consistent good results. Literature review has shown a paucity of Level 1 studies in this regard and more Randomised controlled trials are to be called for. As of this day there is no evidence to demonstrate a clear advantage of use of one over the other.

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Key words: Modular; Monoblock; Cementless; Primary; Acetabulum


INTRODUCTION

Despite improved cementing techniques, a major shift towards use of cementless acetabular cups has been noted. Loosening of the components has been a major cause of failure in the long-term survival of implants in hip arthroplasty. To enhance the biological fixation of these implants, most cementless acetabular components have various porous coatings of cobalt-chrome or titanium beads and the diffusion bonding of titanium. Modular cups offer the advantage of use of offset/constrained liners, option of liner revision and ease to judge the depth of cup insertion. The downside of these first and some second generation modular cups was pelvic osteolysis seen around these cementless cup design which was attributed to the polyethylene wear debris resulting from the micromotion between the nonarticulating side of the polyethylene liner and the interior of the metallic shell (backside wear). Monoblock cups came into use to mainly address wear issues. The flip side was that there was no room for error in the final cup implantation, and also extensive revision surgery was needed for an isolated liner wear. With the advent of third generation modular cups showing drastic reduction in the wear debris generated, survivorship of modern day monoblock and modular cups are impressive.
Review of designs

**Modular cups:** Porous coated cementless acetabular components, that promoted bony ingrowth were first introduced in response to loosening of cemented acetabular components. Contrary to belief, high incidence of failure was noted in the first generation modular cups. The most common reasons of failure were due to early wear of UHMWPE and liner dissociation issues[3]. Incogruity between liner and shell and primitive locking mechanisms were reasons cited for liner dissociation.

The second generation cups in the early 2000s made design changes in providing a more congruous surface preventing liner dissociation but problems of backside wear persisted.

The introduction of highly crosslinked polyethylene allowed for larger diameter femoral heads to be introduced to add stability. Although cross linking decreased wear, the mechanical properties also decreased. The concept of large diameter heads was introduced to increase range of motion without impingement and also reduce dislocation, but this required the use of a thinner liner. To provide dome support liner were made thicker at the centre and thinner at the periphery. This caused liner fractures.

Present third generation modular cups have improved liner locking mechanisms by receding them into the shell and also reduced incidence of liner fractures by containing the liner within the rim of the shell.

Periprosthetic osteolysis and aseptic loosening of implants are important factors accounting for long term survivorship of hip arthroplasty. Even with newer cementing techniques, long term studies have shown the revision rates for acetabular component to be approximately 10 to 15 percent and rates of loosening of the acetabular component of approximately 20 to 40 percent at fifteen to twenty years from the index procedure[3].

**Monoblock cups:** Monoblock cups consist of a metallic shell with compressed molded liner within. Most of the shells are made of titanium and cobalt-chromium alloys. The external porous surface of these metal shells stimulates bone ingrowth into the shells, which ensures long-term biological fixation of the implant. Different techniques like plasma sprays, microporous surfaces and metallic fibre meshes are used to process the external surface of the shell to promote bony ingrowth. This has the advantage of eliminating debris from the interface between the metallic shell and the polyethylene liner (backside wear). The latest designs incorporate a tantalum or trabecular metal shell that is highly porous structure. Its overall geometry is similar to that of trabecular bone. The combination of the large porous surface of tantalum and its elasticity allows for a larger bone penetration volume, which results in a faster biologic ingrowth. The hemiellipsoid configuration helps to obtain rim fit in conjuncton with highly crosslinked polyethylene. Options to use screws at the periphery of the cup exist to enhance stability whenever deemed necessary.

### PROS AND CONS OF MODULAR CUPS

1. **Customization like variability of femoral head size to maximixe PE thickness.**
2. **Availability of lipped liners to reduce the incidence of dislocation.**
3. **Use of adjunctive fixation like screws/pegs.**
4. **Easier revision options of liner replacement only in case of wear and dislocation.**
5. **Introduction of UHMWPE/XLPE/Vit E poly have led to dramatic reduction in the wear rates.**

### DISADVANTAGES

1. **Backside wear-Minimised by highly polished inner metallic surfaces[3].**
2. **Failure of locking mechanism particularly in highly crosslinked polyethylene[3].**

### OFFSET LINERS IN MODULAR CUPS

**ADVANTAGES:**

1. Offset, face-changing polyethylene liners theoretically increase head coverage, allow for larger heads at smaller cup diameters, and offer improved stability.
2. The surgeon can use the face-change to adjust the position of the liner within the shell to correct for a sub-optimally positioned cup.

**DISADVANTAGES – Impingement, Liner dissociation**

**CONTRAINDICATIONS**

1. **Lack of modularity in liner necessitating precise cup placement.**
2. **Revision for isolated liner exchange for wear not possible.**
3. **Difficult to judge bottoming out of the cup.**

## MATERIALS AND METHODS

We conducted a search on Pubmed, Medline and Cochrane database by inclusion of words as cementless/acetabular cups/modular/ monoblock/various names of available cups in different combinations to maximize our search. We enlisted Randomised Controlled trials (Level I/II evidence)/Retrospective comparative study, (Level III evidence) and case series (Level IV evidence) Modular and Monoblock cups over the past 15 years from Jan 1998 to May 2013 in English literature. Since Level II and level III studies were of significantly large number only studies with more than 100 patients recruited and a minimum followup of 10 years were included.

**Inclusion criteria**

**RCT/Prospective studies:** Modular cups: Level II/III/IV studies - More than 100 patients with minimum followup of 10 years with atleast 3 of 6 criterion being included (cup revision, aseptic
loosening, osteolysis, migration, liner wear, survivorship). Monoblock cups: Level II/III/IV studies- More than 100 patients with minimum followup of 10 years with at least 3 of 6 criterion included (cup revision, aseptic loosening, osteolysis, migration, liner wear, survivorship).

**Exclusion criteria**

Studies other than that in humans Lab/Biomechanical studies

Our search yielded total of 124 publications. Titles and abstracts of all publications were screened for inclusion criteria, following which 41 publications were considered eligible. After applying our exclusion criteria, a total of 29 publications (18 Case series modular cups, 7 case series monoblock cups, 3 Comparative studies and 1 RCT) persisted.

**DISCUSSION**

**Literature review on Survivorship of modular cups**

Porous coated hemispherical cup designs have been largely used. Harris Galante (HG) I and II are one such types with sintered titanium fiber mesh at bone implant interface and holes for transacetal screw. The capture mechanism in the type II design was modified from the HG I cup to increase the number and length of the locking tines. Clohisy and Harris et al.[10] showed excellent results with 99% survivorship at 10 years followup. Garcia Rey et al.[13] showed > 95% survivorship with both the HG type I and II designs at 10 years followup.

Engh et al.[17] reported their 15 year survivorship of 4,289 primary total hip arthroplasties performed using hemispheric porous-coated cups. Initial fixation was achieved with spikes (255 AML TriSpike cups), by press-fitting with rim screws (427 Arthropor cups) or by press-fitting the component (83 Harris-Galante, 391 ACS Triloc+, 2,537 Duraloc, and 596 Pinnacle cups). Of 203 revised hips, only 18 cups were found to be loose at the time of revision. Using revision as an end point, 15-year survivorship was 82.9% +/- 0.17 mm/year at an average follow-up of 12 years. In all cases, a modular 32-mm femoral head made of ceramic was used. Cruz-Pardos and Garcia-Cimbelo[24] reported the high wear rate of 0.17 mm/year at an average follow-up of 13 years.

Table 1 Modular cup series over past 15 years (Minimum 100 pts with mean 10 year followup).

**Literature review on Survivorship of monoblock cups**

Poultsides et al.[25] described 258 primary total hip arthroplasties (212 patients) with a monoblock, acetabular component who were followed up for a mean period of 11.1 years (10-15). Average yearly wear rate was 0.08 mm/year. Acetabular radiolucencies were present in 6 hips (2.4%); all were nonprogressive and present in acetabular zone I. Acetabular osteolysis was present in 5 patients (1.9%); all cups were stable. Four acetabular components were revised, 3 because of recurrent instability. No acetabular components were revised for polyethylene wear or dissociation, acetabular osteolysis, loosening, or deep infection. They concluded that this design yielded excellent long term results.

Garavaglia et al.[29] reported excellent results in their series of 357 THAs with a porous coated monoblock cup (Morscher cup) without screw fixation. None of the patients had required cup revision for aseptic loosening. At ten years, the cup survivorship was 98.8% (95% CI 97.4-99.5) with cup revision for any cause as an endpoint. No radiolucencies or osteolysis were seen around the cups. Mean total linear polyethylene wear was 0.9 mm.

Berli et al.[31] reviewed reviewed 261 patients who received the first 280 Morscher Press-Fit Cups with a 15 year followup. They termed their results excellent or good in 96% of the hips. The 15-year overall survivorship was 95.3% and with the end point of aseptic loosening, the survivorship was 97.5%. They concluded that the wear was greater in cups with an inclination greater than 45 degrees and in metal on polyethylene compared with ceramic-polyethylene bearings.

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Table 2 Monoblock cup series over past 15 years (Minimum 100 pts with mean 10 year followup).

**Comparative studies and Randomised Controlled trials of monoblock versus Modular cups**

Yong et al.[32] compared 41 hips treated with a nonmodular, porous-
Table 1: Modular cup studies Minimum Follow up 10 yrs with 100 cases at enrolment (Level of Evidence II/III/IV).

<table>
<thead>
<tr>
<th>Study/Year</th>
<th>Cup</th>
<th>Number Recruited/ No at followup</th>
<th>Mean follow up (years)</th>
<th>Cups revised</th>
<th>Aseptic loosening</th>
<th>Isolated Liner exchange</th>
<th>Wear mm/yr</th>
<th>Osteolysis</th>
<th>Migration</th>
<th>Survivorship(%) Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traptosis et al 2009</td>
<td>HA threaded cup</td>
<td>204/198</td>
<td>10.2</td>
<td>3</td>
<td>0</td>
<td>-</td>
<td>0.15</td>
<td>0</td>
<td>0</td>
<td>97.05</td>
</tr>
<tr>
<td>Gaffey et al 2004</td>
<td>HG 1</td>
<td>120/72</td>
<td>13-15</td>
<td>0</td>
<td>0</td>
<td>0.17</td>
<td>32(42.5%)</td>
<td>0</td>
<td>0</td>
<td>81% Wear rate higher than the Charnley cemented cups.</td>
</tr>
<tr>
<td>Ye et al 2012</td>
<td>Reflection</td>
<td>363</td>
<td>11.6</td>
<td>4</td>
<td>2</td>
<td>8.8%</td>
<td>32(42.5%)</td>
<td>0</td>
<td>0</td>
<td>99.4</td>
</tr>
<tr>
<td>Bidar et al 2012</td>
<td>ABG 1</td>
<td>111/78</td>
<td>13</td>
<td>32</td>
<td>0</td>
<td>-</td>
<td>0.17</td>
<td>9(5%)</td>
<td>0</td>
<td>83.2% High frequency of osteolysis.</td>
</tr>
<tr>
<td>Zweymuller et al 2007</td>
<td>Throded double cone cup</td>
<td>376/232</td>
<td>10.3</td>
<td>2</td>
<td>3</td>
<td>0.13</td>
<td>1</td>
<td>1</td>
<td>-</td>
<td>99.3%</td>
</tr>
<tr>
<td>Reikeras et al 2006</td>
<td>HA hemispherical Coated cup</td>
<td>195</td>
<td>13</td>
<td>Threaded</td>
<td>9</td>
<td>-</td>
<td>0.59</td>
<td>2</td>
<td>3</td>
<td>Threaded 0.91 at 15 yrs</td>
</tr>
<tr>
<td>Engh et al 2004</td>
<td>Spike</td>
<td>435</td>
<td>15</td>
<td>17</td>
<td>11</td>
<td>23</td>
<td>-</td>
<td>9</td>
<td>-</td>
<td>82.9 spike</td>
</tr>
<tr>
<td>Epinette et al 2005</td>
<td>Threaded HA Arc2f</td>
<td>418/304</td>
<td>10</td>
<td>4</td>
<td>2</td>
<td>0.17</td>
<td>69</td>
<td>8</td>
<td>8</td>
<td>71.6 Rimscrew</td>
</tr>
<tr>
<td>Weber et al 2000</td>
<td>Porous HA Optifix cup</td>
<td>198/127</td>
<td>10.6</td>
<td>3</td>
<td>3</td>
<td>-</td>
<td>0.13</td>
<td>2</td>
<td>5</td>
<td>72% pressfit</td>
</tr>
<tr>
<td>Clarius et al 2010</td>
<td>Morning Throded cups</td>
<td>221/84</td>
<td>17</td>
<td>91 (41%)</td>
<td>84 (38%)</td>
<td>23</td>
<td>1</td>
<td>9</td>
<td>-</td>
<td>Porous cups show excellent fixation.</td>
</tr>
<tr>
<td>Aldinger et al 2004</td>
<td>Throded cups</td>
<td>221</td>
<td>12.4</td>
<td>76</td>
<td>69</td>
<td>-</td>
<td>23 Mecring</td>
<td>55</td>
<td>-</td>
<td>98% similar to other designs.</td>
</tr>
<tr>
<td>Demmelmayr et al 2010</td>
<td>Wagner</td>
<td>118/102</td>
<td>12</td>
<td>2</td>
<td>2</td>
<td>-</td>
<td>0</td>
<td>-</td>
<td>0</td>
<td>93.1% Very good long term results.</td>
</tr>
<tr>
<td>Garcia Rey et al 2008</td>
<td>HG I HG II</td>
<td>176</td>
<td>10</td>
<td>5 HG I HG I</td>
<td>4 HG I HG I</td>
<td>4 HG I HG I</td>
<td>5 HG I HG I</td>
<td>96.9 HG I</td>
<td>-</td>
<td>98.3 HG II Stable fixation</td>
</tr>
<tr>
<td>Sanz Reig et al 2011</td>
<td>Perfecta</td>
<td>168</td>
<td>14</td>
<td>16</td>
<td>3</td>
<td>0.21</td>
<td>10</td>
<td>-</td>
<td>0</td>
<td>91.1% Most problems due to cup</td>
</tr>
<tr>
<td>Grubl et al 2002</td>
<td>Throded cup</td>
<td>208/133</td>
<td>10.7</td>
<td>7</td>
<td>5</td>
<td>2</td>
<td>0.1</td>
<td>0</td>
<td>1</td>
<td>0.93 Threaded cup prone to aseptic loosening</td>
</tr>
<tr>
<td>Hamilton et al 2007</td>
<td>Arthropor ACS Triloc+ HG II</td>
<td>433</td>
<td>15</td>
<td>168</td>
<td>20</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>89.3% HG II</td>
</tr>
</tbody>
</table>
Table 2

Monoblock cup studies (Level II/III/IV Evidence) minimum 100 pts with minimum mean followup of 10 years.

<table>
<thead>
<tr>
<th>Study/Year</th>
<th>Number Recruited/ No at followup</th>
<th>Mean follow up (years)</th>
<th>Cup</th>
<th>Aseptic Losing</th>
<th>Wear (mm/yr)</th>
<th>Osteolysis</th>
<th>Migration</th>
<th>Survivorship (%)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poultsides 2012</td>
<td>4/0</td>
<td>11.1</td>
<td>Aseptic Liner</td>
<td>0</td>
<td>0.08</td>
<td>0</td>
<td>Excellent long term survival.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Garavaglia et al 2011</td>
<td>5/10</td>
<td>5.65</td>
<td>Aseptic Liner</td>
<td>0</td>
<td>0.9</td>
<td>NA</td>
<td>Excellent long term survival results.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Udomkiat et al 2002</td>
<td>132/110</td>
<td>1</td>
<td>Aseptic Liner</td>
<td>0</td>
<td>0.11</td>
<td>0</td>
<td>96.8% Excellent long term results.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Berli B J</td>
<td>3</td>
<td>2</td>
<td>Aseptic Liner</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>97.9% Excellent long term results.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gwynne et al 2009</td>
<td>125</td>
<td>5</td>
<td>Aseptic Liner</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>96.8% Excellent long term results.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3

Studies comparing monoblock and modular cups.

<table>
<thead>
<tr>
<th>Study/Year</th>
<th>Number Recruited/ No at followup</th>
<th>Mean follow up (years)</th>
<th>Cup</th>
<th>Aseptic Losing</th>
<th>Wear (mm/yr)</th>
<th>Osteolysis</th>
<th>Migration</th>
<th>Survivorship (%)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gonzalez 2004</td>
<td>129</td>
<td>5.65</td>
<td>Trilogy</td>
<td>0</td>
<td>0.08</td>
<td>0</td>
<td>No difference in the two-cups</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paired study</td>
<td>30</td>
<td>5.65</td>
<td>Trilogy</td>
<td>0</td>
<td>0.08</td>
<td>0</td>
<td>No difference in the two-cups</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trabecular Metal</td>
<td>60</td>
<td>0</td>
<td>Trilogy cup (Zimmer)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>Monoblock-0.08 to -0.26</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weis 2012</td>
<td>21</td>
<td>11.1M</td>
<td>Trilogy</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>Modular-0.13 to -0.33</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Practice Perspective</td>
<td>13</td>
<td>1</td>
<td>Trilogy</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>Monoblock-0.13 to -0.33</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Young 2002</td>
<td>41</td>
<td>3</td>
<td>One piece cup</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.11 Monoblock-2% Modular</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paired study</td>
<td>41</td>
<td>3</td>
<td>One piece cup</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.11 Monoblock-2% Modular</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Halma et al 2003</td>
<td>132/110</td>
<td>1</td>
<td>Monoblock</td>
<td>0</td>
<td>0.11</td>
<td>0</td>
<td>96.8% Excellent long term results.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Halma et al 2003</td>
<td>132/110</td>
<td>1</td>
<td>Monoblock</td>
<td>0</td>
<td>0.11</td>
<td>0</td>
<td>96.8% Excellent long term results.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Halma et al 2003</td>
<td>132/110</td>
<td>1</td>
<td>Monoblock</td>
<td>0</td>
<td>0.11</td>
<td>0</td>
<td>96.8% Excellent long term results.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

CONCLUSION

Both Modular and monoblock cementless cups have distinct features to support their use. While modular cups offer the advantage of an array of choices with respect to liners and their positioning and the ease of revision for wear, monoblock cups are said to have shown less osteolysis and polyethylene wear compared to their modular counterparts. The use of monoblock cups have seen a rise in the recent past. Newer generation modular cups liner have significantly reduced dissociation and rim fracture and highly cross linked polyethylene has proven to decrease wear. The short term and medium term results of monoblock cups have been impressive and coated acetabular component with a matched group of 41 hips treated with a modular acetabular component at mean 5.3 year followup with regards to effect of acetabular modularity on polyethylene wear and osteolysis. The nonmodular acetabular components demonstrated a lower, but not a significantly lower, mean true wear rate than did the modular components (0.11 compared with 0.16 mm/yr, p=0.22) and also a significantly lower rate of osteolysis (2% compared with 22%, p=0.01). They attributed the lower and more consistent true wear rates of the nonmodular components to the fact that they have greater liner-shell conformity, greater liner thickness, and less liner-shell micromotion than modular components.

Weiss et al reviewed 210 primary total hip arthroplasty (THA) procedures in the Swedish Hip Arthroplasty Register that used uncemented monoblock cups during the period 1999-2010 with 1,130 modular cups performed at the same time. The cumulative 5-year survival with any revision as the endpoint was 95% for monoblock cups and 97% for modular cups (p=0.6). They inferred that there was no statistically significant difference in revision risk between the cup designs.

Baad Hansen et al conducted a RCT on 60 patients who underwent THA for noninflammatory arthritis (30 tantalum monoblock vs 30 Trilogy modular cup) with 2 year follow up. Radiostereometric analysis (RSA) showed no statistically significant difference between the cup types with regard to translation. However, less rotation along the transverse axis was seen in the trabecular metal cups than in the modular cups. The degree of periprosthetic bone loss was similar between the cup types in any of the regions of interest at 2 years of follow-up. They concluded that short term results regarding the fixation of monoblock cups to the acetabular host bone are favourable.

Gonzalez DV et al conducted a matched pair study comparing wear and periprosthetic osteolysis in Sixty-three patients (65 hips) with a modular cup (Trilogy) and 64 patients (65 hips) with a monoblock cup (Impex) with an average followup of 5.65 years. The average total wear in the Trilogy group was 0.47 mm for the monoblock cup (Impex) with an average followup of 5.65 years.

The degree of periprosthetic bone loss was similar between the cup types in any of the regions of interest at 2 years of follow-up. They concluded that short term results regarding the fixation of monoblock cups to the acetabular host bone are favourable.

Gonzalez DV et al conducted a systematic search in the Medline, Embase, and Cochrane electronic databases to collect controlled trials comparing monoblock with modular uncemented acetabular components in primary THA and listed 7 studies that met inclusion criteria. Evidence analysis showed no difference in polyethylene wear rate, acetabular osteolysis, frequency of cup migration, and aseptic loosening between monoblock and modular acetabular components.
long term results are awaited. Although few studies have shown that they have an advantage over modular cups in term of osteolysis and wear larger RCT’s and database studies have failed to demonstrate a clear advantage. As of this date both forms have shown good results and multicentric trials are called for to demonstrate the clear advantage of the use of one over the other.

CONFLICT OF INTERESTS

There are no conflicts of interest with regard to the present study.

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