Section: Orthopaedics

JAMP

Original Research Article

CLINICAL AND RADIOGRAPHIC OUTCOMES FOLLOWING HIGH HIP CENTER VS ANATOMICAL ACETABULAR COMPONENT PLACEMENT IN TOTAL HIP ARTHROPLASTY FOR DYSPLASTIC HIPS: A COMPARATIVE STUDY

Shikhar Dogra[1], Jujhar Singh[2], Naval Bhatia[3], Shailendra Khare[4]

[1]Assistant Professor, Dr Radhakrishnan Government Medical College, Hamirpur, Himachal Pradesh, India.
[2]Specialist Orthopaedics, Dr Baba Saheb Ambedkar Medical College & Hospital, Rohini, New Delhi, India.
[3]Consultant Orthopaedics, VMMC & Safdarjung Hospital, New Delhi, India.
[4]SR. Orthopaedic Surgeon & HAG, VMMC & Safdarjung Hospital, New Delhi, India.

Received : 11/02/2023
Received in revised form : 03/03/2023
Accepted : 27/03/2023

Keywords:
High Hip Center, HHS, VAS, Acetabular Fixation, Anatomical Hip, THA.

Corresponding Author:
Dr. Jujhar Singh,
Email: mamcoolife@gmail.com

DOI: 10.47009/jamp.2023.5.3.175

Source of Support: Nil,
Conflict of Interest: None declared

Int J Acad Med Pharm
2023; 5(3); 851-855

Abstract

Background: Total Hip Arthroplasty (THA) in patients with developmental dysplasia of the hip (DDH) can be challenging due to the variable degree of hip deformity. The aim of this study is to compare the clinical and radiographic outcomes with High Hip Center Technique (HHC) versus Anatomical Hip Center Technique (AHC) in Total Hip Arthroplasty (THA) for dysplastic hips. Materials & Methods: A hospital based prospective study done on 30 patients in whom Crowe type-II or type-III DDH were diagnosed and treated by one-stage THA from January 2016 to December2022 at our institute. Patients were then categorized into two groups according to the technique of hip center reconstruction: Group A (AHC technique) and group H (HHC technique). Clinical status of the patients was measured and graded based on the Harris Hip Score (HHS) at the final follow-up. Visual analogous scale (VAS) was also measured to assess thigh pain at the final follow-up. Between groups comparisons were performed using the Student t-test for parametric variables and the Mann–Whitney U test for nonparametric variables. **Results:** Patients in both groups were comparable in terms of the demographic and surgical variables ($p > 0.05$). The mean age at the time of the surgery was 52.6 years in group A and 54.58 years in group H. The cup was inserted in 15 hips (15 patients; 11 female, 4 male) at near AHC in group A and in 15 hips (15 patients; 10 female, 5 male) at HHC position at a distance of 15 mm to 37 mm (mean = 20.13 mm) from the AHC in Group H. There were no differences in both HHS and VAS at the final follow-up between the two groups. In the analyze of component positioning, although V-COR and H-COR were both significantly greater in group H than in group A ($p < 0.001$), there were no significant differences in the other radiographic variables. **Conclusion:** We conclude that the HHC technique using cementless acetabular fixation with or without structural bone graft appears to be a valuable alternative option to AHC technique in cases of Crowe types II and III DDH. With both techniques, favorable clinical and radiographical results can be obtained at mid-term follow-up.

INTRODUCTION

Total Hip Arthroplasty (THA) in patients with developmental dysplasia of the hip (DDH) can be challenging due to the variable degree of hip deformity and the lack of sufficient acetabular bone mass to provide adequate cup coverage.[1] The goal of THA is to restore anatomy of the center of the hip[2] to reduce the load on the hip, improve normal hip biomechanics, and support normal walking function.[3]

In hips with dysplasia, the anatomic hip center can be achieved by placing the cup in the native (paleo) acetabulum, which may result in the use of acetabular bone grafting[5] and/or femoral shortening osteotomy.[4] However, in cases with substantial acetabular bone deficiency at the native acetabulum, surgeons may prefer to place the cup at the high hip center rather than at the anatomic hip center to reduce the risk of neurologic complications and avoid the use of adjuvant procedures[6], thereby reducing associated risks of complications and increased operative time.[7]

The anatomical placement (true acetabulum) of the acetabular component is recommended mainly for biomechanical reasons.[8] On the basis of a mathematical model of the hip joint, Johnston *et al.* [9] suggested that the displacement of the center of rotation of the cemented acetabular component medially, inferiorly and anteriorly reduces hip loads significantly. High placement of the component in the region of false acetabulum has also been proposed.[10] However, at this level, the lever arm for the body weight is much longer than that of the abductors and causes excessive loading of the hip. Also, the shearing forces acting on the acetabular component at a higher level can lead to early loosening. In addition, in unilateral cases a high acetabular component does not correct leg-length and leaves the patient with a limp. In cases of hip dysplasia, according to Hartofilakidis.[8] classification the acetabular cup usually does not pose problems in the ideal placement at the original acetabulum.

In 1991, Russotti and Harris.[11] proposed proximal placement of the acetabular component in revision THA, commonly called "high hip center (HHC)". The advantages of HHC include optimum bone in-growth with greater bone implant contact and simplification of the operation. Kaneuji et al.[12] reported no cup loosening in 30 hips (29 patients) using HHC technique for a mean of 15.2 years after surgery. Nawabi et al.[13] showed no difference in survivorship, wear rates and hip scores between the HHC group and the control group. Even so, high placement of the cup is still controversial and more mid- to long-term follow-up studies are required.

Although several studies have evaluated functional outcomes such as the Harris hip score, revision incidence, and complications associated with THA in dysplastic hips with cups placed at the high hip center.[12,14] or at the anatomic hip center[15,16], there is no clear consensus as to whether cup position has any impact on these outcomes. The aim of this study is to compare the clinical and radiographic outcomes with High Hip Center Technique (HHC) versus Anatomical Hip Center Technique (AHC) in Total Hip Arthroplasty (THA) for dysplastic hips.

MATERIALS AND METHODS

A hospital based prospective study was done on 30 patients in whom Crowe type-II or type-III DDH were diagnosed and treated by one-stage THA from January 2016 to December 2022 at our institute.

Inclusion Criteria

- Crowe type-II or type-III DDH.
- A minimum of two-year-follow-up of patients

Exclusion Criteria

- Lost to follow-up of patients.
- Presence of a concomitant rheumatoid, neurologic, or malignant disease.
- Being unwilling to participate the study

Patients were then categorized into two groups according to the technique of hip center reconstruction: Group A (AHC technique) and group H (HHC technique). To determine the AHC, initial postoperative radiographs were analyzed as described by Pagnano et al.[17] and a vertical distance of 15 mm from AHC was defined as HHC.

Implants and surgical technique

A standard protocol was applied in all operations, which comprised spinal or general anesthesia, thrombosis prophylaxis, an appropriate peri-operative antibiotic regimen for infection prophylaxis, and rehabilitation. Low– molecular-weight heparin was started 12 hours before the operation for thrombosis prophylaxis and terminated when patients were completely mobile. None of the patients underwent prophylaxis for heterotopic ossification. All THAs were performed by two orthopedic surgeons who specialized in arthroplasty. The posterior approach was used in all the cases. Femoral neck osteotomy was performed 2 centimeters above the lesser trochanter. After proper acetabular exploration, reaming was first started with postero-medialization then expanded to periphery. The location of the acetabular cup placement was determined by the responsible surgeon aiming for the highest primary stability that can be achieved. In both groups, a cementless porous acetabular cup was used aiming primary stability with screws.

All patients were encouraged to ambulate with immediate un-restricted weight bearing according to what they could tolerate with two crutches first postoperative day. Under the supervision of physiotherapists, a standardized daily functional exercise program was followed which included range of motion and muscle strength was initiated before discharge from the hospital.

Clinical outcome measures

Clinical status of the patients was measured and graded based on the Harris Hip Score (HHS) at the final follow-up. HHS provides assessments about pain (1 item, 0–44 points), function in the performance of gait and daily activities (7 items, 0–47 points), absence of deformity (1 item, 4 points), and range of motion (2 items, 5 points): the grading is poor (<70), fair (70-79), good (80-89), excellent (90–100).[18]

Visual analogous scale (VAS) was also measured to assess thigh pain at the final follow-up. VAS score used in the current study is a modified and simplified measure in which pain intensity during daily activity is rated on a scale of 0–10, where 0 indicates no pain and 10 indicates the worst pain.[19]

Radiographic outcome measures

Component positioning was assessed based on the following radiographic parameters on final follow-up anteroposterior pelvic radiographs.

ISSN (O): 2687-5365; ISSN (P): 2753-6556

Component loosening was examined on final follow-up radiographs. Radiolucency was defined as a lesion with a clear sclerotic border a minimum of 1mm in width; osteolysis was defined as a radiolucency larger than 2 mm in width.[20] The location of radiolucent lines or osteolysis around the acetabular cup was recorded based on three zones described by DeLee and Charnley.[21]

The cup was deemed as loosened in presence of osteolysis and migration over 5 mm detected on serial follow-up radiographs.[22]

Osseointegration of the acetabular cup was evaluated according to the five radiographic signs of osseointegration described by Moore et al.[23]: 1) the absence of radiolucent lines, 2) the presence of a superolateral buttress, 3) the presence of medial stress-shielding, 4) the presence of radial trabeculae, and 5) the presence of an inferomedial buttress.

Complications

Intra-operative, early, and late postoperative complications were documented. Heterotopic ossification was examined using the Brooker classification on final follow- up radiographs.[24]

Statistical Analyses

IBM SPSS Statistics software, version 20.0 was used for statistical analysis. A $p < 0.05$ was considered statistically significant. Between groups comparisons were performed using the Student t-test for parametric variables and the Mann–Whitney U test for nonparametric variables.

RESULTS

Patients in both groups were comparable in terms of the demographic and surgical variables ($p > 0.05$). The mean age at the time of the surgery was 52.6 years in group A and 54.58 years in group H [Table 1]. The cup was inserted in 15 hips (15 patients; 11 females, 4 male) at near AHC in group A (Figure 1) and in 15 hips (15 patients; 10 female, 5 male) at HHC position at a distance of 15 mm to 37 mm (mean = 20.13 mm) from the AHC in Group H (Figure 2). Metaphyseal/Diaphyseal fitting type femoral stem was used aiming press-fit fixation in all patients. Bone graft from the femur head was used in 5 patients (4 in Group A and 1 in Group H). 2 patients in group A required femoral shortening osteotomy.

There were no differences in both HHS and VAS at the final follow-up between the two groups. According to HHS, most of the patients in both groups exhibited good functional status while no poor results were recorded. In the analyze of component positioning, although V-COR and H-COR were both significantly greater in group H than in group A ($p < 0.001$), there were no significant differences in the other radiographic variables (Table 2).

No significant differences were observed in terms of each complication between the two groups. Although the overall complication rate was higher in group A (66.66%) than in group H (46.66%), this difference reached no statistical significance ($p > 0.05$). Proximal femur metaphyseal fracture occurred intra-operatively in one patient from group A. These complications were managed by cable fixation, and bone union was achieved three to six months after the operation. One patient with Crowe III DDH in group A developed sciatic nerve palsy that resolved spontaneously within the first year of the operation. Other patients with osteolysis did not suffer from any complaint; therefore, the decision for close follow-up with no intervention was made.

Table 1: Demographic and surgical variables of the study participants

Demographic variables		Group A	Group H	P-value
Age at surgery(year)	Mean±SD	52.6±8.24	54.58±7.67	>0.05
Gender	(Female/ Male)	11/4	10/5	>0.05
BMI (kg/m2)	Mean±SD	32.6±3.67	31.2±2.98	>0.05
Crowe type 2 3	N (%)	10(66.66%) 5 (33.33%)	9(60%) 6(40%)	>0.05
Cup size (mm)	Median	46.3	51.98	<0.05*
Acetabular liner Polyethylene Ceramic	N (%)	13(86.66%) 2(13.33%)	12(80%) 3(20%)	>0.05

Table 2: Comparative results of clinical outcome measure & component positioning using anatomical versus high hip centre techniques with complication.

Clinical and radiographic outcome	Group A	Group H	P-value
Clinical outcome			
Harris Hip Score (Mean±SD)	82.78±2.13	83.56±1.98	>0.05
Visual Analogous Scale (Mean±SD)	1.33±0.62	0.78±0.56	>0.05
Radiographic outcome			
Vertical center of rotation (V-COR) (mean)	68.96	83.7	<0.001*
Horizontal center of rotation (H-COR) (mean)	25.1	31.24	<0.001*
Cup inclination (^{0})	39.3	39.66	>0.05
Cup anteversion (^{0})	11.56	10.48	>0.05
Femoral offset (mm)	37.3	37.03	>0.05
Abductor muscle lever arm (mm)	44.76	42.33	>0.05
Leg length inequality (mm)	12.6	13.3	>0.05
Complication			
Proximal femur metaphyseal fracture	1	1	0.00
Sciatic Nerve paralysis	1	0	0.00

ISSN (O): 2687-5365; ISSN (P): 2753-6556

Osteolysis	2	1	>0.05
Heterotopic ossification	4	2	>0.05

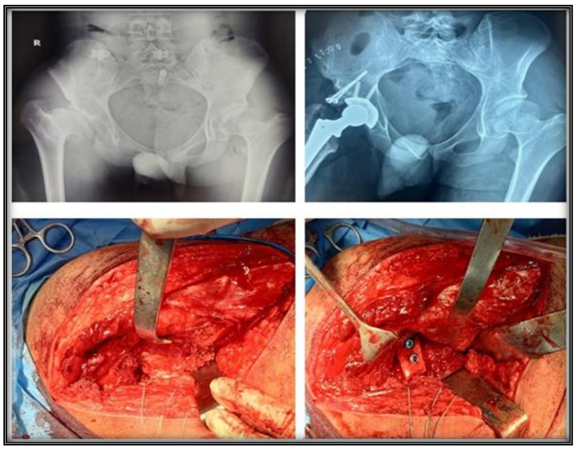

Figure 1: Crowe Grade 3 Dysplastic Hip managed with Bone Grafting, Acetabular Reconstruction & Medial Protrusion Technique with restoration of Anatomical Hip Center (AHC)

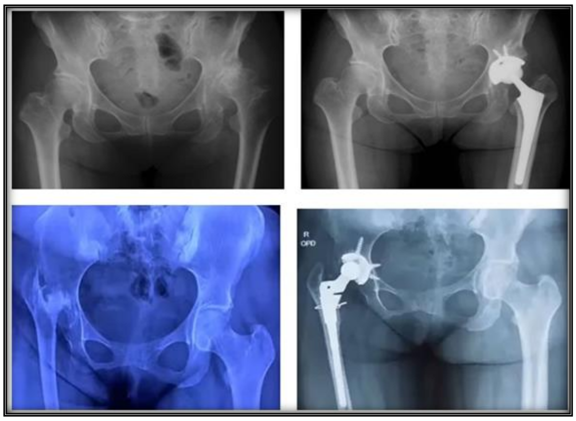

Figure 2. Two Cases of Crowe Grade 2 & 3 Dysplastic Hip managed without bone graft, Medial Protrusion Technique and High Hip Center (HHC)

DISCUSSION

The reconstruction of the acetabulum in patients with Crowe II–III DDH is a demanding procedure for orthopaedic surgeons. Most surgeons find it technically difficult to achieve acceptable cup coverage at the anatomical acetabulum on account of superolateral bone deficiency.[25] Therefore, femoral head structural autograft was usually utilized at the superolateral rim to provide additional support.[26] However, others author have proposed the instability of cemented acetabular component with bulk bone grafts.[27]

One of the major concerns with the elevated hip center is the increased risk of component loosening. Theoretically, the ideal location for placement of the acetabular cup is the anatomic position in the true acetabular region of a dysplastic hip, as non-anatomical positioning of the COR causes increased joint reaction forces and jeopardizes survival of the prosthesis.[28]

In one of the comparative studies on the issue, Russottietal.[11] determined that isolated high positioning of hip center without lateral displacement has no negative effect on the long-term survival of the cemented acetabular components in challenging cases of the acetabular reconstruction such as high dislocation of the hip or re-vision THA. In another comparative study, Murayama et al.[29] found excellent survivorship rates of cement-less THA using AHC (100%) or HHC (97%) in patients with Crowe I to III DDH. In their case series, superior placement of the acetabular cup from the inter tear drop line was not greater than 35 mm (mean, 24.5 mm) in all patients treated by HHC technique, and the authors suggested that moderate superior cup placement without bone grafting at a more medial position than that of anormal hip is an alternative durable solution. In a recent comparative study, Nawabi et al.[13] concluded that fixation of cementless acetabular cup without bone grafting at a HHC could provide high survivorship and excellent hip scores for patients with Crowe II and IIIDDH at a minimum of 10 year follow-up. The common finding of the above comparative studies is that HHC reconstruction can provide as high survivorship and favorable clinical scores as AHC reconstruction in cementless acetabular cup fixation for patients with DDH.

In the current study, as H-COR was higher in HHC group than in AHC group, therefore, we support the notion that placing the cup at a more superior but not more lateral position could ensure a stable fixation as placement of the cup at the anatomical position.

In addition to the two signs of acetabular loosening (radiolucent lines and cup migration), we radiographically examined osseointegration of the acetabular cup in order to improve clinical assessment of acetabular components. In both groups, as a complementary result to lower rates of acetabular loosening, acetabular cups that radiographically demonstrate no signs of acetabular loosening illustrated one or more signs of osseointegration. In addition, there is no study in the literature reporting a relationship between cup size and osseointegration.

CONCLUSION

We conclude that the HHC technique using cementless acetabular fixation with or without structural bone graft appears to be a valuable alternative option to AHC technique in cases of Crowe types II and III DDH. With both techniques, favorable clinical and radiographical results can be obtained at mid-term follow-up.

REFERENCES

1. Argenson JN, Flecher X, Parratte S, Aubaniac JM. Anatomy of the dysplastic hip and consequences for total hip arthroplasty. Clin Orthop Relat Res. 2007;465:40-45.

ISSN (O): 2687-5365; ISSN (P): 2753-6556

2. Dapuzzo MR, Sierra RJ. Acetabular considerations during total hip arthroplasty for hip dysplasia. Orthop Clin North Am. 2012; 43:369-375.
3. Nie Y, Ning N, Pei F, Shen B, Zhou Z, Li Z. Gait kinematic deviations in patients with developmental dysplasia of the hip treated with total hip arthroplasty. Orthopedics. 2017;40: e425-e431.
4. Ollivier M, Abdel MP, Krych AJ, Trousdale RT, Berry DJ. Long term results of total hip arthroplasty with shortening subtrochanteric osteotomy in Crowe IV developmental dysplasia. J Arthroplasty. 2016;31:1756-1760.
5. Kobayashi S, Saito N, Nawata M, Horiuchi H, Iorio R, Takaoka K. Total hip arthroplasty with bulk femoral head autograft for acetabular reconstruction in developmental dysplasia of the hip. J Bone Joint Surg Am. 2003;85:615-621.
6. Ito H, Matsuno T, Minami A, Aoki Y. Intermediate-term results after hybrid total hip arthroplasty for the treatment of dysplastic hips. J Bone Joint Surg Am. 2003;85:1725-1732.
7. Yang TC, Chen CF, Tsai SW, Chen WM, Chang MC. Does restoration of hip center with subtrochanteric osteotomy provide preferable outcome for Crowe type III-IV irreducible development dysplasia of the hip?? J Chin Med Assoc. 2017;80: 803-807.
8. Hartofilakidis G, Stamos K, Karachalios T. Treatment of high dislocation of the hip in adults with total hip arthroplasty. Operative technique and long-term clinical results. J Bone Joint Surg Am 1998;80:510-7.
9. Johnston RC, Brand RA, Crowninshield RD. Reconstruction of the hip. A mathematical approach to determine optimum geometric relationships. J Bone Joint Surg Am 1979;61:639-52.
10. Paavilainen T, Hoikka V, Solonen KA. Cementless total replacement for severely dysplastic or dislocated hips. J Bone Joint Surg Br 1990;72:205-11.
11. Russotti GM, Harris WH. Proximal placement of the acetabular component in total hip arthroplasty. A long-term follow-up study. J Bone Joint Surg Am, 1991, 73: 587–592.
12. Kaneuji A, Sugimori T, Ichiseki T, Yamada K, Fukui K, Matsumoto T. Minimum ten-year results of a porous acetabular component for Crowe I to III hip dysplasia using an elevated hip center. J Arthroplasty, 2009, 24: 187–194.
13. Nawabi DH, Meftah M, Nam D, Ranawat AS, Ranawat CS. Durable fixation achieved with medialized, high hip center cementless THAs for Crowe II and III dysplasia. Clin Orthop Relat Res, 2014, 472: 630–636.
14. Chen M, Luo ZL, Wu KR, Zhang XQ, Ling XD, Shang XF. Cementless total hip arthroplasty with a high hip center for Hartofilakidis type B developmental dysplasia of the hip: results of midterm follow-up. J Arthroplasty. 2016;31:1027-1034.
15. Georgiades G, Babis GC, Kourlaba G, Hartofilakidis G. Effect of cementless acetabular component orientation, position, and containment in total hip arthroplasty for congenital hip disease. J Arthroplasty. 2010;25:1143-1150.
16. Hirakawa K, Mitsugi N, Koshino T, Saito T, Hirasawa Y, Kubo T. Effect of acetabular cup position and orientation in cemented total hip arthroplasty. Clin Orthop Relat Res. 2001;388:135-142.
17. Pagnano MW, Hanssen AD, Lewallen DG, Shaughnessy WJ. The effect of superior placement of the acetabular component on the rate of loosening after total hip arthroplasty. Long-term results in patients who have Crowe type-II congenital dysplasia of the hip. J Bone Joint Surg Am. 1996;78:1004–1014.
18. Harris WH. Traumatic arthritis of the hip after dislocation and acetabular fractures: an end-result study using a new method of result evaluation. J Bone Joint Surg Am. 1969;51:737–755.
19. Langley GB, Sheppeard H. The visual analogue scale: its use in pain measurement. Rheumatol int. 1985;5:145–148.
20. Galea VP, Laaksonen I, Donahue GS, Fukui K, Kaneuji A, Malchau H, Bragdon C. Developmental dysplasia treated with cementless total hip arthroplasty utilizing high hip center reconstruction: a minimum 13-year follow-up study. J Arthroplasty. 2018;33:2899–2905.
21. DeLee JG, Charnley J. Radiological demarcation of cemented sockets in total hip replacement. Clin Orthop Relat Res 1976; 121:20–32.
22. Traina F, De Fine M, Biondi F, Tassinari E, Galvani A, Toni A. The influence of the centre of rotation on implant survival using a modular stem hip prosthesis. Int Orthop. 2009;33:1513.
23. Moore MS, McAuley JP, Young AM, Engh Sr CA. Radiographic signs of osseointegration in porous-coated acetabular components. Clin Orthop Relat Res. 2006;444:176–183.
24. Brooker AF, Bowerman JW, Robinson RA, Riley Jr LH. Ectopic ossification following total hip replacement: incidence and a method of classification. J Bone Joint Surg Am. 1973;55:1629–1632.
25. Olory B, Havet E, Gabrion A, Vernois J, Mertl P. Comparative in vitro assessment of the primary stability of cementless press-fit acetabular cups. Acta Orthop Belg, 2004; 70: 31–7.
26. de Jong PT, Haverkamp D, van der Vis HM, Marti RK. Total hip replacement with a superolateral bone graft for osteoarthritis secondary to dysplasia: a long term follow-up. J Bone Joint Surg Br, 2006; 88: 173–78.
27. Delimar D, Aljinovic A, Bicanic G. Failure of bulk bone grafts after total hip arthroplasty for hip dysplasia. Arch Orthop Trauma Surg, 2014; 134: 1167–73.
28. Bicanic G, Delimar D, Delimar M, Pecina M. Influence of the acetabular cup position on hip load during arthroplasty in hip dysplasia. Int Orthop.2009;33:397–402.
29. Murayama T, Ohnishi H, Okabe S, et al. 15- year comparison of ce-mentless total hip arthroplasty with anatomical or high cup placement for Crowe I to III hip dysplasia. Orthopedics.2012;35:313–318.