Original Article

Free Hand Versus Anatomical Patient Suited Operative Techniques For Cup Abduction In Total Hip Surgery: A Comparative Study

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DOI: 10.47750/pnr.2023.14.03.294

Abstract

Background: Replacement arthroplasty of the hip is one of the common operations in orthopedic practice and the final success depends on the stability of the implant which depends largely on the proper orientation of the cup during sugary, free hand technique is the commonest conventional method used in practice for cup inclination. A more anatomical methods are adapted to seat the cup abduction such as the use of acetabular fossa all aiming at a better patient directed stable cup.

Aims of the Study: To compare the results of the use of acetabular fossa against the use of free hand technique for preoperative seating of acetabular cup inclination in primary cement less hip replacement by the use of post-operative antero-posterior pelvic X-ray to measure the angle of cup abduction and the clinical subjective result as described by the patient.

Method: This is a comparative study which was done during the period from July 2017 to march 2022 in the Medical City directorate, Baghdad - Iraq by one surgical team, All patients treated with the same type of primary cement less replacement of the hip through a Postero-lateral approach during the study period and were divided into two groups; group A of 34 patients where free hand technique used for seating of cup inclination and group B of 36 patients where acetabular fossa used as an anatomical reference for preoperative cup inclination. The results were assessed by the use of antero-posterior pelvic X-ray for measurement of cup abduction and the use of a subjective patient directed clinical outcome for the result of the surgery after two weeks and after three months of operation which was given by the patient as good, fair or bad.

Results: The safe zone of abduction angle identified by Lewinnek et al. which is 40°±10° was used as a gold standard for assessment of the cup inclination. The shortest follow up period was three months. All the angles for the 2 groups fell within the safe zone of Lewinnek, 42.03 ± 4.23 for group A and 42.67 ± 3.92 for group B The patient based clinical outcome was assessed according to WOMAC scoring system and regarding pain domain improved from 12.1±0.98, to 3.6±0.8 2 weeks after surgery and 2.9±0.6 3 months postoperatively and physical activity improved from 43.2±8.1 preoperatively to 26.7±2.2 two weeks after surgery and18.4±1.6 3 months postoperatively for group A with statistically significant result P value <0.05.

Conclusion: A proper preoperative planning and templating as well as a standardized patient set up are of prime importance in proper cup placement regardless the operative technique used.

Keywords: Total hip arthroplasty, Acetabular cup position, WOMAC score

INTRODUCTION

In the 20th century, the hip replacement was assumed to be the most successful surgical treatment in orthopedics [1]. Early postoperative hip dislocation is the most frequent complication and the commonest cause suggested to be improper cup positioning by the surgeon [2-3] cup mal-position acts in adverse in regard of different complications including surface wear, leg length discrepancy, biomechanics, bone osteolysis and others [4]. Conventional methods of cup positioning include external alignment guides and free hand methods, the free hand technique is the most commonly and widely used method for seating the cup inclination, it's found that it can be adversely affected by variable factors including patient body-mass index, pelvic deformity and patient position all in addition to poor visualization at surgery, all of those can affect the final cup position despite adequate surgical experience [4], on the other hand the recently adapted cup implantation techniques are those which depends

on patient's own anatomical morphological markers, those were found to inspired a more suitable and patient specific cup positioning [4-5]. The most frequent cause of revision hip arthroplasty was the instability or dislocation and the proper acetabular cup orientation found to improve the results and decrease the coast [5-6] and the outcome have been shown to be directly affected by the positioning of the total hip components [7]. Optimal cup seating remained controversial and for the last thirty years people used the "safe zone" developed by Lewinnek as a standard for acetabular cup seating to decrease the possible dislocation [8], this zone identified for cup inclination as 40°±10° and anteversion of 15°±10° [9-11]. on the other hand it was found that the orientation of native acetabula do not go with the safe zone of Lewinnek [11-12] that's why techniques using anatomical landmarks was developed to improve the accuracy of cup orientation [13-15]. The cup abduction angle on the AP pelvic radiograph represents radiological cup inclination and is defined as the angle between the inter teardrop line and the major axis of the cup projection [17-19]. Some of the adapted anatomical methods are those using anatomic landmarks of the pelvis as a 'Patient-Specific Morphology' to get a 'Patient-Specific Target Zone' for cup positioning. There are three available anatomical landmarks used for position of the cup; bony, soft tissue, or a combination of both. Four commonly adapted methods includes: Archbold, et al., who used the transverse acetabular ligament [16] used landmarks on the bone around the acetabulum, sciatic notch used [20-21].

Arthroplasty Biomechanics of hip

Understanding the biomechanical reconstruction is important for normal hip function and long survival ship of implant and the cup positioning is the key in this issues [21-24]. when there was malposition of cup regarding depth of mediolateral position , height in super inferior aspect or angular acetabular cup placement regarding inclination and anteversion , the complications rate was increase like (instability, increase wear, impaired muscle function and decrease range of movement) [21-27], despite many advance technologies used for optimizing cup placement like navigation system and 3 dimensional models still there was controversy regarding cup inclination and anteversion and other parameters. Medicalization of cup resulted in the least stress at the cup-head interface and the abductor muscles, with optimum outcome when femoral offset increase to restore the global offset [24-33]. Many researchers were showed increase in head size of femur decrease in rate of dislocation in primary total hip arthroplasty [34-36]. Callanan et al., concluded variation in acetabular component positioning as inter-surgeon and intra-surgeon, they were found 63% within cup-abduction angle and 79% within version range.

METHOD

Study design and included patients

This was a prospective comparative study conducted in two of the hospitals of Medical City directorate Baghdad - Iraq, Hospital of specialized surgeries and the Nursing Home Hospital. During the period from October 2015 to August 2018, 70 consecutive patients who were indicated for primary cement less total hip replacement and accepted to be part of this study were included. they were divided into two groups; starting with group A where 34 consecutive patients were operated using free hand technique to set the cup inclination, afterward we started with group B that included 36 consecutive patients operated using anatomical acetabular fossa landmarks for acetabular cup inclination. All patients done by the same surgical team and the least follow up period was 3 months. Included patients were those having primary osteoarthritis (OA) or secondary to Aseptic necrosis of femoral head with a relatively preserved acetabulum as well as patient with femoral neck fracture who was indicated for cement less hip replacement. We excluded patients with severe OA and seriously deformed acetabula as well as those with previous acetabular surgery, fracture, trauma, childhood deformities and those with protrosia acetabula. Detailed history and proper clinical examination done including general physical examination and local examination of the involved hip same side knee and spine. All necessary investigations were done like Complete Blood Count, Blood Sugar, Renal function, Urinalysis, Bleeding profile, ESR, titer of C-Reactive proteins, and virology tests. Patients were sent for supine anteroposterior pelvic radiograph and important measurement was done including: acetabular coverage, center of rotation, joint space and acetabular index, also Osteophytes, possible acetabular retroversion and the center-edge angle was assessed. All patients were informed about the surgery and the study and a written consent to be involved in this study was signed by the patients. Operations were done under spinal or general anesthesia, all patients received antibiotic prophylaxis 30-60 minutes prior to surgery and for 72 hours afterwards. Anticoagulants prophylaxis of low-molecular-weight heparin used 12 hours following operation up to at least 3 weeks with a dose of 4000 IU, according to the risk of the American college of chest physicians Evidence-Based clinical practice guidelines [36]. All operations done by the same surgical team to overcome bias. All operations done through poster lateral approach and after hip dislocation and exposure of the acetabulum patients in group A acetabular cup inclination was achieved by free hand technique. In group B we adapted the anatomical method of acetabular cup positioning that was suggested by Junwei Li and his colleagues [37], using the bony landmarks of the acetabular fossa to guide the cup positioning during surgery and as follows; after exposure of acetabulum and prior to acetabular reaming, the central acetabular axis identified figure (1) by drawing of 2 parallel lines, the first one through the two ends and along the acetabular transverse ligament line A1-B1, the a second one is parallel to first line in the middle of the acetabular fossa, line A2-B2, the middle point of those

lines are identified by Electrocautery Z1, and Z2. The central axis now is drawn from these 2 points up to the superior acetabular rim marked as point M. The central axis of the acetabulum is along the Z1-M line.

Figure 1: Clarification of the method used.

The midpoint (point C) of the axis (Z1-M line) is marked it represented AP pelvic x-ray as the most medial point of the acetabulum. At point C a drill-hole with a 4-5mm depth is done. Then acetabular reaming initiated so that the widest diameter of the reamer should be in conjunction with the Z1-M line, and the central hole of the reamer at the midpoint C. For both groups and after metal cup insertion followed by insertion of the metal cup and stability checked using a Kocher clamp for at least 3 times. This to be followed by the insertion of polyethylene liner and completion of surgery in steps. Postoperative care regarding antibiotics, anticoagulants, physiotherapy and rehabilitation all are followed intimately. Anteroposterior post-operative x-ray of the pelvis done with the x-ray beam centered midway between the symphysis pubis and the line connecting both ASIS. Cup abduction angle measured by drawing a line along the long axis of cup ellipse and the inter-teardrop or the inter-ischia tuberosity line, the angle between those lines is the cup abduction angle, figure (2).

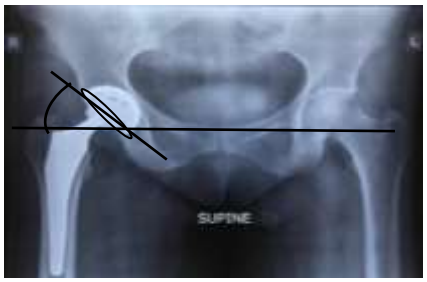

Figure 2: Anteroposterior pelvic x-ray showing Right cement less Total hip prosthesis, with measurement of the cup abduction angle which is the angle between longitudinal axis of the ellipse (L) and the horizontal interteardrop line.

The patient perceived subjective outcome of the operation was asked to the patients after 2 weeks and after 3 months of the surgery, and patients were asked directly to rate the clinical outcome as one of three; Good, Fair or Bad. Regarding the clinical evaluation we were depending on WOMAC scoring system designed by [38] which was regarding an important clinical evaluation tool for assessment of postoperative results after arthroplasty depending on 3 domain pain, physical activity and stiffness [39]

Statistical analysis

For statistical analysis and procedures, the statistical package for social sciences was used. Statistical tests applied according to the variable type, qualitative variables compared using chi square test and Fisher's exact test. Quantitative variables compared by student's t test for two means of two independent groups. Bivariate correlation analysis performed with Kendall's Tau-b test, correlation coefficient (R) value was calculated which is an indicator of the strength of a correlation, R value ranged between zero (complete no correlation) and one (Perfect correlation), however, R value close to one indicates the stronger correlation. The negative sign of R indicate an inverse (negative) effect of a variable on the outcome under study. In all statistical procedures, level of significance set at ≤ 0.05 to be significant difference or correlation.

Results

There were 72 patients enrolled in this study, equally assigned into two groups; A and B with 36 patients in each. Both groups were not significantly different in their baseline characteristics including age, gender, pathologies and Cup abduction angle, in all comparisons, P-value > 0.05. From other point of view, the mean age in group A and B was 58.5 ± 12.6 and 52.4 ± 13.8 years, respectively. In both groups, males were dominant represented 66.7% and 55.6%, respectively. Regarding the pathologies, in both groups AVN was the more frequent followed by Femoral Neck Fracture while OA was the least frequent, tables (1-3).

Table 1. Age and gender distribution of the studied groups

Variable		Group A	Group B	P. value
Age (mean ± SD) year		58.5 ± 12.6	52.4 ± 13.8	0.056 ns
Gender n (%)	Male	24 (70.5%)	20 (55.6)	0.334 ns
	Female	10(29.4%)	16 (44.4)	
Total		34 (99.9%)	36 (100.0)	
SD: standard deviation of mean ns: not significant				

Table 2. Distribution of pathologies in both studied groups

Pathology	Group A		Group B		P. value
	No.	%	No.	%	
AVN	17	50	17	47.2	0.916 ns
Femoral Neck Fracture	14	41.1	15	41.7	
OA	3	8.8	4	11.1	
Total	34	99.9	36	100.0	

Table 3. Comparison of Cup abduction angle between the studied groups

Group	Mean ± SD	Range
Group A	42.03 ± 4.23	35 – 50
Group B	42.67 ± 3.92	35 - 50
P. value	0.423 ns	

As shown in table (4), no significant difference in the Subjective feeling of patients after 2 weeks and 3 months postoperatively, (P>0.05), however, within each group, a significant change was reported after 3 months than that at 2 weeks, where the number of patients with good Subjective feeling increased from 18 to 30 in group A and from 17 to

30 in group B, also the number of patients with fair Subjective feeling reduced from 15 to 4 in group A and from 14 to 6 in group B. Bad Subjective feeling reduced from 3 to only 2 in group A and from 5 to none in group B, in both comparisons within each group, P-value < 0.05.

Table 4. Subjective feeling of patients after 2 weeks and 3 months postoperatively

Subjective feeling	Group A No.	%	Group B No.	%	P. value Between groups
After 2 weeks Good	16	47.05	17	47.2	0.755 ns
Fair	15	41.7	14	38.9	
Bad	3	8.3	5	13.9	
After 3 months Good	28	82.3	30	83.3	0.301 ns
Fair	4	11.1	6	16.7	
Bad	2	5.6	0	0.00	
Total	34	100.0	36	100.0	
P. value within group	0.008 sig		0.003 sig		

sig: significant, ns: not significant

Dislocation after surgery reported in only one patient in

group A giving an incidence rate of 2.8%, while none in group B, table (5).

Table 5. Dislocation after surgery in both studied groups

Dislocation after surgery	Group A No.	%	Group B No.	%	P. value
Yes	1	2.95	0	0.00	0.916
No	33	97.05	36	100.0	ns
Total	34	100.0	36	100.0	

Further analysis was performed to assess the possible effect of patients characteristics on their postoperative subjective feeling at 2 weeks and 3 months, no significant effect was found to each of age, gender, Pathology and cup abduction

angle in both groups, (P-value >0.05). However, in group A, dislocation after surgery has negative significant impact on the subjective feeling of patients postoperatively at 2 weeks and 3 months, (Tables 6 & 7).

Table 6. Results of bivariate correlation analysis between Subjective feeling of patients and other variables in Group A

----------	Statistics	Subjective feeling after 2 weeks	Subjective feeling after 3 months
Age	R	0.011	0.107
	P. value	0.939	0.445
Gender	R	0.202	0.155
	P. value	0.216	0.351
Pathology	R	0.076	0.083
	P. value	0.634	0.605
Cup abduction angle	R	0.058	0.030
	P. value	0.678	0.832
Dislocation after surgery	R	-0.317	-0.422
	P. value	0.038*	0.012*
R: correlation coefficient * significant correlation			

Table 7. Results of bivariate correlation analysis between Subjective feeling of patients and other variables in Group B

Variable	Statistics	Subjective feeling after 2 weeks	Subjective feeling after 3 months
Age	R	0.010	0.219
	P. value	0.940	0.121
Gender	R	0.051	0.050
	P. value	0.754	0.767
Pathology	R	0.023	0.069
	P. value	0.882	0.673
Cup abduction angle	R	0.346	0.155
	P. value	0.013	0.285

Regarding to WOMAC clinical scoring system (Western Ontario and McMaster Universities Osteoarthritis Index), which is disease-specific questionnaire , were shown highly significant improvement in all three domain (pain, stiffness and physical activity) in group A and B where P value < 0.005 and this gave us impression about the patient

satisfaction and expectation after replacement therapy. Till now the measurement of satisfaction is complex as the meaning of satisfaction and expectation varies from person to person, so in this study we were depending on functional scoring as reflection of satisfaction in addition to direct question about patient satisfaction.

Tables 8: Distribution of clinical and functional Assessment according to WOMAC score 2 weeks and 3 months postoperative group A.

WOMAC score	Preoperative assessment	2 week postoperative assessment	3 months postoperative assessment	P value P*, p#
Pain Domain	12.1±0.98	3.6±0.8	2.9±0.6	0.0001,0.0001
Stiffness Domain	6.3±0.9	2.4±0.6	2.1±0.5	0.0001,0.0001
Physical activity Domain	43.2±8.1	22.2±1.8	18.4±1.6	0.0001,0.0001

P* comparison between the preoperative mean score and 2 weeks postoperative

P# comparison between the preoperative mean score and 3 months postoperative

Table 9. Group B assessment of total hip by Womac score

WOMAC score	Preoperative assessment	2 week postoperative assessment	3 months postoperative assessment	P value P*, p#
Pain Domain	11.9±1.04	3.9±0.7	2.6±0.6	0.0001,0.0001
Stiffness Domain	6.2±0.7	2.2±0.7	1.9±0.6	0.0001,0.0001
Physical activity Domain	46.1±2.2	26.7±2.2	19.4±1.4	0.0001,0.0001
Total score	64.7/96	28.2/96	23.4/96	

P* comparison between the preoperative mean score and 2 weeks postoperative

P# comparison between the preoperative mean score and 3 months postoperative

Discussion

Total hip arthroplasty is one of the most important revolution in orthopedic surgery that lead to relief of pain and return to nearly normal daily activity for elderly and young hip arthritic patient who was crippled [40-41]. One of important challenge in the surgical procedure of THR is the acetabular component positioning and orientation, as there were some significant complications related to the mal positioning of acetabular cup such as dislocation, impingement and increase wear due to edge loading which leads to poor hip function on long term outcome [35, 42]. In this comparative study, our work was to compare between two methods of acetabular cup positioning (free hand surgical technique and acetabular fossa regarding functional and radiological evaluation. The plane radiograph of hip joint still one of the most valuable methods to assess postoperative acetabular cup orientation and inclination in the THR as it has low cost, easy available, portable and less irradiation than CT-scan [12, 17]. The Western Ontario and McMaster Universities (WOMAC) osteoarthritis index is a well-known and widely used index to assess health status after THR [38-39]. The mean age in our study was 58.8 years, 52.4 years respectively where as in the study done by Kalties and Handel et al., [42] was 63.6 years and study done by Mariana Katia and Rampazo-Lacativa et al., [43] was 68.8 years and the differences may be related to the fact that the last researches studied quality of life in elderly people after hip arthroplasty. The predominant of male gender in our study may be related to fact avascular necrosis and fracture neck of femur more common in male in our society, unlike the study done by Van Der Wees P and Wammes [44], which was

shown predominant of female gender (62.8%). The optimal acetabular cup positioning in total hip arthroplasty can improve hip function and decrease future complications like wear, dislocation and implant failure [13, 17]. The postoperative radiographic assessment of cup inclination angle still one of most important way to evaluate the ecetabular component positioning and even comparable to computer tomography based assessment. Zhou Lu M, Zhang Du [37, 45]. In our study the mean cup abduction angle was 42.03º ±4.23º for first group and 42.67º ±3.92º for second group and this result was slightly higher than study done by Delagrammaticas D and Ochenjele G [46] which was 40.95º ±2.87º and differences may be related to fact that last study measurement of abduction angle depend on intraoperative fluoroscopic interpretation. The WOMAC score assessment in our study was 12.2 ±0.98 for group 1 and 11.9±1.04 for group 2 for preoperative pain domain and improved to3.6±0.8 for group 1and 3.9±0.7 for group 2 with statistically significance P value < 0.0001and this agreed with result of Dung TT, Hieu PT et al (47) . In the stiffness domain according to WOMAC score preoperatively were 6.3±0.9 for first group and 6.2±0.7 for second group preoperative and showed significant improving 2 weeks and 3 months postoperatively 2.4±0.6 G1 and 2.2±0.7 G2 P-value < 0.0001 with comparable result of Dung TT, Hieu PT et al., [47] (6.08±1.41 preoperative to 2.7±0.58 3 month postoperatively). In Neuprez A, Kaux AF et al., [48] the physical activity domain significantly improved from 39.3±12.51 preoperatively to 18.36±14.11, 3 months after surgery comparable to our study (G143.2 ± 8.1 and G2 46.2 ± 19.4±1.4 3 months after surgery with statistical significance < 0.0001. In Xing Q. et al [49] study the patient satisfaction and subjective feelings score showing no significant elevation in patient specific instrumentation group 9.1±0.8 relative to conventional techniques group (8.7 ± 1.0) with p value > 0.05 which is comparable to our study results, but with time and ongoing follow up a significant elevation in satisfaction score and subjective feeling within each group is obvious.

Conclusions And Recommendations

Although different techniques are applied to guide cup placement in an optimal position and accurate orientation, a proper preoperative planning and templating is of prime importance which will in turn increase the stability of articulation and reduce the risk of primary dislocation. A standardized patient set up is applied to all participant in the same way to avoid position variability which will affect free hand technique. Because the surgical experience level play a role in the accuracy and consistency of cup placement a special surgical team in this study to overcome and avoid unpredictable variances.

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