and abrade it. Then limb is internally rotated till tibia is perpendicular to thigh and floor. Box cut is taken and canal finder is introduced and trial stem of two different offsets are used keeping vertical offset same i.e. from Centre of head to Centre of lesser trochanter (Figure 1).

Figure 1:

During each procedure, surgeon measured stability keeping 0º adduction of hip at 90 and 110 degrees of flexion and internally rotating the hip till it starts dislocating using trials of 2 stems one with high horizontal offset (figure 2) and other with low horizontal offset (figure 3).

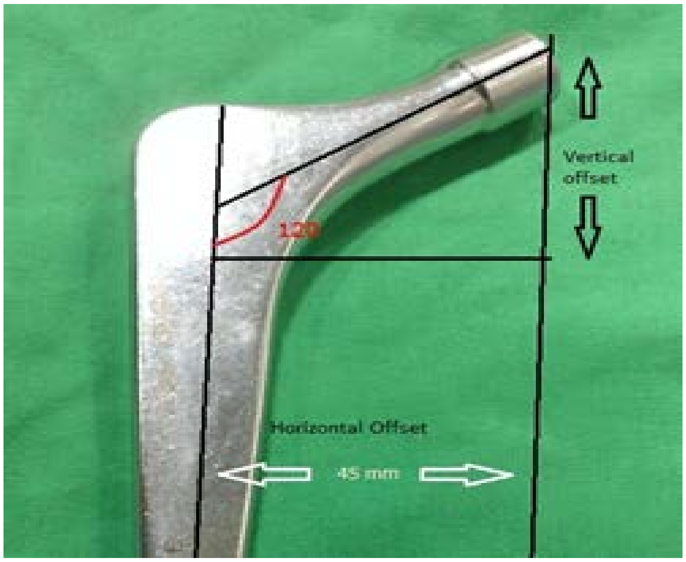

Figure 2:

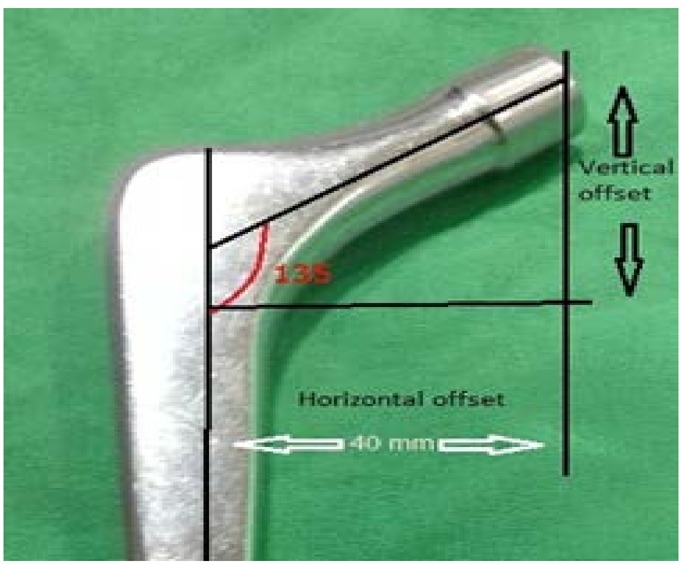

Figure 3:

During the procedure while comparing vertical offset was kept same, which was calculated on preoperative radiographs. Trial stems which were intraoperatively unstable and not snug fit were excluded from the study. Any loosening or rotation of trial stem was disregarded and next bigger size was used to make sure there is no intramedullary movement of trial stem. Standard neck cut of 1 cm. was used in all cases to remove any confounding bias.

Using the trial head, reduction is done and horizontal offset measured from Centre of head to tip of greater trochanter using stainless steel scale with millimetres marking on it. The stability of hip at 90- and 110-degrees flexion was measured by internally rotating the hip using goniometer. End point of internal rotation is taken when head just starts dislocating i.e. at least half of trial head is out and is observed to be due to intra prosthetic impingement and is confirmed by feeling with finger when neck touches the rim of bipolar head and cause it to dislocate (figure 4).

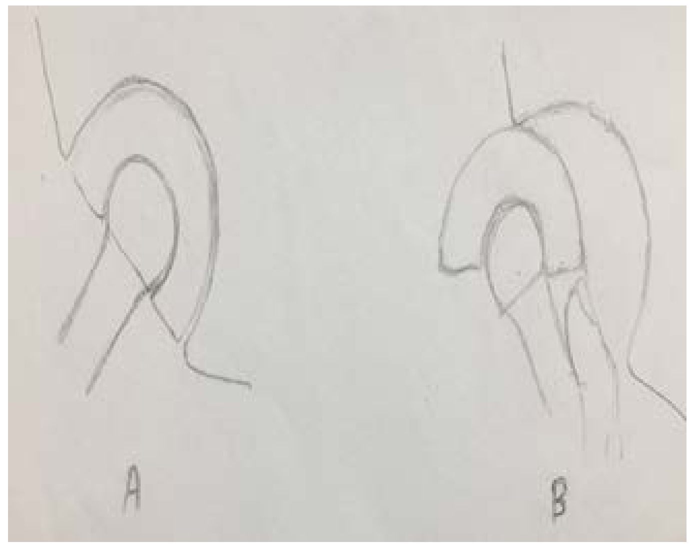

Figure 4:

Similar protocol was followed, with identical broach trial of same size and standard neck length i.e. zero, with appropriate head of same size but higher offset. Thus the comparison were made in every case, for critical range of rotation, as measured by goniometer with all the variables exactly same but with higher offset broach provided by same manufacturer (figure 5 and 6).

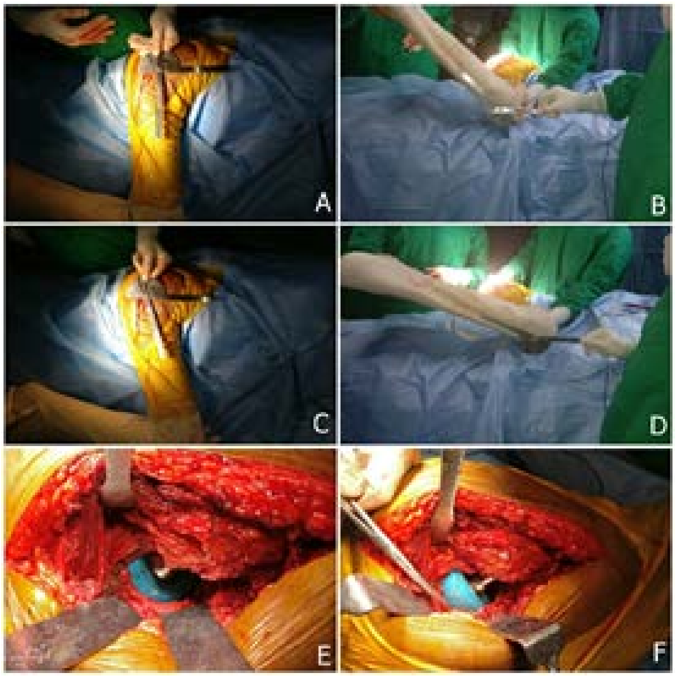

Figure 5:

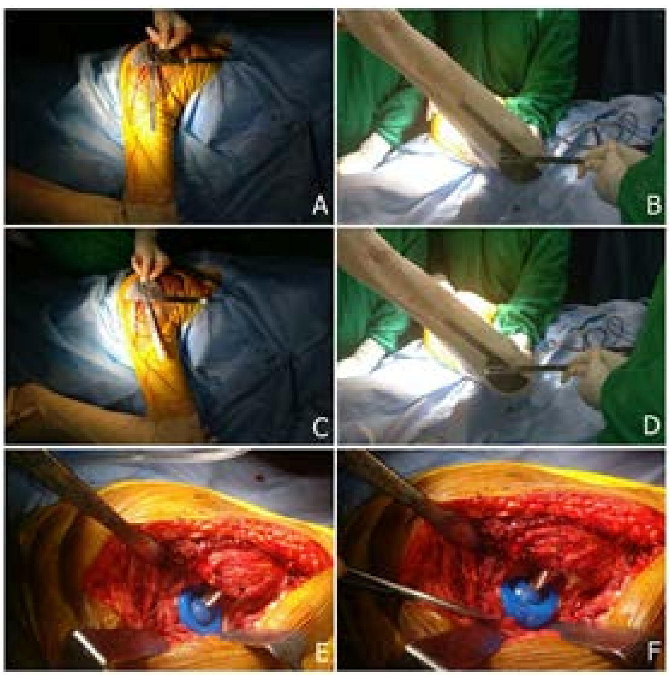

Figure 6:

All readings of goniometer are confirmed by two or more observers. Final stem is decided depending upon stability of trials. Post operative full weight bearing started from next day, avoiding flexion and adduction at hip.

Ethical aspects: Ethical approval for conducting the study was taken from the Ethical Committee of the local institution.

Data analysis: The data of patients who fulfilled the inclusion criteria were tabulated in electronic spreadsheet (Microsoft Excel 2010) and data was analyzed using SPSS 24.0.

Results

Stability of hip increased in a femoral offset dependent manner as seen by higher rotation required to dislocate the trial, when higher offset were used. Significant (p=<0.001) increased stability in internal rotation at 90º flexion and 0º adduction is seen by 40±7º in low offset to 63±11º in high offset (Table 2). Similar extremely significant results (p=<0.001) of increased stability in internal rotation at 110º flexion and 0º adduction is seen by 31±7º in low offset and 52±12º in high offset using Mann- Whitney test (figure 7).

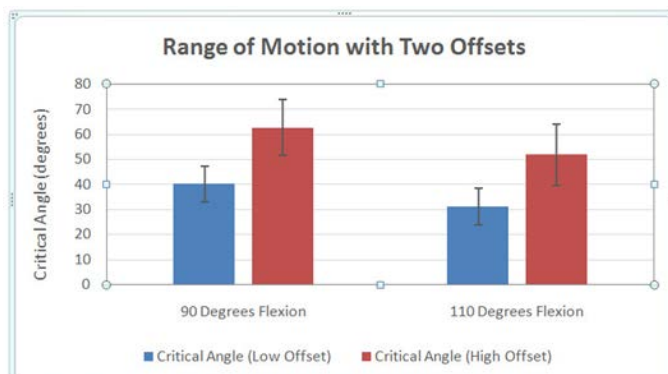

Figure 7:

Table 2: Range of motion with different offset stem

Degree of Flexion	Internal Rotation with Low offset Implant	Internal Rotation with high offset Implant
90 degrees	40 ± 7.07º	62.6 ± 11.19º
110 degrees	31.2 ± 7.4º	51.8 ± 12.23º

Discussion

Stability after hip arthroplasty is governed by multiple factors; one of these is the combined femoral offset vertical and horizontal. In present study, in order to decide whether horizontal offset alone as a variable contributes to stability we neutralized confounders like same surgeon, same manufacturer, standard neck cut, same vertical offset, same size broach, neck length. Previous studies have shown favorable effects of the femoral offset on postoperative hip abductor function [26,2]. Although theoretical effects of the femoral offset on joint stability also have been suggested, [27,28] previous clinical studies have failed to show the effects of femoral offset on postoperative dislocation rate. [29,12,30]

In the present study femoral offset has a significant effect on joint stability. With low offset range of internal rotation at 90 and 110 degrees came out to be 0º to 40±7º and 0º to 32±7º respectively compared to high offset which was 0º to 63±11º and 0º to 52±12º.This could be related to intra prosthetic impingement rather than bony impingement as we confirmed on palpation with finger. Posterolateral displacement of femur in relation to pelvis on increasing the offset decreases the likelihood of bony impingement between proximal femur and pelvis in internal rotation [27]. A cadaveric study on 11 hips by Matsushita et al [28] showed, with a 4-mm femoral offset, the range of flexion improved by 21.1°; and the range of internal rotation with 0° and 20° adductions improved by 13.7° and 16.4°, respectively. Compared to our study there was gain of 23 degrees and 20 degrees in internal rotation at 90- and 110-degrees hip flexion. In same study by Matsushita et al greater range of motion (ROM) was achieved with 8-mm femoral offset. Because femoral heads larger than 26 mm produced osseous impingement, increased femoral offset led to an increase in the distance between the pelvis and femur, thereby increasing the ROM until impingement of the femur and pelvis occurred.

Similar study “Intraoperative evaluation of the effects of femoral component offset and head size on joint stability in total hip arthroplasty” [31] included 30 hips found significant results with increase in offset, The average range of internal rotation to subluxation of all the cases was 68.4+17.1º at 45º hip flexion and was reduced to 46.8 + 13.4º at 90º hip flexion.

Increased femoral offset was expected to improve tension in the soft tissue, such as the gluteus Medius muscle, thus improving joint stability [32]. A cadaveric study by Davey et al [9] confirms that increasing the femoral offset cause decrease in abductor muscle force required for normal gait hence, decreasing the resultant force on hip joint. Thereby decreasing the chances of impingement and increasing soft tissue tension. Asayama et al reported that increasing the femoral offset increased ROM and provided beneficial effects for the abductor muscles, increased stability. An increased femoral offset decreases the abductor force required for walking and thereby reduces the energy requirement for gait and the overall reactive force at the articulating surface of the femoral head [26]. Furthermore, it is possible in the clinical situation that abductor strength increased by lengthening the functional lever arm [26, 2] also enhances the joint stability postoperatively. [27]

Other factors offering stability is the femoral head size [28,31]. As we used maximum possible head occupying the acetabulum which was equal to the patient’s own native femoral head, as is the case with bipolar hip arthroplasty, was not included as a variable for hip stability in our study.

One issue where there is common opinion is that hips with mechanical compromise of the capsule are at heightened risk of dislocation. Inherent advantage of contracted inferomedial capsule which is a self-stabilizer in cases of hip arthritis is absent in femoral neck fractures. This is manifested most directly in terms of the greatly increased incidence of dislocation in hips that have had a prior surgery [33], particularly a previous THA [34]. Other corroborating evidence is the differential of dislocation rates among alternative surgical approaches [35, 36] and the differential of dislocation rates without versus with capsule repair [37, 38], especially when a posterior approach is used without complete soft tissue repair.

Repair of the posterior capsule and the short external rotators, known to be effective for prevention of dislocation when a posterior approach is used [37] may be difficult if the greater trochanter is over-lateralized with a high-offset stem. Designing femoral prosthesis with smaller neck shaft angles and longer femoral necks is necessary to increase offset without changing leg length, which in turn increases bending moment on the prosthesis straining the medial cortex and early failure of femoral component [39]. Davey et al reported that the lever arm of the bending moment increases because of an increased offset, whereas the bending moment only marginally increases because of a decrease in the resultant force [9].

Conclusion

This study indicated that longer horizontal femoral offset are effective in preventing hip instability after primary bipolar hip arthroplasties via a posterior surgical approach and can be considered as useful option in hips found unstable intraoperatively. This will benefit all elderly co-morbid neck femur fractures with instability in terms of stability immediate postop and offer extended stability till the pseudo-capsule is formed. It will decrease the readmission rate in these fractures, for dislocation as a cause and reduce the health care burden.

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