The Journal of
Maharashtra Orthopaedic Association
March - 2006

Review of Cemented Metal Backed Acetabular Cups : Do They Have A Role ?

Dr. Parag Sancheti *Dr. L. Cochrane*
Dr. W. Hadden *Dr. R. Abboud*

Sancheti Institute for Orthopaedics & Rehabilitation, Pune. E-mail : parag@sanchetihospital.org

Introduction

Harris (1971) introduced the concept of metal-backed cups. He had initially designed it for high density polyethylene acetabular components to allow replacement of an excessively worn out polyethylene liner. It gained more popularity when finite element analysis showed that metal backing of cemented cups improved the stress distribution in the acetabular area.

The aims of the study were to assess the outcomes of cemented metal-backed Exeter cups, compare the results of Exeter metal-backed cups with the Exeter all polyethylene cup and the Ogee cup and to determine the survivorship of acetabular cups.

❖ Methods And Materials ❖

This was a retrospective study. Patients who underwent Total Hip Replacement using the Exeter metal-backed cup (MB), the Exeter all polyethylene cup (EXP) or the Ogee cup (OG), before December 1997 at the Perth Royal Infirmary were selected for the study. All patients were operated on by a single senior orthopaedic surgeon. A total number of 108 cases with complete data were studied. The femoral component used was either an Exeter polished monobloc stem with a sharp angle or a Universal Exeter modular stem with a rounded shoulder. The head size used was 26 mm.

Pre-operative and post-operative radiographs at one year, three years, five years, 10 years and any subsequent follow-up were obtained.

DeLee and Charnley's criteria (1976) were used for radiological assessment of the acetabular cups. Radiographs were screened for demarcation, migration and for impending failure of the cups. Harris Hip scores were recorded for all patients, pre and post-operatively.

Assessment of Acetabular Cup

DeLee and Charnley (1976) described a method of quantifying radiological demarcation of cemented sockets in total hip replacement. The width of the radiolucent zone around the cement was measured on radiographs without correction for magnification. The width was divided into four groups: less than 0.5 mm, 0.5 to1 mm, 1 to 1.5 mm and greater than 1.5 mm. As the width varied at different points the widest diameter was recorded.

In addition to the width of demarcation its distribution around the circumference of the socket was categorised into three types or zones (Figure 1).

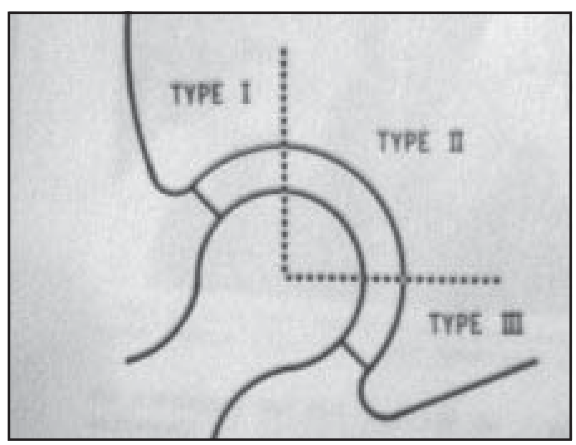

Figure 1 : DeLee and Charnley acetabular zones DeLee and Charnley (1976).

- **Type 1 -** Lateral to a vertical line drawn through the centre of the acetabulum.

- **Type 3 -** Below a horizontal line to run through the centre of the acetabulum.
- **Type 2 -** The remainder.

A New Scoring System For Demarcation

To ease the assessment of demarcation we developed a new scoring system. This scoring system depended upon the width of the demarcation measured in the three types as per the Charnley and DeLee criteria. This scoring system is not a substitute for the DeLee and Charnley criteria but can be considered an adjunct to it.

Points were calculated as per the dimensions of the demarcation. Zero points were given if there was no demarcation, one point was given if demarcation was less than 0.5 mm, two points were given if the demarcation was between 0.5 and 1 mm, three points were given if the demarcation was between 1 to 1.5 mm and four points were given if the demarcation was more than 1.5 mm.

The main benefit of this scoring system was when demarcation extended to two or more zones. If demarcation was seen in two or more zones then the points scored in each zone were added. These points depended on the width of demarcation measured in each zone. After adding the points in each zone a final demarcation score was calculated.

Table 1 : New scoring system.

Zones	Sub Types	Width of Demarcation	Points
Type 1	A	Less Than 0.5 mm	1
	B	Less Than 1.0 mm	2
	C	Less Than 1.5 mm	3
	D	More Than 1.5 mm	4
Type 2	A	Less Than 0.5 mm	1
	B	Less Than 1.0 mm	2
	C	Less Than 1.5 mm	3
	D	More Than 1.5 mm	4
Type 3	A	Less Than 0.5 mm	1
	B	Less Than 1.0 mm	2
	C	Less Than 1.5 mm	3
	D	More Than 1.5 mm	4

Radiological Evaluation

Evaluation of X-rays focused on appearance of demarcation (radiolucency) at the cement bone interface and migration of acetabular component. It was classified using the De Lee and Charnley criteria The demarcation was studied in terms of its location, thickness and progression. Also the demarcation score was calculated as per the new scoring system made by us.

To judge migration the radiographs were assessed for migration of the socket in relation to the bone of the pelvis. Migration less than two mm and tilting less than two degrees were not considered significant (Rockborn and Olsson 1993).

The Harris Hip Score (HHS) described by Harris (1969) enables the status of the hip to be described with a single number in the range 0 - 100. The factors assessed are pain (total score 44), function (total score 47), range of motion (total score 5) and absence of deformity (total score 4). Scores of 90 -100 are considered excellent, 80-90 good, 70-80 fair and less than 70 poor.

Harris hip scores were recorded pre-operatively, at one year, three years, five years and ten years. These scores were available from the Hip database in the orthopaedic department of Perth Royal Infirmary.

For impending failure we used the radiographic criteria described by Dorr et al (1983). They describe impending failure as a radiolucent line at the cement bone interface which is continuous throughout the interface, including around the cement projections into keying holes and is at least two millimetres thick at every point.

We calculated the survivorship in our series using impending failure and revision as the end point. Just using revision as the only end point to assess survivorship could be misleading

❖ Results ❖

A total number of 108 cases were studied retrospectively.There were 61 females and 47 males. 70 cases were unilateral and 38 bilateral giving us a total of 146 hips.There were 79 right hip operations and 67 left hip.

The minimum follow-up was six years and maximum 19 years, with an average of 10.9 years.The age of the patients at the time of surgery ranged from 45 to 92 years, with a mean of 70.7 years.The average stay in the hospital was 13.4 days (range six to fifty four).

Cups Used

The three types of cups used in the study were the metal-backed Exeter cup (MB) (51) all polyethylene Exeter cup (EXP) (40) and Ogee (OG) (55).

Diagnosis

The majority of cases in our study were osteoarthritis. The diagnoses of all patients in the study are listed in Table 2.

Table 2 : Diagnosis

Diagnosis	No. of cases
Osteoarthritis	77
Rheumatoid Arthritis	16
Avascular Necrosis	3
Ankylosing Spondylitis	3
Congenital dislocation of hip	2
Fractures	3
Others	4

Dislocation

Out of the 146 we had dislocation in eight hips. Out of the eight dislocated hips two were Ogee, two were MB and four were Exeter poly cups. Seven of the eight hips had the diagnosis of OA. Out of the eight hips which dislocated, six dislocated only once and did well once they were reduced. None of the hips showed any migration but did show some demarcation.

The remaining two hips dislocated several times. One hip out of these showed migration, which subsequently had to be revised from its original EXP to OG cup and then had no further dislocation. The other hip was of a frail, elderly patient in whom the dislocation was accepted.

Revision

Seven of the 146 hips were revised .Four out of the seven were EXP cups, two were MB and two were OG. Of the seven hips which were revised in all, six were revised to an Ogee cup (Figure 7), and one of the metal-backed cups was revised to an EXP cup. The average HHS was 44.3 in these cases and the final HHS before revision was 65.7. Three hips showed migration and a continuous zone of demarcation. One cup which was alright till 3 years (Figure 8) had migrated and also had severe tilting but showed no demarcation (Figure 9).

Demarcation and Migration

Demarcation was evaluated as per the DeLee and Charnley criteria and accordingly out of a total of 146 hips, demarcation was seen in 59 hips (40.4%). Out of these 59 demarcated hips, 25 were in metal-backed cups. 20 were in Exeter poly cups and 14 were in the Ogee cups. Total absence of demarcation throughout the period of follow-up was seen in 87 hips (59.6%).

Demarcation was seen in 12 hips in the first year (Figure 4 and Figure 6). Out of these 12 only three progressed further. Nine hips had the same radiolucency throughout the period of follow-up.

Demarcation appeared in three hips in the second year, eight in the third year, 14 in the fourth year, 12 in the fifth year and the remaining ten in the subsequent years (six to nine).

The average demarcation score as per the new scoring system evolved by us was 3.79 (range 0 to 8).The demarcation score was significantly lower in the OG cups (P=0.05).

The average follow-up for OG cups was 8.1 years, MB cups 13.1 years and EXP cups 11.6 years. Since the minimum follow-up was six years for all

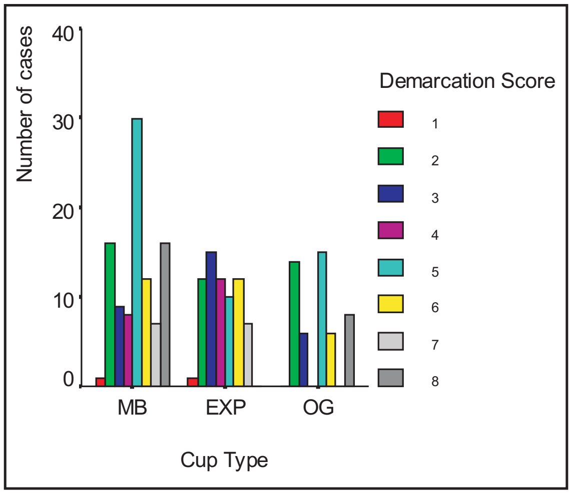

Figure 2 : Demarcation score in different cup types.

the cups, we looked at the demarcation score at five years, which was the minimum period common to all. The mean demarcation score at five years was 3.0. We had a score of 2.1 in OG cups, 4.1 in MB cups and 2.8 in EXP cups. The demarcation score at five years was significantly higher in MB cups ($P = 0.03$) than OG and EXP cups. The risk of demarcation was higher in MB (49%) and EXP (50%) as compared to the OG cups (25%).

Impending failure as per the criteria described by Dorr et al (1983) was seen in 17 of the 59 cases which showed demarcation.The risk of demarcation was higher in RA (48%) than OA (40%). However this was not statistically significant. The average age of the patients with demarcation was 58.3 years which was 12.4 years lower than the overall average age.

Table 3 : Status of cup types.

Cup Type	Demar-cation	Migr-ation	Impending failure	Revision
EXP	20	2	4	4
OG	14	2	2	1
MB	25	7	11	2

Migration (Figure 5) was seen in 11 hips

Harris Hip Score

Table 4 : HHS (1 year, 3 years, 5 years, 10 years) in different cup types.

Cup Type	Pre-op HHS	One Year	Three Year	Five Year	Ten Year
MB	43	90	87	85	82
EXP	46	86	85	83	80
OG	51	93	90	80	---

The average pre-operative HHS was 45.6. At one year it was 90.1. At three years it was 88.6. At five years the average HHS was 85.3 and ten years it was 81.9.

It was seen that the HHS in terms of the Hip score was maintained throughout the initial five years and fell by 4% in the tenth year. However, the function score in the HHS was low to start with (82.7). It fell by 8% by the end of the fifth year and 12% by the end of the tenth year (Figure 3). There is a reduction in the Function part of the HHS as compared to the Hip score part. The OG cup had the highest pain and function HHS score as compared to the MB and EXP cups.

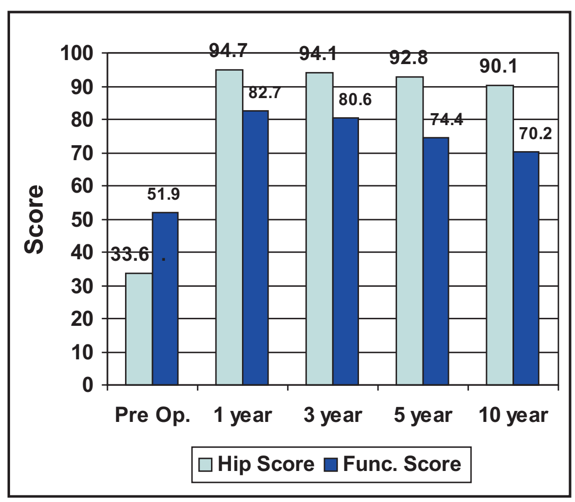

Figure 3 : Comparison of Hip score and Function score.

Survival Analysis :

Table 5 : Survival Analysis.

Cup Type	Years Since Operation	No. at Start	Impending Failure	Revision	Failure Rate	Prosthesis Survival Rate %
	5	51	2	---	4.0	96.0
MB	9	51	4	1	9.9	90.1
	15	41	5	1	14.7	85.3
	5	40	1	1	5.0	95.0
EXP	9	40	1	2	7.5	92.5
	15	28	2	1	10.8	89.2
OG	5	55	1	---	1.9	98.1
	9	55	1	1	3.7	96.3

❖ Discussion ❖

Problems with acetabular component loosening and failure after cemented total hip replacement have led to the development of newer designs and biomaterials. The ultimate aim of these developments is to improve the longevity of the cups. Metal backing was added to acetabular cups with the hope of doing so. However, studies reporting high failure rates of cemented metal-backed cups have questioned their use.

We established various significant findings in our study. In our series the overall mean demarcation was least in Ogee cups (P = 0.01). The risk of migration was significantly higher (P = < 0.001) in the metal-backed cups than in either the EXP or OG cups. Overall demarcation scores were least in Ogee cups (P = 0.05) and comparable in the metal-backed and Exeter all poly cups. The risk of demarcation was lower in Ogee cups (25%) than in metal-backed (cups 45%) and Exeter all poly (50%). There were no differences in demarcation in the unilateral and bilateral procedures.

We developed a new scoring system to assess the demarcations in the acetabular area. This scoring system was based on the DeLee and Charnley criteria, DeLee and Charnley (1976) which describes three areas in the acetabulum for observing demarcation. They further divided the demarcation into four groups depending on the width of the demarcation: (a) less than 0.5 mm, (b) less than 1.0 mm, (c) less than 1.5 mm and (d) more than 1.5 mm. If the demarcation was in more than one zone it became difficult to interpret. To make the interpretation easier we complimented the DeLee and Charnley criteria by developing a new scoring system for assessing demarcation (details mentioned in chapter 3). This proved to be a reliable way of recording demarcation.

The clinical efficacy of metal backed components also has been called into question. Ritter *et al* (1990) reported accelerated rates of failure of metal-backed components when compared with all polyethylene components. They had a 6 % revision rate, 4 % failure rate, 39 % incidence of radiolucency in 138 cups at an average follow-up of 5.2 years. In our series we had a 4 % revision rate, 21 % failure rate and 49 % incidence of radiolucency at an average follow up of 10.9 years. Results of survivor analysis in our study using component revision and impending failure as endpoints showed 85 % survivorship at nine years in MB cups as compared to 98 % in OG cups and 89 % in EXP cups.

Our study does have its limitations. The high incidence of fixation failure observed in this series may be attributed to other factors such as cup placement, primary femoral stem loosening causing secondary loosening of the acetabular cup, femoral head size and offset. Acetabular cup placement does play a role in cup loosening. Ritter (1995) showed that a more vertical cup placement (> 45 degrees) causes increase in compression forces predisposing to implant failure. Cates et *al* (1993) reported increased incidence of cup revision when a larger head size of 32 mm was used The larger head size resulted in reduced thickness of polyethylene causing early wear. The head size used in our study was 26 mm. We also have not looked at the polyethylene wear rates due to technical difficulties. It has been shown that metal backing of acetabular component has resulted in increased polyethylene wear. Cates *et al* (1993) reported a 37 % increase in polyethylene wear rates for metal-backed cups as compared to all polyethylene cups at six years. This again was attributed to reduced thickness of polyethylene due to the use of metal backing. These issues of polyethylene wear, head size and cup placement are of value but it was beyond the scope of this study to address them however the literature quoted does show their relevance.

Though various authors have shown that metal-backed cups have not resulted in improved clinical outcomes or component longevity, the explanation for the failure of metal backed cups has not been pin pointed. It is a fact that polyethylene thickness is reduced by the metal backing. Though metal backing reduces the bone and cement stresses, the stresses within the polyethylene are actually increased by metal backing. Thus a combination of a less thick polyethylene and increased stresses within them causes early wear and subsequent failure. This could be a reasonable way to explain the poor results of cemented metal backed cups.

To summarize, the theoretical mechanical advantages of metal backed cups have not been supported by the clinical results. The results of our study confirm the suspected trend of increasing failure rates of these components over time. Our study and also other comparable studies have emphatically shown that metal backing of acetabular components have not improved overall implant longevity. Based on our findings, it is evident that the use of metal backed cups does not offer any added advantage. Thus we do not recommend the use cemented metal backed acetabular components because of the lack of evidence of improved implant longevity and clinical benefits as compared to the Ogee cup and the Exeter all polyethylene cup.

❖ Conclusion ❖

It has been well documented that in cemented total hip replacement failure, of fixation of acetabular component is a major problem. Most often the cause is aseptic loosening. Harris popularized metal-backing of high density polyethylene acetabular components in the hope of providing a solution to this problem.

By finite element analysis, the stress distribution in the acetabulum has been extensively studied. Most authors concluded that the introduction of cemented acetabular components of high density polyethylene results in disturbance of stress distribution. The peak stresses after THA occur in the cement, cancellous bone superior to the cup and medial wall of the ilium. It was proposed that a way to reduce the peak stress in these critical areas was to stiffen the acetabular cup by using a metal backing. Thus, based on this proposition metal-backed cups came into clinical use. Initial studies did show favourable results and were encouraging. However, long term studies with the metal-backed cups did not reproduce the initial results and were not as encouraging.

Our present study shows that use of metal-backed cups in cemented total hip replacement did not offer any special advantage. Metal backing of the cups did not reduce the incidence of demarcation or migration. In fact, in our series, cups without metal backing showed less demarcation and migration. Our work correlates well with other published data, which have also shown failure of cemented metal-backed cups.

In conclusion we feel the use of metal backing in cemented cups have not proved to be a reliable way to increase the longevity of the cemented acetabular cup and thus we do not recommend its use. Whether metal backing has any role to play in uncemented cups is a separate issue.

It is clear that long term survival of an implant is not dependant on a single factor such as metal backing. Other factors such as implant design, cement properties, cementing techniques, instrumentation, operating room environment and surgical expertise are probably equally important.

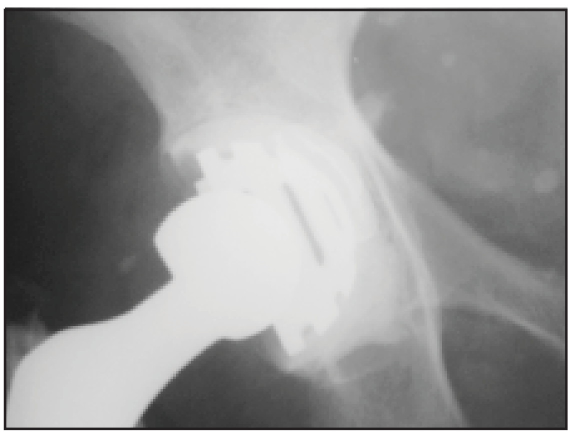

Figure 4 : X-ray of a metal-backed cup showing early demarcation.

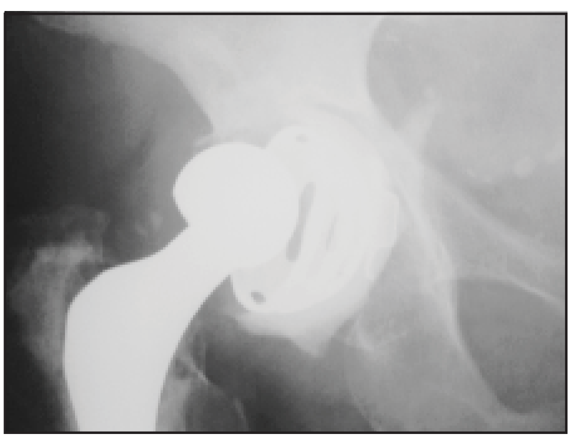

Figure 5 : X-ray showing cup migration.

Figure 6 : X-ray of all polyethylene cup showing demarcation in all three zones

Figure 7 : Revision done using Ogee cup.

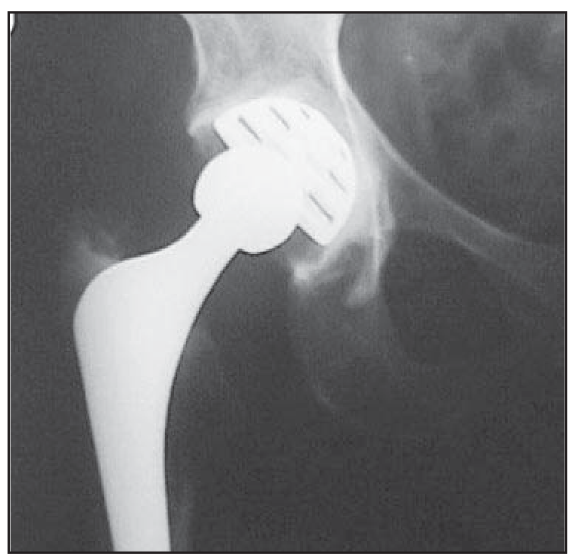

Figure 8 : X-ray of metal backed cup at three years post operative.

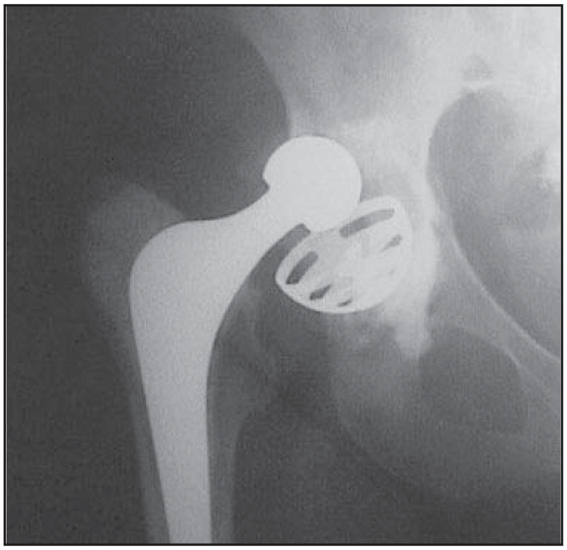

Figure 9 : X-ray of the same patient showing slipping of the cup within an intact cement mantle.

References

1. **Carter DR, Vasu R, Harris WH.** Stress distribution in the acetabular region 2. Effects of cement thickness and metal backing of total hip acetabular component. J. Biomechanics; 15: 165-70, 1982.

2. **Carter DR.** Finite-element analysis of a metal-backed acetabular component. The Hip; Proceedings of the Eleventh Open Scientific Meeting of the Hip Society: 216-28, St Louis, Mosby 1983.

3. **Cates HE, Faris PM, Keating EM, Ritter MA.** Polyethylene wear in cemented metal-backed acetabular cups. J. Bone Joint Surg; 75-B(2): 249-53, 1993.

4. **Charnley J.** Low friction Arthroplasty of the Hip. Springer-Verlag, New York, 1979.

5. **Crowninshield RD, Pedersen DR, Brand RA, Johnston RC.** Analytical support for acetabular metal backing. The Hip; Proceedings of the Eleventh Open Scientific Meeting of the Hip Society: 207-15, St Louis, Mosby 1983.

6. **Dalstra M, Huskies R.** The influence of metal backing in cemented cups. Orthop. Trans; 16: 272-75, 1991.

7. **DeLee JG, Charnley J.** Radiological Demarcations of Cemented Sockets in Total Hip Replacement. Clin Orthop; 121: 20-32, 1976.

8. **Dorr LD, Takei GK, Conaty JP.** Total hip Arthoplasties in patients less than forty-five years old. J. Bone Joint Surg; 65-A(4): 474-79, 1983.

9. **Fehring TK, Hurley PT, Braun ER.** Modular acetabular components: are they really metal backed. Orthop Trans; 16: 46-51, 1992.

10. **Fowler JL, Gie GA, Lee AJC, Ling RSM.** Experience with the Exeter Total Hip Replacement since 1970. Orthop Clinic North Am; 19(3): 477-489, 1988.

11. **Harris WH, Penenberg BL.** Further follow-up on socket fixation using a metal-backed acetabular component for Total Hip Replacement. J. Bone Joint Surg; 69-A(8): 1140-43, 1987.

12. **Harris WH, White RE**. Socket fixation using a metal-backed acetabular component for Total Hip Replacement. J. Bone Joint Surg; 64-A(5): 745-48, 1982.

13. **Harris WH**. A new total hip implant. Clin Orthop; 81: 105-13, 1971.

14. **Markel DC, Hua MH, Kalkin PD, Salvati EA.** Use of cemented all polyethylene and metal-backed acetabular components in total hip arthroplasty-A comparative study. J. Arthroplasty; 10 (Suppl): S1-7, 1995.

15. **Mattingly DA, Hopson CN, Kahn A, Giannestras NJ**. Aseptic loosening in metal-backed acetabular components for Total Hip Replacement. J. Bone Joint Surg; 67-A(3): 387-91, 1985.

16. **Mulroy WF, Estok DM, Harris WH.** Total hip arthroplasty with use of so-called second generation cementing techniques. J. Bone Joint Surg; 77-A: 1845-89, 1995.

17. **Raut VV, Siney PD, Wroblewski BM.** Survivorship analyses of revised cemented sockets: a study of potential risk factors. J. Orthopaedic Rheumatology; 9: 78-81, 1996.

18. **Ritter MA.** The cemented acetabular component of a total hip replacement: all polyethylene versus metal backing. Clin. Orthop; 311: 69 -74, 1995.

19. **Ritter MA, Keating EM, Faris PM, Brugo G**. Metal-backed acetabular cups in Total Hip Arthoplasty. J. Bone Joint Surg; 72-A: 672-77, 1990.

20. **Rockborn P, Olsson SS.** Loosening and bone resorption in Exeter hip arthroplasties. J. Bone joint Surg; 75-B(6): 865 -68, 1993.

21. **Schulte KR, Callaghan JJ, Kelley SS, Johnston RC.** The outcome of Charnley total hip arthroplasty with cement after a minimum twenty year follow up: the results of one surgeon. J. Bone Joint Surg; 75-A: 961-66, 1993.

22. **Williams HDW, Browne G, Gie GA, Ling RSM, Timperly AJ, Wendover NA**. The Exeter universal cemented femoral component at 8 to12 years. J. Bone Joint Surg; 84-B(3): 324-34, 2002.