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To Evaluate Effect Of Horizontal Hip Offset And Leg Length Reconstruction On Functional Outcome Of Total Hip Replacement : Prospective Cohort Study

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Abstract

Background: For total hip replacement besides long term durability a optimal postoperative functional outcome is essential.so aim of this study was to determine the combined influence of hip geometry reconstruction on the clinical outcome following primary total hip replacement for unilateral osteoarthritis.

Methods: A hospital based prospective study was carried out on 60 cases of unilateral osteoarthritis with normal contralateral hip. We prospectively assessed the clinical outcome and radiographic parameters for hip geometry reconstruction using validated measurements for the operated hip compared to the contralateral native hip with primary unilateral THA. The correlation of reconstruction parameters was investigated using a multivariate polynomial regression model for the dependent variable ΔHHS (difference between the Harris hip scores preoperatively and 6 months postoperatively). Target zones for hip reconstruction were investigated for an association with superior clinical outcome.

Results: The regression model demonstrated a significant correlation for the ΔHHS and both hip offset (HO) reconstruction and leg length difference. Patients with accurate to slightly increased HO reconstruction combined with balanced leg length demonstrated a significantly higher ΔHHS than patients outside this zone.

Conclusion: HO and leg length reconstruction demonstrated an additive effect on clinical outcome and surgeons should aim for high accuracy in the reconstruction of both factor.

Keyword: Hip Offset, Total Hip Arthoplasty , Harris Hip Score.

Introduction

Total hip replacement(THR) is a surgical procedure, which has relieved millions of people from incapacitating pain arising from the hip joint. At

present it is the most commonly performed adult re-constructive hip procedure.[1] The success of Total Hip Replacement is its ability to relieve the pain associated with hip joint pathology, while maintaining the mobility and stability of the hip joint.

Evaluation of long term outcomes of an operative procedure is important to determine the durability of the procedures like total hip replacement (THR). Patient derived outcome scales have become increasingly important to surgeons and clinical researchers for measuring improvement in function after surgery. It provides a means for comparison of the results of different clinical interventions which may lead to changes in operative technique and implant design over time. The Harris hip score is the most widely used scoring system for evaluating hip arthroplasty.[2]

here is, however, limited literature reporting the effect of implant position and reconstruction of centre of rotation and (femoral and acetabular) offset on the outcome of THA. Despite the theoretical biomechanical benefits of medializing the acetabular component and increasing femoral offset to compensate for this resulting in a more favourable moment arm[3,4] there is limited literature to support any clinical effect. Studies by McGrory et al.[5] and Asayama et al.[6] demonstrated improved abductor muscle strength and a lower rate of Trendelenburg positive patients with increasing femoral offset, respectively.

Cemented and cementless hip arthroplasty have demonstrated very good survival rates into the third decade of 93% to 95% after 22 and 26 years[7,8]. Besides long-term durability, an optimal postoperative functional outcome is essential for patient satisfaction, which has been reported to be associated component positioning and reconstruction of hip geometry[9]. Reconstruction of the femoral offset (FO) accounts for joint stability reducing the risk of dislocation, allowing for a good range of motion with a low risk of bony or soft-tissue impingement, sufficient abductor muscle strength without alteration of gait and minimized polyethylene wear[10-15]. Leg length difference (LLD) should be kept to a minimum, while studies on the influence on clinical outcome are inconsistent[16-19]. It remains unclear, to what extent offset can be increased to gain a maximum of joint stability while avoiding leg lengthening, without compromising the functional outcome. Most studies focus on a limited number of parameters and have retrospective designs, while there is a lack of prospective studies investigating the interactive effect of multiple acetabular and femoral reconstruction parameters on functional outcome.

Therefore, the present prospective and retrospective study investigated the effect of hip geometry reconstruction and component positioning on improvement in clinical outcome at a minimum of six months after THA, specifically asking:

1) Does the postoperative change in radiographic reconstruction parameters and postoperative cup positioning correlate with the pre-/postoperative difference in the Harris hip score (ΔHHS)?
2) Which potential target zones for combined horizontal hip offset and leg length reconstruction are associated with a better ΔHHS?

This study is undertaken to evaluate effect of horizontal hip offset and leg length reconstruction on functional outcome of total hip replacement in our institution.

Material And Methods

Study type: Hospital based prospective cohort study

Study place: Department of orthopaedics - SMS Medical College, Jaipur, Rajasthan.,India

Study duration: One year, April 2018 to june 2019.

Selection criteria

Inclusion criteria

Adult age > 18 years (male and females)

- Avascular necrosis of femur head (ficat and Arlet stage 3 and 4) with bone collapse.
- Advanced Arthritis of hip joint
  - Primary osteoarthritis
  - Rheumatoid arthritis
  - Ankylosing spondylitis
  - Secondary
    - ✓ Perthes disease
    - ✓ Slipped capital femoral epiphysis
    - ✓ Septic arthritis
- Patients with old fracture neck femur with failed osteosynthesis or failed hemiarthroplasty

Exclusion criteria

- Patient aged ≤18 years (male and females)
- Patient operated bilateral total hip replacement.
- Hip surgery prior total hip arthroplasty.

Pre- Operative Planning

Clinical assessment: Detailed history weight, BMI, comorbid condition, drug history and proper clinical examination is essential to find out: Duration of illness, focus of infection in the body, sensory motor examination, vascularity of limb, ambulatory status of the patient, deformities of the hip, ROM (Range of motion) of the hip and status of the other joints. The deformity and ROM was measured with goniometer. All the patients were assessed using Modified Harris Hip Score (HHS).

Radiological assessment: Radiograph of the x-ray lumbo sacral spine and pelvis with both hips with proximal half of shaft of femur AP (anteroposterior) view was taken for all patients. The radiograph was evaluated for

- Size of the acetabulum
- Bone stock of the acetabulum
- Any protrusion and periacetabular osteophyte formation
- The structural integrity of the acetabulum
- Need for bone grafting
- Size of the femoral canal

Templating was done for the acetabular and femur components. The appropriate acetabular cup size, and anteversion was determined. On the femoral side, using a template, appropriate neck length, offset and stem size of the implant was chosen.

The aim of the pre-op planning was to obtain the following results post-operatively:

1. An acetabular socket located in the anatomical position.
2. Centre of rotation of femoral head located in its normal anatomical position.
3. Restoration of limb length.
4. Restoration of abductor moment arm.

Post-operative protocol

- The hip was positioned in approximately 15 degrees of abduction while the patient was recovering from the anaesthetic using a triangular pillow to maintain abduction and prevent extremes of flexion.
- Postoperative intravenous antibiotics was given for 5 days.
- Active toe and ankle movements and static quadriceps exercises were encouraged as early as possible.
- First postoperative dressing and drain and urinary catheter was removed on 2nd postoperative day.
- Postoperative radiographs of hip were obtained on 2nd postoperative day.

- Patient was encouraged to stand on the 2nd postoperative day.
- Walking with support on 3rd post-operative day.
- Stitch removal was done on 15th postoperative day and patient was discharged on the same day to be reviewed after one month. They were advised
  - Not to squat
  - Not to sit cross legged
  - Not to use Indian toilets
  - Not to cross the lower limb across the midline

Follow Up: The patients were followed up at 6 weeks, 3 months, 6 months, 1 year and at yearly intervals. Patient follow up was for a minimum of 6months.

Clinical assessment: During each visit, medical history was taken and physical examination was done. The deformity and ROM was measured with goniometer. The clinical and functional outcomes were evaluated by

Modified Harris Hip Score: Based on a total of 100 points possible, each question is awarded a certain number of points. Questions are further grouped into categories. The first category is pain. No pain in the hip is awarded 44 points, slight pain 40 points, down to 0 points for disabling pain. The second category is function. If there is no limp, do not use a walking aid, and can walk more than six blocks, 33points were awarded; less if the patient was use a cane, or walk only two blocks, etc. The third category, functional activities, consists of questions about how the patient climb stairs, put on shoes, length of time you can sit in a chair, and if the patient can use public transportation. Finally, the physical exam results are tabulated, and based on the absence of deformity and range of motion, up to 9 points were awarded.

Rationale of Modified Harris Hip Score Evaluation: Pain and functional capacity are the two basic considerations. They constitute the indications for surgery in the vast majority of patients with hip problems, and hence receive the heaviest weighting. In specific cases, correction of deformity or restoration of motion may be of prime importance but such cases are uncommon. Based on this reasoning a point scale with a maximum of 100 points is used with the following maximum possible scores:

- Pain 44
- Function 47
- Range of Motion 5
- Absence of deformity 4
- Total 100

Radiological Assessment: A radiograph was taken at the end of the procedure and during follow up visits. The standard radiograph was an anteroposterior view of pelvis include both hips and sufficient length of femur. The radiological assessment including positioning and alignment of the acetabular and femoral components and complications such as periprosthetic fractures, loosening, osteolysis, dislocation, subsidence and heterotrophic ossification. Cup inclination was determined on the anteroposterior pelvic radiograph with a horizontal reference line drawn through the base of both teardrops. This radiograph was compared with the one made at the time of the last follow-up evaluation to determine fixation, total wear, the annual wear rate, and the presence, extent, and location of osteolysis. Cups without radiolucent lines or migration on the radiographs that was made at the time of the last follow-up was considered to be well fixed.

The FO was measured as the distance between the center of rotation of the femoral head (COR) and the proximal femoral shaft axis (FSA)[20,21]. The acetabular offset (AO) was measured as the distance between the COR and a vertical line through the ipsilateral teardrop[20]. Hip offset was calculated as the sum of FO

and AO[20]. The COR height (CORH) was measured as the distance of the COR to the trans-teardrop line (TTL). Radiographic leg length difference (LLD) was measured as the difference between both hips for the distance between the TTL and the most prominent aspect of the lesser trochanter[20,22,23].

Cups with a circumferential radiolucent line of <1 mm in width and without migration was considered to have a stable fibrous union. Cups with progressive radiolucent lines and those exhibiting migration was considered to be loose. The prevalence, location, and extent of osteolytic lesions, progressive radiolucent lines, and calcar resorption was determined on anteroposterior radiographs made at the time of the last follow-up. Radiographic osteolysis was defined as so-called punched-out areas devoid of trabecular bone, usually with a sclerotic border. Periacetabular osteolytic lesions was assessed according to the zones described by DeLee and Charnley and the femoral osteolytic lesions was assessed according to the zones described by Gruen. Calcar resorption (defined as rounding of the calcar with a convex shape and loss of calcar-collar contact) was differentiated from calcar osteolysis (defined as a punched out, expansive area with a concave shape).

We evaluated patient satisfaction in both the study groups postoperatively by allotting a score on a scale of 1 – 10, with 1 being the least satisfactory levels and 10 being the highest level of satisfaction.

Outcome measures: The primary outcome parameter was improvement in functional outcome, defined as the difference between post- and preoperative assessed Harris Hip Score (ΔHHS=HHS postop –HHS preop) [26,27]. A 15.9 to 18-point difference in ΔHHS has been reported as a clinically important change from the patient's perspective[28]. The power of the study was sufficient (80%) with the available sample size to detect a difference of 9 points for the ΔHHS (mean 37.2; SD 16.6) at the $p<0.05$ level. The HHS were assessed one to five days preoperatively and postoperatively at a minimum of 6month of follow-up (range, 1 to 2.5). Secondary outcome measures include the registration of complications such as revision surgery, dislocation, nerve palsy and periprosthetic fracture.

Statistical Analysis

Non-parametric tests were used after testing for normal distribution. P-values of less than 0.05 was considered statistically significant. A regression analysis was conducted with the ΔHHS as the dependent variable, adjusted for age at surgery, HO, CORH, LLD.

In order to answer question two, zones with ±5 mm intervals for combined HO difference and LLD was constructed. This interval would be reported to be used as a cut off value for a clinically relevant under- or oversized restored hip offset and leg length difference[15,20]. The process was repeated for zones of ±5 mm for HO and LLD.

Regarding cup positioning, only a small zone size (±5°) has been reported to be associated with statistically significant and clinically important improvement in Δ Harris Hip Score. The process was repeated for zones of ±10° and ±15°. The mean ΔHHS within each zone was compared to the corresponding ΔHHS outside each zone, using a Mann-Whitney-U test. Statistical analysis was conducted using SPSS for Windows version 23.0.

Results

Final results were assessed after a minimum follow up of 6 month.

Following criteria for evaluation of results was used

1. Complaints of the patient.
2. Complete clinical examination using modified Harris hip score.

3. Deformity if any.
4. Complications if any.
5. Radiological analysis for determination of migration of acetabular components and loosening of femoral component
6. Assessment of activities of daily living.

Patients were evaluated according to modified Harris hip score. These scores were then compared with preoperative scores and last follow up scores. Based on the Harris hip score the final results were classified as

Excellent - Hip Score more than 90 points

Good - Hip Score 81-90 points

Fair - Hip Score 71-80 points

Poor - Hip Score 70 points and below

The influence of horizontal offset and LLD was measured by change in Harris Hip Score (ΔHHS).

Observations and Results

Table 1: Age Distribution

Age (yrs)	No. of patients	Percentage
20-30	13	21.67
31-40	8	13.33
41-50	14	23.33
51-60	16	26.67
61-70	8	13.33
71-80	1	1.67
Total	60	100.00

Most of patient in our study are below 60 years of age. Of these most of from 51-60 years of age group. In above 70 years of age group THR rarely done and also below 20 years of age group no THR done. 50% patient are41-60 year age group.

Table 2: Δ HHS in Different Age Distribution

Age (yrs)	Modified harris hip score		Mean ΔHHS
	Pre op (Mean±SD)	Post op (Mean±SD)	
20-30	15.30±15.96	90.31±12.20	75.92±25.56
31-40	17.37±9.07	92.25±4.04	68.75±24.19
41-50	18.71±11.63	88±8.88	67.28±26.28
51-60	19.18±18.33	86.75±18.44	67.62±24.61
61-70	13.75±18.44	92.62±18.09	78.87±13.08
71-80	26±0.00	84±0.00	58±0.00

In different age group pre op HHS are low. After THR post op HHS increased in all age groups. HHS above 85 shows significant improvement in life style activities.

Table 3: Complications Wise Distribution

Complications	No. of patients	Percentage
Lengthening	5	8.83
Dislocation	1	1.67
Infection	9	15
No complications	45	75
Total	60	100.00

In our study 75% of patient operated with THR living without any significant complications . Remaining 25% had any form of complication among these 1.67% and 8.33% patients show lengthening and limping. Most important things is only 15% patient have post-operative infection which was most common complication . In these mostly late infection seen.

Table 4: Femoral Head Size Distribution

Femoral head size	No. of patients	Percentage	Post op HHS (Mean±SD)
28	35	58.33	89.45±8.90
36	25	41.67	88.64±7.58
Total	60	100.00	-

In this study we used 28 and 36 head size post op HHS of both sizes are on average equal. Size of head not influence on HHS, but the stability of 36 size are more than 28 size. 28 head size implant are cost effective than 36 and in our set-up most patients are poor so mostly we are using 28 head size.

Table 5: Acetabulum Component Size Distribution

Acetabulum component (mm)	No. of patients	Percentage
44	6	10.00
46	3	5.00
48	9	15.00
50	9	15.00
52	16	26.67
54	10	16.67
56	5	8.33
58	1	1.67
60	1	1.67
Total	60	100.00

Size of acetabulum component depends mostly upon gender, patient body built and pathological involvement of acetabulum. In our study most patients are male. So were used acetabulum component of large size in most cases.

Table 6: HHS Relation to Gender

Gender	Modified harris hip score		Mean ΔHHS
	Pre op (Mean±SD)	Prost op (Mean±SD)	
Male	20.46±10.04	87.16±8.86	66.41±16.97
Female	14.82±8.57	94.05±3.59	79.29±10.74

P value 0.005

Average post op HHS in male was 87.16% and in female was 94.05%. It denotes that more improvement in functional outcome occur in female than male.

Table 7: Relation Between Horizontal Offset Difference And ΔHHS

HO difference	Mean ΔHHS	r value	p value
<-5	59.43±19.53	0.209	0.005
-5 to -1	76.54±19.56		
0 to 5	90.08±7.728		
>5	51.75±13.61		

The table denotes relation between HO difference and ΔHHS It shows that if HO difference <-5 the mean ΔHHS very low (59.43). As the HO difference decrease, the ΔHHS increases. Which denotes functional outcome are more when HO difference is less.

If HO difference is >5 ΔHHS is very low (51.75) as the HO difference decrease the ΔHHS increase.

When HO difference is zero, the ΔHHS become highest and functional outcome are maximum.

Table 8: Relation Between Lld Difference And ΔHHS

LLD difference	Mean ΔHHS	r value	p value
<-5	57.00±15.87	0.201	0.005
-5 to -1	71.11±15.52		
0 to 5	78.33±15.36		
>5	53.00±13.86		

The table denotes relation between LLD difference and ΔHHS It shows that if LLD difference <-5 then mean ΔHHS very low (57.00). As the LLD difference decrease, the ΔHHS increases. Which denotes functional outcome are more when LLD difference is less.

If LLD difference is >5 ΔHHS is very low (53.00) as the HO difference decrease the ΔHHS increase.

When LLD difference is zero, the ΔHHS become highest and functional outcome are maximum.

Table 9: Δ Harris Hip Score Wise Distribution

ΔHHS	No. of patients	Percentage
41-50	11	18.33
51-60	5	8.33
61-70	14	23.33
71-80	10	16.67
81-90	13	21.67
91-100	7	11.67
Total	60	100.00

The table shows that most of the patient have ΔHHS value 61-90 extreme group are less in number.

Table 10: Cumulative Effect of Ho Difference And LLD Difference on Harris Hip Score

LLD difference	HO difference							
	<-5		-5 to -1		0 to 5		>5	
	N	Mean ΔHHS	N	Mean ΔHHS	N	Mean ΔHHS	N	Mean ΔHHS
<-5	5	59.08	0	0	0	0	2	50
-5 to -1	4	66.00	13	72.66	0	0	1	71
0 to 5	0	0	11	81.77	12	92.33	0	0
>5	7	55.42	0	0	0	0	5	48.75
Total	16	-	24	-	9	-	6	-

In above table it shows that the mean ΔHHS is maximum when HO difference and LLD difference is minimum and vice versa. So when horizontal offset and vertical offset become nearly equal to opposite normal hip, the harris hip score become maximum and consequencely the functional outcome become maximum.

So the horizontal offset and vertical offset both have influence on functional outcome of THR independently. Both have additive effect.

By this table following results were found:

If both factor worst
HO difference <-5
LLD defense <-5
→ ΔHHS – 59.08

If both factor good
HO difference 0-5
LLD defense 0-5
→ ΔHHS – 92.33

If both factor worst
HO difference <5
LLD defense <5
→ ΔHHS – 48.75

Discussion

Accurate hip geometry reconstruction has an important influence on clinical outcome, dislocation risk, range of motion, impingement, abductor muscle strength and polyethylene wear.[15-20]

The most relevant finding of our study is, that good clinical outcome correlated with accurate HO reconstruction and minimized LLD. A positive linear correlation has been reported for FO reconstruction and hip abductor strength, with and without adjustment for confounding factors. [19] However, a recent study by Whitehouse et al. reported no linear correlation of LLD and Oxford Hip Score in a multivariate model.[23]

In contrast, our study suggests that an excessive positive or negative difference in hip offset and / or leg length, is associated with a worse HHS.

One more important finding in our study is that ΔHHS (functional outcome) **not** linearly dependent on either Horizontal offset or LLD individually. ΔHHS dependent on both variable equally and have additive effect so during surgery care must be taken to achieve both horizontal and vertical offset nearly equal to contralateral normal side.

Patients demonstrated best improvement in clinical outcome with a combination of complete to slightly increased HO reconstruction and a marginal leg length difference. Significance could be demonstrated for

both, smaller and larger zones of reconstruction (HO and LLD ±5 mm and ±5 mm). For the smaller zones, a significantly better ΔHHS could be detected only for one zone with complete to slightly increased HO reconstruction and minimized LLD (HO 5±5 and LLD 0±5 mm).

Our findings are in line with a study by Mahmood et al. reporting weaker hip abductor muscle strength in patients with a decrease in HO by more than 5 mm, compared to the HO reconstructed group. Similar results have been reported for a decrease in femoral offset. Sariali et al. reported an altered gait with asymmetry between sides, reduced range of motion and a lower maximal swing speed on the operated side for patients with a minimum decrease in FO of 15%.[16] Cassidy et al. reported that patients with a decrease in FO of more than 5 mm had worse WOMAC scores than patients with reconstructed or increased FO. However, both latter studies evaluated only the influence of femoral offset (FO) without regard to the change in Acetabular offset (AO) and Horizontal offset (HO). The change in hip offset reflects the tension of the hip abductor muscles and reconstruction of the lever arm, accounting for an increase in FO compensating for cup medialization due to a sufficient press-fit fixation. Our results for HO change are consistent with a recent study by Renkawitz et al., reporting a higher Froude number, normalized walking speed and hip range-of-motion in gait analysis for patients with HO and LLD reconstruction within 0±5 mm.[21] The literature on the influence of LLD is inconsistent, though the consensus agreement recommends that LLD should be kept to a minimum.[22-24,] Interpreting our findings in context of the literature, we hypothesize that our significantly better improvement in clinical outcome for adequately restored HO and LLD is mainly attributable to better hip range of motion, abductor function and soft tissue tension, due to better lever arm reconstruction and minimized patient awareness of the LLD.

Several limitations of the study have to be addressed. First and most important, we tried to minimize a potential selection bias by applying strict inclusion criteria, identifying a consecutive cohort and including only patients with a maximum two implant design to minimize its effect on the potential of hip geometry reconstruction.

Second, measurements were performed on plain radiographs, underestimating FO by approximately 13% and therefore influence HO calculations.[35] As the study aimed to express the reconstruction of hip geometry after THA compared to the contralateral native hip, the objectives were not to provide absolute measurement values but the difference in millimeters. Thus, we reduced the risk of measurement bias of the femoral offset due to projection errors.

Third, we are aware that radiographic LLD measurements do not necessarily reflect the clinical leg length difference.[36] Therefore we aimed to determine the radiographic change in leg length after THA and not to give functional clinical values being a result of a complex interaction of the bones, implants and soft tissue contractures. [34,37] Fourth, we could not measure stem anteversion and could not evaluate the influence of combined anteversion on clinical outcome. we only evaluated the postoperative improvement in clinical outcome with the ΔHHS. With respect to a detailed evaluation of patient satisfaction, additional scores for health-related quality of life might be valuable.

Conclusion

According to study, patients operated with unilateral THR due to hip pathology both horizontal offset and leg length should be reconstructed. Since both factor

demonstrated a comparable additive effect on clinical outcome.

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