ORIGINAL ARTICLE

Fixed versus mobile bearing unicompartmental knee replacement: A meta-analysis

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KEYWORDS
Unicompartmental knee replacement; Fixed; Mobile; Bearing; Meta-analysis

Summary This systematic review compares the clinical, radiological and kinematic outcomes of fixed compared to mobile bearing unicompartmental knee replacements (UKRs). A meta-analysis of pooled mean difference and relative risk data was undertaken following a review of electronic databases. Five studies were identified. Analysis suggested that there was no significant difference in clinical outcome or complication rate between mobile and fixed bearing UKR. However, the evidence reviewed presented with a number of methodological limitations. Areas for further study are recommended.

Level of evidence: Level I.

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Introduction

When first introduced, the unicompartmental knee replacement (UKR) had poor clinical outcomes with a corresponding high failure rate [1–4]. With the improvements in implant design, surgical techniques and appropriate patient selection, the UKR is increasingly accepted as a reliable procedure for the management of patients with unicompartmental osteoarthritis of the knee [5–11].

There remains controversy over whether there is a clinical difference between fixed or mobile bearing UKR.

Advocates of the mobile bearing UKR have suggested that this offers patients increased survivorship compared to fixed bearing prostheses, with meniscal bearings advocated as reducing the surface and subsurface contact stresses by offering a higher degree of conformity between articular surfaces [6,12–14]. Mobile bearing knees may replicate tibiofemoral biomechanics better than fixed bearing prostheses to permit more natural joint mechanics for this younger, higher demand patient group [15]. Furthermore, in lateral UKR designs, the lateral femoral condyle rolls back with flexion creating greater shear forces on the lateral tibial polyethylene component compared to medial compartment prostheses [16,17]. Surgeons have suggested that the mobile bearing device is technically more difficult to implant, most notably in respect to precise alignment and ligament balancing. If incorrect, this may lead to bearing
dislocation or impingement, causing increased wear [15,18]. Proponents of fixed bearing devices argue that they provide similar satisfactory outcomes, with reduced complication rates.

The purpose of this study was to review systematically the evidence base to compare the clinical, radiological and kinematic outcomes of fixed versus mobile bearing UKRs.

Methods

Eligibility criteria

All randomised and non-randomised clinical trials (RCT, nRCT) comparing fixed to mobile bearing UKR were included. This strategy was non-specific with regards to joint prosthesis type, subject age, gender or rationale for surgery. Both medial and lateral UKRs were included. The search was not limited by language. Single case reports, comments, editorials, protocols, guidelines, and review papers were excluded. Publications presenting the findings of surgical registries were excluded. The reference lists of review papers were appraised for relevant papers not identified by the initial search. Animal and cadaver studies were excluded.

Search strategy

The primary search used the electronic databases Medline (1950 to January 2009), CINAHL (1982 to January 2009), AMED (1985 to January 2009) and EMBASE (1974 to January 2009), searched via Ovid using MeSH terms and Boolean operators “knee” AND “fixed bearing” OR “mobile bearing”. A secondary search assessing unpublished literature was assessed using the databases System for Information on Grey Literature in Europe (SIGLE), the National Technical Information Service, the National Research Register (UK), the British Library’s Integrated Catalogue, and Current Controlled Trials databases. Corresponding authors of each included paper were contacted for additional citations.

Study selection

T.S. and L.D. independently evaluated all identified titles and abstracts. The full text of eligible or potentially eligible articles was ordered, and the reference lists of these were scrutinised for any previously unidentified publications. Any disagreement on paper eligibility was resolved through discussion. The two investigators were blinded to the source, publication date, authors and author affiliations for each paper during the data extraction, appraisal and analysis.

Data extraction and critical appraisal

Data was extracted from included papers by T.S. and verified by L.D. All included papers were independently assessed by T.S. and L.D. using the Cochrane Bone, Joint and Muscle Trauma Group quality assessment tool [19–21]. Any disagreement which arose was resolved by consensus.

Data analysis

Data analysis was performed by T.S. The difference in clinical, radiological and kinematic outcomes was compared for fixed versus mobile bearing UKR. Three publications provided insufficient data for a meta-analysis. Attempts were made to contact corresponding authors to obtain this data.

Figure 1  A QUORUM chart.
Alternatively, frequency, mean and standard deviation data was acquired from graphical illustration where possible.
Heterogeneity in results was statistically measured using Chi² and I² statistical tests. Where appropriate, a random-effects meta-analysis method was employed to pool results. Mean difference was assessed for continuous variables. The Mantel-Haenszel method was used to calculate pooled odds ratios and relative risk. Given the kinematic differences between the medial and lateral tibiofemoral compartments, a separate analysis of medial and lateral UKRs was performed \[17,22–24\]. Publication bias was assessed using a funnel plot of the outcome measure recorded in the largest number of clinical trials. A probability of \( p < 0.05 \) was determined as statistically significant. Ninety-five percent confidence intervals were calculated for each measure. Meta-analysis was carried out using REVMAN software (version 5.0 for Windows®. Copenhagen: The Nordic Cochrane Centre, The Cochrane Collaboration, 2008).

Results

Search results

A total of 737 citations were identified from the search strategy (Fig. 1). Five satisfied the eligibility criteria and were included for analysis. The assessment of publication bias using incidence of revision surgery indicated no substantial evidence of bias through a broadly symmetrical funnel plot (Fig. 2) \[25,26\]. When meta-analysis was deemed appropriate, there was no evidence of statistical heterogeneity between the primary studies reviewed (Table 1).

Population characteristics

A total of 159 mobile bearing knees and 165 fixed bearing UKR were included. The prostheses used are described in Table 2. All papers provided surgical information to indicate that all prosthesis were cemented, and followed a minimally or reduced incision approach \[12,15,17,27,28\].

Four studies assessed outcomes after medial UKR \[12,15,27,28\], one study evaluated lateral UKR \[17\]. When populations were compared, the 146 medial mobile bearing knees in 134 patients, were compared to 147 fixed bearing knees in 142 patients. Thirteen lateral mobile bearing knees in 12 patients were compared to 17 fixed bearing UKRs in 16 patients. Mean age of mobile cohorts was 64.7 years (S.D. 6.4), compared to 69.6 years (S.D. 5.0) in fixed bearing groups \[12,15,17,27,28\]. Mean weight was presented in three papers \[12,15,17\] as 79.0 kg (S.D. 1.2) in the mobile bearing group, compared to 79.1 kg (S.D. 7.9) in the fixed bearing groups. Follow-up period ranged from 6 months \[12\] to 13.2 years \[12\] with the literature presenting a mean follow-up period of 5.8 (S.D. 3.1) years.

Medial UKR

Functional measurements collected included clinical and functional Knee Society Scores, Oxford Knee Score, Italian Orthopaedic UKR’s Users Group (GIUM) score, Bristol Knee Score, the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) scores, the Short Form-36 score, pain and range of motion. Due to insufficient data, it was not possible to perform a meta-analysis of the clinical outcome data for this review.

There was no significant difference between fixed and mobile bearing groups when assessed for GIUM score \((f = 73.8 \text{ vs. } m = 75.5; p = 0.7)\) \[28\], Bristol Knee Score \((f = 89 \text{ vs. } m = 84.1; p < 0.05)\) \[15\], WOMAC score \((f = 74 \text{ vs. } m = 76; p < 0.05)\) \[27\], Short Form-36 score (physical \(f = 37 \text{ vs. } m = 40; p < 0.05; \text{p-value})\) in 16 patients. Mean age of mobile cohorts was 64.7 years (S.D. 6.4), compared to 69.6 years (S.D. 5.0) in fixed bearing groups \[12,15,17,27,28\]. Mean weight was presented in three papers \[12,15,17\] as 79.0 kg (S.D. 1.2) in the mobile bearing group, compared to 79.1 kg (S.D. 7.9) in the fixed bearing groups. Follow-up period ranged from 6 months \[12\] to 13.2 years \[12\] with the literature presenting a mean follow-up period of 5.8 (S.D. 3.1) years.

### Table 1  Meta-analysis of the clinical complications for medial UKR.

<table>
<thead>
<tr>
<th>Complication</th>
<th>Papers assessed</th>
<th>Incidence</th>
<th>RR (95% CI)</th>
<th>P value</th>
<th>Heterogeneity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mobile</td>
<td>Fixed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aseptic loosening</td>
<td>[12,27,28]</td>
<td>2—98</td>
<td>0/99</td>
<td>3.03 (0.32—28.46)</td>
<td>0.33</td>
</tr>
<tr>
<td>Persistent pain</td>
<td>[15,28]</td>
<td>2/67</td>
<td>1/77</td>
<td>1.47 (0.09—25.29)</td>
<td>0.79</td>
</tr>
<tr>
<td>Progression of OA</td>
<td>[12,27]</td>
<td>5/76</td>
<td>7/77</td>
<td>0.73 (0.21—2.50)</td>
<td>0.62</td>
</tr>
<tr>
<td>Intra-op tibial plateau fracture</td>
<td>[15,28]</td>
<td>2/67</td>
<td>0/77</td>
<td>3.29 (0.35—30.78)</td>
<td>0.30</td>
</tr>
<tr>
<td>Tibial component subsidence</td>
<td>[12,15,28]</td>
<td>1/117</td>
<td>4/128</td>
<td>0.40 (0.06—2.57)</td>
<td>0.33</td>
</tr>
<tr>
<td>Revision surgery</td>
<td>[12,15,27,28]</td>
<td>13/145</td>
<td>12/156</td>
<td>1.13 (0.49—2.59)</td>
<td>0.78</td>
</tr>
</tbody>
</table>

OA: osteoarthritis.
Table 2: Study characteristics.

<table>
<thead>
<tr>
<th>Paper</th>
<th>Design</th>
<th>Sample</th>
<th>Prosthesis</th>
<th>Follow-up period (years)</th>
<th>Gender (m/f)</th>
<th>M</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Li et al. [27]</td>
<td>RCT</td>
<td>28/28</td>
<td>28/28</td>
<td>28/28</td>
<td>74/70</td>
<td>20/8</td>
<td>19/9</td>
</tr>
<tr>
<td>Forster et al. [17]</td>
<td>Obs Comp</td>
<td>13/13</td>
<td>12/12</td>
<td>16/16</td>
<td>75/55</td>
<td>7/5</td>
<td>5/11</td>
</tr>
<tr>
<td>Emerson et al. [12]</td>
<td>Matched Comp Obs</td>
<td>51/51</td>
<td>50/50</td>
<td>43/43</td>
<td>65/65</td>
<td>11/9</td>
<td>33/28</td>
</tr>
<tr>
<td>Confalonieri et al. [28]</td>
<td>RCT</td>
<td>20/20</td>
<td>20/20</td>
<td>20/20</td>
<td>69.5/69.5</td>
<td>11/9</td>
<td>12/10</td>
</tr>
<tr>
<td>Gleeson et al. [15]</td>
<td>RCT</td>
<td>47/47</td>
<td>49/49</td>
<td>43/43</td>
<td>66.7/66.7</td>
<td>20/20</td>
<td>20/20</td>
</tr>
</tbody>
</table>

Alleg: Allegretto (Cenerpulse, Baar, Switzerland); AMC: AMC-Unicondylar-Knieprothese (Alphanorm, Quierschied, Germany); Av: average; Comp: comparative; F: fixed; M: mobile; f: females; m: males; Miller Galante (Zimmer, Warsaw, USA); Obs: observational; Oxford: Oxford Unicompartmental Knee Replacement (Biomet, Warsaw, IN); Preservation: Preservation UKR (DePuy, Johnson & Johnson, Warsaw, IN); RCT: Randomised Controlled Trial; Robert Brigham: DePuy, Johnson & Johnson, Warsaw, IN; St George Sled: Waldemar Link GmbH, Hamburg, Germany.

Although Li et al. [27] and Emerson et al. [12] reported that there was no difference between fixed or mobile UKRs in respect to pain ($p > 0.05$), Gleeson et al. [15] reported that total pain score, as assessed using the Bristol Knee Score, was significant greater in the fixed bearing, compared to mobile bearing knee prosthesis at 2 years ($p = 0.013$).

As Table 1 demonstrates, the relative risks for aseptic loosening, persistent pain, progression of tibiofemoral or patellofemoral degenerative changes, intraoperative tibial plateau fractures, tibial component subsidence or the frequency of revision surgery was not significantly different between mobile and fixed bearing unicompartmental cohorts ($p > 0.05$). There was no substantial difference between the groups for length of hospital stay ($f = 4.8$ days vs. $m = 5$ days; $p = 0.5$) [28], surgical duration ($f = 45.7$ minutes vs. $m = 47$; $p = 0.6$) [28] or wound drainage ($f = 142$ ml vs. $m = 146$; $p = 0.7$) [28]. There was no substantial difference between fixed and mobile bearing UKRs for polyethylene wear on radiographs [12], loose bodies [27], clicking [27], patellofemoral pain syndrome [12], infection [27], bearing impingement [12], sepsis [28], deep vein thrombosis [28] or surgical difficulty [15].

The incidence of radiolucent lines at the bone–tibial implant interface was only examined in one paper. In this study, Li et al. [27] reported that there was a greater incidence of radiolucent lines at 2 years postoperative in the fixed compared to mobile bearing medial UKR cohorts (37% vs. 8%; $p = 0.02$) [27]. Knee alignment angle, assessed using the Hip-Knee-Ankle angle, was not significantly different between the mobile and fixed bearing groups ($f = 180$ vs. $m = 180$; $p = 0.05$) [27].

The kinematics of fixed versus mobile bearing medial UKR was only evaluated in Li et al.’s [27] study. These authors suggested that there was a significantly greater increase in tibial internal rotation in mobile compared to fixed bearing UKRs at 90° flexion ($p = 0.04$), but not at 0°, 30° or 60° ($p < 0.05$). There was a significant difference in medial femoral condyle translation between the mobile bearing group reporting 2 mm translation from its initial position relation to tibia during knee flexion, compared to 4.2 mm anterior translation from the initial position in the fixed bearing knees ($p = 0.03$). Similarly, there was a significant difference in the tibiofemoral contact point between the groups ($f = 4.0$ mm vs. $m = 2.1$ mm posteriorly to overall contact point motion; $p = 0.003$).

**Lateral UKR**

One study was identified assessing the clinical outcomes of lateral UKRs [17]. This assessed OKS, clinical and functional American Knee Society Score and range of knee motion. These authors reported that there was no significant difference between mobile and fixed bearing groups for these outcome measures ($p > 0.05$). Three cases of tibial loosening required revision surgery in the mobile bearing group, whilst no patient following fixed bearing UKR required revision procedures. One intraoperative tibial fracture occurred in the fixed bearing group only, in an osteoporosis octogenarian.
Neither a radiological or kinematic analysis was presented in Forster et al.’s [17] paper.

Critical appraisal

The methodological quality of the literature review is presented in Table 3. The literature provided insufficient details on randomisation or whether assignment was concealed prior to randomisation in their studies. Although surgeons could not be blinded to whether their patients underwent mobile or fixed bearing UKR, no study blinded patients or assessors to the type of prosthesis used. The indications for surgery and detailed the surgical interventions were presented with clarity in all five studies reviewed. Furthermore, the outcomes used were appropriate to assess functional outcomes and complications in all papers reviewed. Although sample sizes remained low in all five studies, this was justified by power calculations in three studies, indicating sufficient populations [17,27,28]. Although all studies employed inferential statistics to review their findings, no studies reported whether their results were normally distributed, limiting an analysis of whether the statistical tests used were appropriate in their samples. No paper assessed the precision of their statistical findings using confidence intervals.

Discussion

The findings of this review indicate that the clinical outcome and complication rate does not significantly differ between medial and lateral fixed and mobile bearing UKRs. There may be a difference in knee kinematics where the medial mobile bearing knee closer approximates that of the normal knee which may account for the significantly lower frequency of radiolucent lines in mobile rather than fixed bearing prostheses. This has only been examined in one study, further evaluation on large cohorts may be required to evaluate whether there remains a difference in radioluency, and if this is symptomatic or not in these two cohorts. This would support Price et al.’s [34] suggestion that complete radiolucency lines around the tibial component may not correlate with failure as this has not been determined in UKR populations, although consistent with implant loosening and radiological failure in total knee arthroplasty populations [18].

The literature suggests that lateral UKRs should not be regarded as the same as medial UKRs with respect to clinical, radiological or biomechanical results since femoral rollback occurs to a greater degree in the lateral compared to the medial compartment [17,22–24]. Clinically, the results of survivorship of the original design of Oxford UKR are different in the medial and lateral compartments [35]. Whilst the medial prosthesis designs have shown “excellent” long-term result with a bearing dislocation rate of 10%, lateral Oxford unicompartmental replacements have shown a 21% failure rate at 5 years [35,36]. This difference has been attributed to an increased laxity of the lateral stabilising structures with the adductor moment of the knee, compared to the medial compartment [36]. In response to these biomechanical differences, Biomet (Biomet, Warsaw, IN) have recently developed a new ‘domed’ lateral Oxford UKR reported to have a lower dislocation rate than previous lateral mobile bearing designs (Murray DW and Dodd CA, personal communication). Further study is required to determine the efficacy of this new prosthesis compared to fixed bearing UKRs in the management of lateral compartmental osteoarthritis.

An absolute requirement for medial meniscal bearing stability in the Oxford UKR is the presence of a functioning anterior cruciate ligament (ACL) with survival rates of 95% if the ACL is intact compared to 81% if it is not [33,35]. Although many surgeons have considered that the requirement for a functioning ACL is necessary for a mobile or fixed bearing prostheses, a small number of observational studies have demonstrated that an ACL reconstruction may be performed simultaneously to a UKR [37–40]. No published evidence has compared the results of fixed versus mobile bearing UKRs in this subgroup of patients. Further clinical and kinematic analysis would therefore be warranted if surgeons increasingly reconstruct the ACL to facilitate UKR surgery.

Table 3 Percentage score of Cochrane Musculoskeletal Group methodological quality assessment scheme.

<table>
<thead>
<tr>
<th>Paper</th>
<th>Total percentage score (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Confalonieri et al. [28]</td>
<td>58</td>
</tr>
<tr>
<td>Forster et al. [17]</td>
<td>58</td>
</tr>
<tr>
<td>Emerson et al. [12]</td>
<td>50</td>
</tr>
<tr>
<td>Li et al. et al. [27]</td>
<td>50</td>
</tr>
<tr>
<td>Gleeson et al. [15]</td>
<td>42</td>
</tr>
</tbody>
</table>
Whilst our study has shown no difference in outcome between fixed and mobile UKRs, there are inherent complications of mobile bearings not exhibited in fixed bearings for the medial compartment. There is a risk of ‘overstuffing’ the medial compartment [2,12,41,42]. This can increase the valgus angle resulting in a tighter knee exerting greater contact stress on the lateral compartment increasing the progression of lateral compartment osteoarthritis. Our limited findings would suggest that there is not a statistical significant difference in incidence of progression of degenerative changes between mobile and fixed bearing cohorts. However, such complications have been suggested to be less common with fixed bearing UKRs where there may be a tendency to leave more play in the compartment, causing undercorrection of the deformity, and therefore more varus [12].

In other arthroplasty procedures, reduced congruence has been implicated as a cause of polyethylene failure [43–45]. However, no clinical retrieval studies were identified to compare polyethylene wear between medial or lateral mobile and fixed UKR. This is an area for further analysis since Li et al. [27] reported that a femoral component which slides or rolls up to 5 mm on its polyethylene insert during knee flexion in fixed bearing knees, may have a higher potential for delamination than a stationary femoral component with mobile bearing UKRs.

Previous authors have proposed that there is a correlation between revision rate and number of UKRs performed annually, suggesting that surgical experience correlates with UKR outcome in mobile bearings [2,33,46,47]. This reflects the greater technical demands of the mobile UKR and greater learning curve which may be reduced with the advent of computer navigation [18,33,42,48,49].

Publications based on arthroplasty registry’s were excluded from this review paper. This was deemed appropriate to prevent the methodological limitations inherently associated with arthroplasty registry publications such as not being able to control for surgical experience, subject age, gender, specific implant comparisons and peri- and postoperative care, from influencing the findings of this meta-analysis. Nonetheless, the published literate on the Swedish Arthroplasty Registry was specifically identified by the search strategy employed [33,47,50]. The findings from these publications mirrored the conclusions drawn from this study, whilst presenting comparatively weak methodological quality when compared to the Cochrane Musculoskeletal Group appraisal tool (8% respectively).

Conclusions

Our meta-analysis of the current literature showed no significant difference in clinical outcome between medial and lateral mobile and fixed bearing UKRs. There is still a need for large, well-designed RCTs with a long follow-up to assess the clinical, radiological and kinematic outcomes of mobile versus fixed bearing UKR.

Conflicts of interest

None.

Acknowledgements

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References


