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Clinical and radiological outcome analysis of cementless total hip replacement: A case series study

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Abstract : *Fifteen adult cases of uncemented total hip replacement were assessed clinically (by Harris Hip Score) and radiologically by serial radiographs and CT scan. In the postoperative Harris Hip Score the neck of femur groups and the arthritic hip groups had comparable results and uncemented total hip replacement gives acceptable results in otherwise disabling condition of hip. Prospective evaluation of fifteen patients in the age group of 18 years to 60 years with good general condition and no septic foci underwent uncemented total hip replacement for various indications during June 2013 to March 2015. The periodic evaluations were done clinically and radiologically and CT scans at regular intervals. Among the fourteen patients with fifteen hip replacements (one bilateral) the overall improvement in average Harris Hip Score was from 29.9 preoperatively to 91.4 postoperatively and in one case we observed detoriation in Harris Hip Score by loosening but it still gave fair result. In this study clinical assessment correlated well with radiographic appearance and CT scan. There were no evidences of osteointergration in any case possibly because of short duration of study. The postoperative Harris Hip Score has significant (p<0.001) improvement during follow-up.*

Keywords : *Arthroplasty , Osteointergration, Loosening- radiolucent lines*

I. Introduction

Total hip replacement (arthroplasty) has proved to be an exceptionally satisfying procedure with the good results. This procedure improves the qualities of life of the individual with functional improvement of almost every patient if it is done properly. The effectiveness of implant design, fixation types and bearing surfaces was based on the in-growth of bone (Osteo-integration) achieving more dependable fixation of the prosthesis and at the same time facilitate the restoration of bone stock if a revision total hip arthroplasty is needed. Outcome evaluation after total hip replacement is specifically in clinical and radiological basis is significant to assess standards of practice and for systematic research. The clinical and radiological outcome assessment of this has been reported in the current study. This is accomplished without bone cement to bond between the implant and the bone. This osteo-integration is studied radiographically by viewing the prosthetic bone interface for incorporation in the form of radio dense lines or loosening in the form of radiolucent zones.

II. Materials And Methods

Osteo integration is a good sign of stability in uncemented total hip replacement. In uncemented total hip arthroplasty , the prosthetic fixation depends on bone ingrowth into a porus implant surface or bone on growth to a biologically active implant surface such as hydroxyapatite or sand blasted surface. With absence of texturing like sand blasting –rough surface, or absence of coatings like hydroxyapatite, on growth of bone cannot happen comfortably to achieve any long term implantation in patients with uncemented total hip arthroplasty. To achieve a reliable ingrowth of bone, the best possible pore size must be near that of a normal cancellous bone i.e. 100 to 400 µm. There are evidences if the micromotion between the implant and bone is more than 50 µm results fibrous fixation and only below that any bone ingrowth is possible. This may have a bearing on the neo angiogenesis and growth of bone through the new vessels.

In case of the acetabulum, hydroxy apatite coated uncemented total hip arthroplasty acetabular sockets get osteointegrated and provide good clinical results, however in osteoporotic there is more chance of post-operative bone loss. Uncemented total hip arthroplasty with coated implants, in which distal bone ingrowth have more risk of stress shielding. A simple classification system by Engh and Bobyn [1],[2] for implant fixation was based on roentegenographic examination alone. The fixation was classified as (1) bone ingrowth (2) stable fibrous and (3) unstable. Fixation by bone ingrowth is defined as an implant with no subsidence and minimal or no radiolucent lines formation around the stem and the bone- implant interface appears stable.

In the present study a prospective evaluation of 15 patients in the age range of 18 to 60 years with good general condition and no septic foci who underwent uncemented total hip replacement for various indications was carried out. The study participants were recruited between June 2013 to September 2015 from the Department of Orthopaedics and Traumatology, Thanjavur Medical College Hospital, Tamil Nadu, India. These patients had periodic evaluation both clinically and radiologically and with CT scans at regular intervals (3 weeks, 6 weeks, 3 months, 6 months and yearly thereafter. The inclusion Indications in our study for cementless hip replacement was that the patients with good bone stock and no evidence of septic foci preoperatively , avascular necrosis of femoral head, fracture neck of femur with non union and chronic arthritis of hip.

1.1 The surgical technique

We used Moore's posterior[3] approach in all the patients. First step is an adductor tenotomy in old chronic arthritis cases. The patient was placed in lateral position with the affected limb on the upper aspect. The step by step procedure is provided in Fig.1. An incision was started 5 cm posterior and lateral to the postero inferior iliac spine towards greater trochanter and then along the line of shaft of the femur. The fascia late was incised in line with the skin incision and centered over greater trochanter and divided. The gluteus maximus was divided along it fibers and retracted with Charnley's self-retracting retractor exposing the origin of the lateral rotators of the hip on the greater trochanter. Tendons of short lateral rotators are cut 1cm from the greater trochanter and were retracted medially protecting the sciatic nerve in the process. The incision was carried distally along the shaft also to aid exposure. The psoas tendon was erased off the lesser trochanter. Thigh was internally rotated and the capsule of the joint was exposed and incised. Hip was dislocated by internal rotation. In case of fracture of neck of femur the head was delivered by a murphy's skid or by a corkscrew.

Figure 1: The step by step surgical procedure viz., incision, acetabulum preparation, acetabulum cup,press fit acetabular cup, femoral preparation with femoral stem and head insertion, reduction and closure.

The cup and stem size were determined by pre-operative planning with the help of templates. This was done by drawing two horizontal lines one joining both teardrop and the other joining the lesser trochanter. Then measure limb length discrepancy as the difference in lengths of lesser trochanters. The instruments used in for acetabular and femoral preparations were provided in the Fig. 2. In case of acetabulam, place acetabular templates on the film and select a size that closely matches the contour of patient's acetabulum. The medial surface of the cup is at the tear drop and the inferior limit is at the level of obturator foramen. Mark the new center of rotation of hip. In case of femur, select a size that most precisely matches the contour of proximal canal . Select a neck so that the difference in the height of femoral and acetabular center is equal to the limb length discrepancy. Later mark the level of anticipated neck cut and measure its distance from the lesser trochanter.

Figure 2: The instruments used in for acetabular and femoral preparations

In total hip replacement preoperative templating to determine lateral and anterior inclination of the cup is important to avoid postoperative impingement, dislocation, high wear rate and loosening. Charnley[4] recommended 0 degree of anterior inclination, Coventry[5] recommended 40 degree of lateral and 15 degree of anterior inclination, and Harris[6] recommended 30 degree of lateral and 20 degree of anterior inclination. Based on previous studies, cup inclination angle typically ranges from 30 to 50 degree lateral and 0 to 30 degree anterior.

In patients with hemi-osteoarthritis of the hip joint the position of the femoral head on the healthy side can be used as a point reference .However, in patients with bilateral osteoarthritis there is no physical point of reference apart from the height of the teardrop.

Ranawat[7] et al proposed using the true acetabular region as the area of cup position and the approximate femoral head center as the reference i.e., by placing the cup at an inclination of approximately 45 degree lateral and 25 degree anterior. The cup size was selected to fit the anteroposterior acetabular diameter and to contact the medial wall of the acetabular floor in depth. The inferior cup edge was placed at the level of the inferior acetabular margin.

Figure 3: Ranawat triangle with Senton’s line (S_1S_2), Kohler’s line (K_1K_2), the lowest point of the teardrop (intersection of S_1S_2 and K_1K_2) and 20% height of pelvis (D-C)

The implant on the acetabular side is the standard cup is a modular acetabular implant consisting of a titanium shell and a polyethylene liner insert. The outer titanium shell consists of a convex outer surface, which is rough sand blasted surface to enable osteointegration. In its proximal half this shell has openings for proper cancellous bone screws, which are countersunk and which need to be inserted parallel to the leading direction i.e. towards the sacroiliac joint. These countersunk screw heads do not protrude above the surface interfering with the polyethelene insert and allows positioning of screws at any angle within a 30^0 range. The screw sockets have a hemispherical form with a sharp edge and the outer shell surface. Such sharp edges make sure the anchorage of the implant in the cancellous acetabular bone even when in some cases no fixation screws were used. The screws used are 6.5 mm countersunk cancellous screws made of titanium and the head has a hexagonal socket. In the distal half of the shell,there were no screw opening so that screws were not inserted even erroneously. Here there were sharp edged elevations, which can penetrate into the cancellous bone, when the cup is impacted thus increasing the primary stability. Like prevention of rotation and tilting .These also will offer a large surface area for subsequent osteointegration.

Figure 4: Acetabular implant - outer titanium shell with sand blasted surface and polyethylene liner and Femoral stem component (titanium alloy with hydroxyapatite coated)

A slightly greater diameter of the implanted cup shell than the previously reamed acatabulum , ensures primary stability . Thus the implant was pressed into a bone hollow which is somewhat slightly smaller by 2 mm. This causes to high circular tension, surrounding the implanted cup. The standard cup was available in 2 mm steps with diameter form 44 to 62 mm. The threaded hole at the pole of the titanium shell served for the mounting on the setting instrument. Also the pin on the convex pole of the high density polyethylene inserts fit into this central hole and can be used as a guide for insertion into the titanium shell. As it is impacted into the outer titanium shell, the polyethylene insert becomes wedged behind the recess around the edge of the titanium shell and snap into position.. Uncemented direct anchorage of the titanium shell in the acetabulum was by press-fit and later by osteointegration. if necessary extra screw fixation can be done.

The Uncemented femoral stem component was made up of a titanium alloy of high strength with a rough sand blasted finish was used alongwith a modular head made up of cobalt –chromium – molybdenum alloy Similar to the acetabular cup implantation, for femoral stem also, the three-dimensional press fit gives immediate mechanical stability. The frontal and sagittal planes of the prosthesis is conical while the anterior and posterior proximal surfaces of the stems have paralleled, longitudinally arranged conical ribs. The stem's rotational stability was achieved by means of the ribs, which were connected and bond into proximal cancellous bone. The optional fit was achieved by press fittings the stem in the femoral medullary canal.

Standard antero posterior radiograph of pelvis an antero posterior radiograph of hip showing upto the lower end of femoral prosthesis were taken for this study. The radiographs were cautiously reviewed to determine the presence and progressions of radio dense and radio lucent lines, the position and migration of the acetabular cup and femoral components, the extent of femoral component filling in the intramedullary canal, the remodeling of host bone around the implant and heterotropic bone formation. Solid fixation was indicated by spot welds and trabeculae of cancellous host bone extending to the stem of the prosthesis. Each component was assessed for the presence and progressions of radiodense lines at 7 zones described by Gruen[8] along femoral component and three zones described by DeLee and Charnley[9] along the acetabular component. Cross sections in transverse planes in CT scan, for acetabular component, the DeLee and Charnley zones were kept as guidelines. For femoral component the Gruen zones were kept as guideline. Harris hip score [10] is used for evaluating outcome after THR. The indication for THR is particularly pain and impaired physical function which are the main domains in Harris Hip Score (HHS). The function domain consists of daily activities (stair use, using public transportation, sitting, and managing shoes and socks) and gait (limp, support needed, and walked distance). Deformity takes into account hip flexion, adduction, internal rotation, limb length discrepancy. Range of motion measures hip flexion, abduction, external and internal rotation, and adduction. There are 10 items and the maximum score of 100 points, pain(1 item,0-44 points), function(7 items,0-47 points), absence of deformity(1 item,4 points), and range of motion(2 items,5 points).

1.2 Statistical Analysis

The descriptive statistics were expressed using frequency, percentages for categorical variables and mean, median along with standard deviation (SD) and range for continuous variables. After testing for normal distribution, comparison of pre and post-operative Harris Hip Score (HHS) were analyzed using repeated measure Analysis of variance (RMANOVA). P<0.05 was considered statistically significant.

III. Results

The patients were grouped according to age and sex. The mean age of all patients was 42.47 years with the range of 18-60 years. Majority of them were males 15/20 (66.7%). All patients were available for follow up. The summary of basic clinical variables is presented in Table 1. As far as possible periodic review by clinical evaluation was done immediate post operatively and after 3 weeks, 6 weeks, 3months, 6 months and yearly. The follow up was done by the same authors on appropriate dates

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IV. Figures and Tables

Table 1: Descriptive statistics of clinical and preoperative variables of all patients.

Clinical Variables	Mean ± standard deviation	median (range)
Age (years)	42.47 ± 15.43	45 (18 – 60)
Sex (Male: Female)	10 : 5	
LLD (Cm)	0.35 ± 0.29	0.2 (0.1 - 1.09)
Cup Size (mm)	50.8 ± 3.84	50 (46 - 58)
Anteversion (Deg)	21.57 ± 6.68	21 (11.2 – 32)
Inclination	41.83 ± 10.07	40.6 (26.7 - 64.7)
Stem	1.4 ± 1.45	1 (0 - 5)
Head Size (mm)	28.27 ± 1.03	28 (28 – 32)
Anteversion (Deg)	15.47 ± 7.01	14 (8.7 - 36.9)

To evaluate the patients preoperatively and post operatively HHS were assessed with a specific question of if there was substantial anterior thigh pain or not. These data were analyzed for statistically significant change in the score between time points and the results are presented in Table 2. The mean HHS was 29.93 with a range of 18 to 41 at pre-operative. However the mean score reached 73.67 (range 70 – 76) at 3 month and 87.13 (range: 73 – 100) at 6 month and 93.2 (range: 76 – 100) at the end of one year. The improvements were statistically significant (P< 0.001) from pre-operative score.

Table 2: Comparison of Harris Hip Score (HHS) at different follow-up with pre-operative

Time of the measurement	Harris Hip Score	P Value$
Pre-Operative	29.93 ± 9.42 (33 ; 18 - 41)	< 0.001 Pre-op Vs Immediate : 0.019 All pairwise <0.001
Immediate	36.33 ± 0.98 (37 ; 35 - 37)	
3 week	40.07 ± 1.28 (40 ; 39 - 42)	
6 week	53.67 ± 4.51 (56 ; 43 - 57)	
3 months	73.67 ± 2.19 (75 ; 70 - 76)	
6 months	87.13 ± 6.75 (88 ; 73 - 100)	
1 year	93.2 ± 6.54 (92 ; 76 - 100)	
Repeated Measure ANOVA, Mean ± standard deviation (median; range), $: Greenhouse-Geisser adjusted		

V. Conclusion

The purpose of the study was to analyze the post-operative radiographic and CT scan features that can predict osteo-integration and the final success of uncemented total hip arthroplasties. Engh et al., [1],[2] found no significant acetabular changes in radiography within two years. In this study also we were not able to find any significant, constant pattern of new bone formation around acetabular component radio graphically and also with CT scan. The earlier study [2] also found the radiographic signs of fixation and stabilities of stem inserted without cement. The lack of reactive lines and presence of spot welds of new bones around the surface can be called as osteointegration. So in our study demonstration of endosteal new bone radiographically(radiodense) and confirming by CT scan one year postoperatively associated with good clinical results (Average Harris hip score of 92) can also be considered major signs of osteointegration.

There was good improvement in pain score, and no anterior thigh pain in cases who had good radiological and CT Scan results. There was also noted that new bone formation with clinical stability was seen in CT compare to plain radio graphically due to sensitivity of modern CT scan machines to cut reflections from metals and can produce better images. Atleast one year follow up is enough for the assessment of uncemented total hip replacement [1]. With all radiographic reviews it was dependent on the observations and interpretations of the reviewers. Clinical assessment correlated with radiographic and CT scan evidences of osteointegration CT scan is better that radiograph is assessing the new bone formation around prosthesis.Since we have done a short term review of clinical and radiographic assessment on uncemented total hip replacement a longer follow up period may show further changes in radiographic and CT scan findings of osteointegration.

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