Evaluation of Uncemented Total Hip Arthroplasty in Acetabular Protrusio

Atanu Mohanty[1], Saroj Parida[2], Rupak Biswas[3], Anuraag Mohanty[4]

ABSTRACT

Introduction: A lack of bone stock, deficient medial cup support and medial & proximal migration of the joint center are the main challenges in treating cases of protrusio acetabuli with end stage arthritis. The purpose of this prospective study was to assess the functional outcome, radilogical parameters & complications related to uncemented total hip arthroplasty in these patients.

Material and methods: From November2017 to December 2019, 20 patients (33 hips) with secondary acetabular protrusions (25 grade II & 8 grade I) with end stage arthritis underwent uncemented total hip arthroplasties with or without autologous bone grafting. The Harris hip scoring system was used to evaluate hip function during follow-up. X-rays were taken to assess the prosthesis loosening, bone graft healing, cup inclination angle & comparing various pre and postoperative radiological parameters.

Results: The operation time ranged from 60 to 120 min (mean =77.12 ± 14 min). The blood loss was 200 to 400 mL (mean = 252 ± 49.5 mL). The average follow-up duration was 1.5 years (range 6m-2yrs). Postoperative X-rays revealed bone graft union at 6 months post-surgery. The Harris hip scores increased from 34.07 ± 11.43 to 86.22 ± 6.85 postoperatively that was statistically significant ($P < 0.01$). The distance from the center of the femoral head to Kohler's line increased from 18.76 ± 3.7 mm to 20.4 ± 3.3 mm after the operation ($P < 0.01$). During follow-up, no hip acetabular prosthesis loosening & progression of protrusio was evident.There was no dislocation but one case of infection and one case of sciatic nerve injury as postoperative complication.

Conclusion: The use of impacted or unimpacted morselized autograft in conjunction with porous-coated cementless acetabular components was a technically straight forward solution through which the hip bio mechanics were restored and strong fixation was achieved, thereby preventing recurrence of protrusio in grade II or III. For grade I protrusio with end stage arthritis only uncement THR without bone graft was adequate.

Keywords: Acetabular Protrusio, Morselized Autograft, Total Hip Arthroplasty.

INTRODUCTION

Protrusio acetabuli was initially described by Otto in 1824, in cadaver studies as a deformity of the medial wall of the acetabulum with a consequent migration of the femoral head into the pelvis.[1]

The first case report in english literature was described by White in 1883. Scherlin in 1910 was the first to perform radiographic diagnosis.[1]

Primary or essential protrusion of acetabulum is a pelvian deformity characterized by increased depth of cotiloid cavity with depression.[2] In Sotelo-Garza & Charnley studies, the incidence of primary protrusio acetabuli was of 75.3% & as secondary causes, rheumatoid arthritis was evident,with 18.7%.[3] It is believed to have a familial trend as suggested by MacDonald[4] et al, Simmons[5] et al, Hooper[6] et al, Friedenberg[7] who reported changes in acetabular cartilage ossification leading to protrusion.

It is considered as multifactorial and can be classified into two basic types.[8]

Primary: also called idiopathic, affects young patients nevertheless is generally diagnosed at adult age.

Secondary: the protrusion is due to a pre-existing disease, which weakens medial acetabular wall, such as rheumatoid arthritis, ankylosing spondilitis, osteoarthritis, chronic renal osteodistrophy, rachitism, osteoporosis, Paget's disease, neoplasias, surgery sequelae, traumas and infections, and even Marfan's syndrome.[9]

Several methods were proposed to rate protrusio acetabuli, all of them based on radiographic studies. Some of these, the simplest, are adequate for identifying protrusion, but not to grade it as: tear drop signal, Wiberg's angle and changes in the Shenton's arch or line. The most accepted and diffused is the one by Ranawat. Other rating with good parameters is based on the Kohler's line. It is an ilial-ischiatic line, measuring the distance from it to the medial wall of the acetabulum; several authors use it.[10,11,12] With this method we can assess the variant distance in males (> 3 mm) and females (6 mm).[10,11]

Sotelo-Garza & Charnley[3] classified it into 3 grades based on distance between floor of acetabulum & ilioischeal line- grade I <5mm, grade II -6 to 15 mm & grade III > 15 mm.

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Total hip replacement (THR) in secondary protrusio acitabuli with end stage arthritis is technically demanding due to associated significant medial and proximal migration of the centre of the joint, deficient bone medially and reduced bony support to the acetabular component peripherally.

Different techniques in the surgical management of protrusio described in literature include using cemented acetabular components with cement alone or in association with morselised bone to reconstruct the acetabulum.[10-17] However, cement alone has a high incidence of migration[13] and high rates of loosening have been reported in the medium term for bone graft used with cement.[10,14] in younger patients The use of cemented acetabular components may result in early loosening and high revision rates during the first decade after implantation[15] Other methods for reconstruction of the acetabulum like use of metal cages, mesh or reinforcement rings or block bone graft[16,17,18] add too much cost & increase the complexity of the procedure.

Using impacted or unimpacted morsilised auto bone graft and cementless acetabular component helps in restoration of hip mechanics, provide a biological solution to medial bone defeciency and ensure a long term fixation without loosening or migration.[19]

The purpose of the study is to highlight the preoperative, intraoperative and postoperative hurdles encountered in performing a total hip replacement in patients with arthritis of hip with protrusio acetabuli & evaluation of functional outcome using uncemented THR with or without bone graft with a short term follow up of upto 1 year (mean).

MATERIAL AND METHODS

This prospective study was conducted on patients with protrusion acetabuli with end stage arthritis secondary to Ankylosing spondylitis & Rheumatoid Arthritis who were treated with Total Hip Arthroplasty as advised, in The Department of Orthopaedics, S.C.B Medical College and Hospital, Cuttack, Odisha. This study was approved by the Medical Ethics Committee of the SCBMC&H Cuttack. Informed consent was obtained from all individuals. All patients provided written informed consent prior to participation.

Inclusion criteria

- Patient of age more than 25 years.
- Patient with protrusion acetabuli (pelvic AP radiographic evidence that the acetabular site had moved over Kohler's line) secondary Ankylosing spondylitis & Rheumatoid Arthritis with end stage arthritis.
- Patient willing for surgery and post surgery life style modification

Exclusion criteria

- Age less than 25 years
- Involvement of ipsilateral knee joint
- Patient unwilling for surgery and post surgery lifestyle modifications
- Patient medically unfit for surgery
- Patient having clinically detectable active foci of infection
- Lost to follow-up

Patient Information

Between November 2017 to December 2019, 20 patients (33 hips) with protrusion acetabuli secondary to RA & AS with end stage arthritis were treated via total hip arthroplasty with uncemented porous-coated hemispheric cup with or without bone grafting in 25 & 8 hips respectively at our institution. There were 9 males (13 hips) and 11 females (20 hips). Patients 'age ranged from 32yrs to 55 yrs (mean =42.65 years) at the time of index arthroplasty. 13 patients(65%) had bilateral lesions and 7(35%) unilateral with 3 left and 4 right lesions. The underlying diagnosis was rheumatoid arthritis for 24 hips (72%), and ankylosing spondylitis for 9 hips(28%). No patient had previous hip surgery

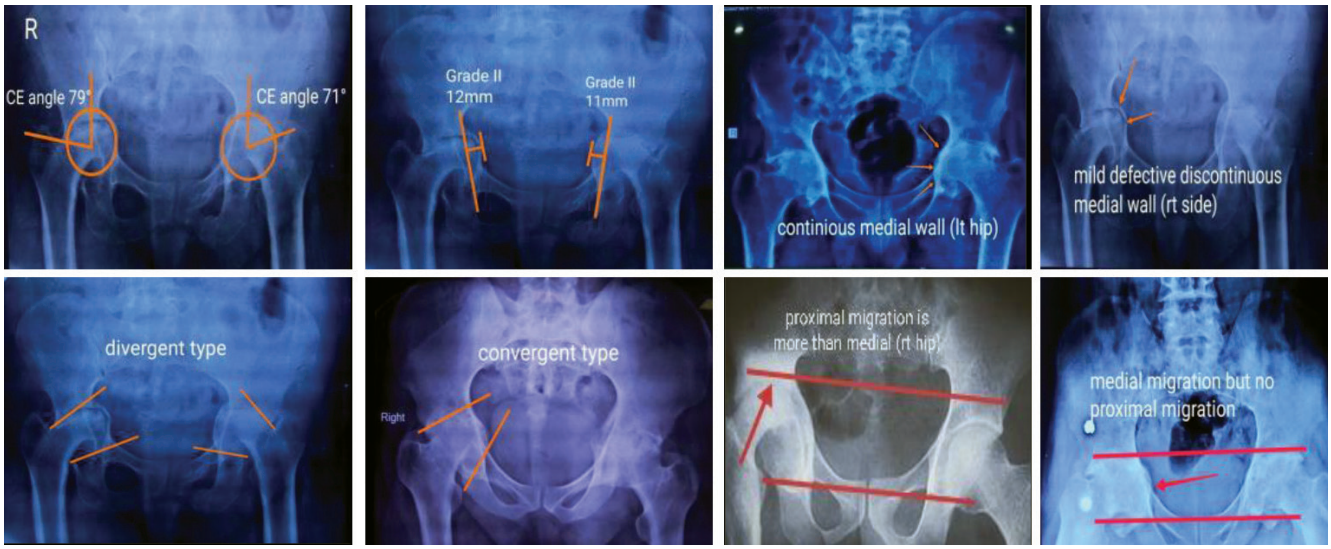
The principal clinical manifestations were hip pain during standing and walking and limitation of joint movement. Severe (outreach angle < 25°) and mild (outreach angle > 25°) abduction limitations were evident in 25 hips (75%) and 8 hips (25%), respectively. In addition, 7 B/L cases (14 hips) exhibited muscle strength of grade III, and 13 cases (19 hips) had muscle strength of grade IV according to MRC muscle grading. The Trendelenburg sign was always positive. The duration of RA-related hip disease ranged from 8 to 17 years (mean = 11.84 years) & that of AS ranged from 12 to 25 yrs (mean = 18 yrs)

Preoperative radiographic assessment

Routine preoperative X-ray of B/L hip with pelvis (AP & Lateral) were obtained. Preoperative radiological analysis of following parameters were done - (1) grading (2) CE angle (3) convergent or divergent (4)medial wall status (5) simple or complex (6) distance from femoral head center to kohlers line (7) distance from femoral head center to ischeal tuberosity (8) templating. X-rays of the anteroposterior pelvis aided in the diagnosis & grading of the acetabular protrusion, which was evaluated by the relative positions of the medial acetabular wall and Kohler's line. The extent of the protrusion in the 20 patients (33 hips) ranged from 3 to 15 mm (mean =9.16±3.73 mm). Using the Sotello-Garza and Charnley classification[12], 25 hips(75%) were of type II (protrusion 6 to 15 mm), and 8 hips(25%) were type I (1–5 mm); we encountered no type III cases(> 15 mm). 11 hips were of divergent configuration, in 8 hips medial wall was discontinuous and in all cases medial migration was more than proximal migration.

Operative technique

Total hip arthroplasty was performed under general or spinal anesthesia. In all cases, the posterior or southern approach was used, with the patient placed on the contralateral side. Commencing 1 cm posterior to the tip of the greater trochanter, a straight skin incision approximately 12 cm in length was created. The gluteus medius was retracted, and the short external rotators were isolated and detached. The insertion of the quadratus was spared. Sciatic nerve lies very close to hip joint in cases of protrusio and was carefully protected throughout the surgery.



In all cases hip were mobilized by circumferential capsular release. The rim osteophytes were chiseled off. In some cases gluteus maximus tendon was divided partially about 0.5-1 cm from its femoral insertion at gluteal tuberosity. Attempt to dislocate hip was done in all cases. Dislocation was done very gently & avoiding excessive rotational maneuver so as to prevent any spiral fracture of shaft of femur in osteoporotic RA cases.

Because the femoral head protruded intrapelvically, it was difficult to dislocate the femoral head in most of the divergent types than convergent Protrusio, as the mouth of acetabulum was small in the divergent ones. Contracted soft tissue & the deformity were other contributory reasons for difficulty in dislocation. In those cases, the femoral head and neck were completely trapped in the acetabulum, and common osteotomy of the femoral neck was difficult to perform. In such patients, part of the edge of the femoral head and part of the neck lying inside the acetabulum were first removed using a drill or a narrow bone knife. Exploiting lower limb traction and abduction, the femoral neck was then partially exposed to facilitate osteotomy. Thus 14 hips (42%) had an in situ femoral head osteotomy.

Head of femur was extracted by a cork screw. Cases in which mouth of acetabulum was narrow, it was difficult to remove the head intact; thus, we removed the head in piecemeal.

The acetabular preparation was performed in two stages, that of the periphery and then that of the medial floor.

Periphery preparation:- In cases with small acetabular mouth & divergent protrusio, the peripheral walls become divergent medially instead of of normal convergent configuration. In such cases unlike standard reaming, we did not start with the smallest reamers with the aim of preparing the floor first. Instead, the peripheral cartilage was reamed down at first, albeit preserving the subchondral bone using larger reamers, to one or two sizes smaller than the final cup size templated. The aim was to convert divergent types to normal convergent configuration of acetabulum. But in cases with covergent configuration we followed the standard technique.

Medial floor preparation:- In preparation of the medial floor, we gently resected the synovial tissue and soft tissue in geodes in the acetabulum with curette and then only exposed bleeding subchondral bone with drilling multiple small holes on the acetabular wall using a Kirschner wire wherever the subchondral bone appeared to be very sclerotic.The medial reaming was performed very carefully because it can lead to penetration of the thin medial wall. The cup should be in contact with at least 50% of good quality acetabular bone for adequate stability of the cup to facilitate bone in growth into the shell and provide sufficient mechanical support to the underlying graft.

Regarding bone graft preparation we used three techniques.

Technique 1- In cases where we were able to dislocate the head and impaction graft were needed for either defects of medial wall or divergent configuration, we prepared bone grafts from that fermoral head with the help of oscillating bone saw, osteotome, bone cutter & nibbler to obtain a particle size that was 5 to 10 mm in diameter.Rinsing of bone graft with saline was avoided because it leads to loss of osteogenic factors in the graft.

Technique 2:- In cases where head was delivered and medial wall was continuous or convergent configuration of acetabulum we required snugly fitting fine grafts. In those cases we hold the femoral head tightly with pointed forceps and reamed it on table to get fine morselized grafts.

Technique3:- In those cases where we were not able to dislocated the head after doing neck cut we used smallest reamer to cut the head inside acetabular cavity under Carm guidance. Once the smallest reamer was filled up with bone we proceed to next up size reamer. Lastly thin layer of femoral head shell was scooped out with the help of bone scoop. Bone grafts harvested by this procedure were more fine and homogenous compared to the 1st procedure.

The fenestrated trial cup allowed for visualization of the adequacy of peripheral fit and the gap between the apex of the trial cup and the bottom of the floor.

In cases of grade II protrusio where medial wall defect were there or cases with divergent configuration of acetabulum, impaction bone grafting was done with bone grafts of size

5mm to 10mm size blocks. For the methods of impaction bone grafting, either the trial head of the hemiarthroplasty prosthesis or mallet was used for impacting after putting the morselized graft inside the acetabular cavity. A trial head with a size smaller than the diameter of the acetabulum is used for the impaction of the grafting bone until rigid compression of the bone is obtained. Although vigorous impaction is recommended, care was taken to avoid fracturing the acetabular wall because many patients were osteoporotic. The deficient acetabulum was filled with multiple layers of graft, each successive layer being impacted onto the previous one until the defect was filled and the acetabular floor was adequately lateralized. This was confirmed by using the trial cup to ascertain that there was a sufficient buildup of the floor with graft but that it was not excessive and likely to interfere with full seating of the cup.

In cases of grade II protrusio with continuous medial wall or convergent configuration with simple variety type, morselized graft were placed and reverse reaming was done. In such cases snugly fitting graft was enough without any requirement of impaction.

After preparing the medial wall with graft, the cementless acetabular component (multi hole porous coated cup) was inserted and fixed with supplemental screws. In all cases judicious lateralization of cup was done to keep the acetabular medial margin at coxa profunda level (inner margin of cup touches the kohlers line). Too much lateralization of cup will result in increase in offset resulting in trochanteric pain and was kept in mind.In all cases for femoral component we performed uncemented fixation with porus coated or hydroxyapatite coated stem.

All patients were allowed to transfer from the bed to the wheelchair on the first postoperative day. If satisfactory cup rim fixation was evident during surgery, full weight bearing was also allowed on the fifth day not first day first day after surgery. Given the thin acetabular rim and the fact that bone grafts were placed on the poor quality of acetabular bed, the acetabular components of the total hip arthroplasty that were used in this series were as follows: porous tantalum acetabular cups (TM cups; Zimmer, USA) were placed in 7 patients (9 hips), and sintered, three-dimensional, asymmetric, titanium, porous coated cups (multi hole cups; Smith & Nephew, USA) were placed in 13 patients (24hips). In all cases the high-level cross-linked polyethylene-liner were used.

Drain was given & skin was closed in layers. Abduction pillow was used during the sleeping time for 7 to 10 days postoparatively. We followed a single dose antibiotic preoperatively & continued for 2-3 days postoperatively.

Postoperative protocol:

(1).Active & passive range of motion within the first 24-48 hrs. (2).Non weight bearing walking with crutch or walker for 6 wks.(3)Partial weight bearing with a walker was advised upto 3 months untill bone grafts appeared to be incorporated in x ray.(4)Full weight bearing at 3 months.

Postoperative radiographic assesment:

An AP radiograph of the pelvis were obtained immediately after surgery, at 6 weeks, at 3 months at 6 months, and annually thereafter. The radiographs were carefully assessed by the senior surgeon and an independent observer. A magnification factor using the known diameter of the femoral head was used to correct for magnification.

We measured the following: (1) the acetabular angle(inclination);(2) the vertical distance of the new hip center from the ischial tuberosity (3) the horizontal distance of the hip center from kohlers line (4)medial bone stock (5)limb length discripency (LLD) (6) bone graft union (7) judicious lateralisation of cup with medial most margin at coxa profunda level.(8) CE angle.

RESULTS

Operational parameters: The operation time ranged from 60 to 120 min (mean =77.12 ± 14 min). All grade II cases bone grafting was done using the femoral head. The blood loss ranged from 200 to 400 ml(mean = 252 ± 49.5 ml). All cases received postoperatively one unit of blood transfusion.

Functional outcomes: All patients were followed up for 6m to 1.5 year. The mean preoperative Harris hip score was 34.07 ± 11.43, which improved significantly, to 86.22 ± 6.85, at a mean followup of 6 months (t = 3.429 P = <0.01).

Radiographic findings: The immediate, postoperative, anteroposterior pelvic radiographs showed that the acetabular cups and femoral stem prostheses were correctly positioned in all cases(33 hips). The mean acetabular inclination angle was 42.30° (range 38°–46°).In all cases, radiographs showed that the impacted morselized bone grafts became incorporated into the surrounding bone. Follow-up radiographs showed that the bone grafts united within 4 to 6 months (mean = 5.5 months) after surgery, and continuous trabecular bone that grew through the junction of the host bone and the bone graft was apparent. All acetabular components were stable at the last follow-up, and no perceptible positional change was noted.At the final follow-up, no radiolucency or sign of bone graft absorption was apparent at the periphery of the cup. No component migrated superiorly or medially,and we found no evidence of recurrence of protrusio acetabuli in any case. The distance from the femoral head center to Kohler's line increased from18.28 ± 2.90mm preoperatively to 2O.5 ± 2.53 mm postoperatively (t = 2.426 P=<0.01); the distance between the femoral head center and the ischial tubercle connection decreased significantly from 78.82 ± 8.61 to 73.71± 7.88 mm postoperatively (t = 3.24 P= <0.01). Thus, the new hip rotation center migrated from a superior and medial position to a lateral and inferior position, which is normal.

DISCUSSION

Most patients presenting with protrusio acetabulum the subcontinent appear to be younger than 50 years.[20]

Only uncemented THR is adequate for grade I protrusio acetabuli. Primary total hip replacement in grade II & III is technically demanding due to associated significant medial and proximal migration of the centre of the joint, deficent

bone medially and reduced bony support to the acetabular component peripherally.[21]

THR in the presence of protrusio acetabuli of grade II & III often requires bone grafting or cement or both in order to restore bone stock, establish a medial buttress for the acetabular component and appropriately lateralise the cup to restore the hip centre.[21] So options available for acetabular reconstruction in these cases are (i)only cemented (ii) cemented with bone graft (iii) only bone graft. Cage or ring or mesh may be needed in grade III protrusio acetabuli.

Using only cement for acetabular reconstruction in protrusio acetabuli has had unacceptably high rates of recurrence, with components migrating into the acetabulum.[22] Thermal necrosis of the thinned out medial acetabular wall caused by heat of polymerization of the cement.[23] has been reported to be one of the factors responsible for the poor outcome.

Although the use of impacted morselized bone graft along with a cemented or cementless component are other options in the management of protrusio during THR, literature is relatively sparse on the use of this technique and as to its effectiveness (Table-1).

Impaction bone grafting, along with a cemented cup for acetabular reconstruction in protrusio during THR was first proposed by Slooff et al.[14] A recent 20- to 28-year review of their series of 42 cases (all performed in patients aged< 50 years) by Busch et al[26] reported a survivorship of 73%at the end of 20 years. Similarly, Rosenberg et al[24] reported90% survival in 36 hips at a mean follow-up of 12 years in rheumatoid patients with protrusio where acetabular reconstruction was performed using impacted morselized bone graft and cemented cups. Hence, although the medium-term results of using impaction bone grafting and cemented cups for protrusio acetabuli are encouraging, the long-term results of this procedure are not as gratifying, especially in patients aged < 50 years.

In contrast, the results of cementless acetabular reconstruction in patients aged < 50 years have revealed significantly better survival rates compared with cemented acetabular reconstructions.

In their series of 29 primary THRs (mean age at surgery,66 years) for arthritis with protrusio acetabuli using morselized autograft and dual-geometry acetabular component, Krushell, Fingeroth and Gelling[25] reported good to excellent clinical results in 76% of hips, with no incidence of radiographic aseptic loosening or recurrence at a mean follow-up of two years. In their series of 23 primary THRs(mean age at surgery 62 years)for arthritic hips with cavitary acetabular bone defects using morselised autograft and cementless cup, Pereira et al[19] reported good to excellent clinical results in 91% of hips, and 100% survival with revision and radiographic loosening as endpoints at a mean follow-up of 7.8 years. Mullaji AB et al[20] study of 30 primary THRs (mean age at surgery, 46 years) with protrusio, acetabular reconstruction was performed using a cementless cup supplemented with impacted, morselized autograft. At a mean follow-up of 4.2 years (2 to 10),27 hips (90%) had good to excellent clinical results, with none of the hips showing any radiological signs of loosening, instability or recurrence of protrusio.

The results of our series support the contention that a cementless acetabular reconstruction in conjunction with impaction or non impaction bone grafting, restores bone stock, provides a more biological mode of fixation,helps in judicious cup lateralization (coxa profunda level) and a more enduring solution.

A standardized procedure for impaction bone grafting can facilitate successful bone graft consolidation. Paramount steps for this are ensuring a uniform size of the bone graft particles[23,27] preparing a vascular host bed for the graft, and optimal impaction of graft material.[28] Contact of the bone graft with saline and lavage of the acetabular floor are to be avoided so as not to cause loss of osteogenic factors in the graft material. It is important to oversize the cementless cup in order to achieve a peripheral rim fit of the cup. Consolidation of the graft will establish a medial buttress for the acetabular socket, and enhance stability toresist the superomedially directed joint reaction force. Acetabular cages and rings may only be required if the bony rim of the acetabulum is not intact, or the defect is enormous(grade III). Radiographs did show several radiolucencies around some of the screws, however none of these exceeded 2 mm.There was no evidence of progression of protrusio or socket loosening in any of our cases. Also we have not seen osteolytic lesions up to the present time.The shape of the femoral canal(Dorr types) determined choice of stem. We have used cementless stems,and have observed graft consolidation in all cases, irrespective of stem configuration.

Study	Hips (n)	Age at surgery (yrs)	Technique	Survival rate of acetabular components
Rosenberg et al[24]	36	53	Impacted bone graft with cemented component	90% at 12 years
Garcia-Cimbrelo et al[13]	148	54	Cemented polyethylene component	79% at 16 years
Welten et a[l4]	69	56	Impacted bone graft with cemented component	94% at 12.3 years
Pereira et al[19]	23	62	Impacted, morselized bone graft with cementless component	100% at 7.8 years
Mullaji AB et al[20]	30	46	Impacted, morselized bone graft with cementless cup	100% at 4.2 years
Krushell et al[25]	29	66	Impacted, morselized bone graft with dual-geometry cementless component	100% at 2 years
Busch et al[26]	37	< 50	Impacted bone graft with cemented polyethylene component	73% at 20 years

Table-1: Comparison of results of different techniques used to treat acetabular protrusio with primary total hip replacement in literature published since 2000

Like in studies of Mullaji A B et al[20] and Pereira et al[19] in our study the mean Harris hip score improved to 88.22±6.8 in our patients.Excellent & good results in 17 patients (85%), fair in 2 patients (10%) & poor in 1 patient (5%) collaborates well to their studies.The poor result in 1 patient and the fair results in 2 patients can be ascribed to the involvement of multiple joints by rheumatoid arthritis in these patients, leading to their overall debility. The Harris hip score in the group of patients with good or excellent results remained unchanged after a mean follow-up of 1 year.

In our study there was significant increase in mean distance from femoral head center to Kohlers line, deccrease in femoral head center to ischeal tuberosity distance & CE angle postoperatively like in studies of Millaji A B et al[20], Pereria et al[19] & Krushell et al.[25]

With no revision or migration of the cup, 100% rate of graft incorporation as well as consolidation, and minimal radiolucencies with no significant osteolysis, the results are encouraging. Because the follow-up in this study extends to the short term only, all our patients are being evaluated at regular intervals and the long-term results will become available in time.

CONCLUSION

In conclusion we can say that, the use of impacted or non-impacted morselised autograft in conjunction with porous-coated cementless acetabular components is a technically straight forward solution, through which the hip mechanics are restored and sound fixation can be achieved, thereby preventing recurrence of protrusio in grade II or III. For grade I protrusio with end stage arthritis only uncement THR without bone graft is adequate.

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