SECTION VIII - SUMMARY OF PUBLISHED DATA

This section includes summaries of published articles reporting clinical outcomes on mobile bearing knees, as well as reports of two meta-analyses. One meta-analysis compares clinical outcomes of mobile bearing knees of different types. The second compares the survivorship of mobile bearing knees versus fixed bearing knees.

Clinical Outcomes Summaries

The following mobile bearing knee clinical outcomes summaries are from articles published in peer-reviewed journals identified through a comprehensive medical database search, conference and symposium search, and bibliographical review. They are organized by the following mbk device types:

- Multidirectional platform;
- Rotating platform;
- Meniscal bearing;
- A combination of rotating platform and meniscal bearing implants were used;
- Unicondylar mobile bearing; and
- Review articles

In addition to the summaries of each article that appear below, this information is summarized in a series of tables found in Appendix 3. These include:

- Table 7: Clinical outcomes, mbk articles
- Table 8: Complications/adverse events, mbk articles
- Table 9: Mbk Survivorship (summaries of all mbk articles that contain a survivorship variable)
- Table 10: Fixed bearing survivorship (summaries of articles reporting TKAs with well designed fixed-bearing prostheses that have provided durable long-term fixation and are commonly cited in the literature).

Definitions for each device type are as follows:

Multidirectional platform - A single polyethylene bearing that allows both rotation and A/P motion in the transverse plane.

Rotating platform - A single polyethylene bearing that rotates in the transverse plane without A/P motion.

Meniscal bearing - Separate medial and/or lateral mobile polyethylene bearings that slide independently in tracks that run anteriorly and posteriorly in the fixed, metal tibial component.

Unicondylar meniscal bearing - An implant in which the medial or lateral compartment of the knee is replaced. Typically, the polyethylene either runs in a track as defined above or is not attached to either metal component, but is held in place by its reciprocal shape and the tension in the ligaments.

A complete bibliography of articles cited is found in Appendix 6 and complete copies of the cited references are presented in Appendix 7.

Multidirectional Platform Devices

Duffy & Phillipson[44] reviewed 74 knees in 61 patients implanted with the Accord total knee arthroplasty. At the time of study, 16 patients with 20 knees had died, 6 were lost to follow-up and one knee had become infected. Twenty-five knees had been revised or undergone further surgery. The mean knee score was 60 and the mean function score was 42. Of the 25 failed knees, 19 had been revised due to instability. Survivorship was 58% at 10 years with an average follow-up of 5 years 4 months. These results are poor compared with more conventional TKAs.

Kaper et al.[81] reported results of 172 cases in 141 patients receiving the Self Aligning I knee. Average follow up was for 5.6 years with a range of 5 to 8 years. Average age was 71 (47-90) at time of surgery. All patients suffered from osteoarthritis. Preoperative KSS was 81 and ROM was 6° to 110°. Postoperative KSS was 155 and ROM was 0° to 111°. Patient satisfaction of good or very good at last follow up was 94%. Survivorship with an endpoint of revision was 91.7% and with polyethylene wear as an endpoint was 98.8%. 115 cases reviewed at minimum 5 yr follow up (37 patients died prior to 5 years, 4 died after 5 but before follow-up, 15 excluded because of revision, 1 lost to f/u). Complications reported 41 deaths, 4* infections, 4* aseptic loosening, 2* poly wear, 4 (2*) fractures, 1* stiffness and 1* pain. (*revised).

Morgan-Jones et al.[118] conducted a prospective, consecutive study that enrolled 62 patients (75 knees). The mean follow-up was 2.5 years. Average pre-operative Knee Society clinical rating score was 96 (0-200) and at 2 year follow-up was 188. Average post-operative flexion at 2 years was 133 °. No mobile bearing dislocation, subluxation, or breakage has occurred. Radiologically, there was no evidence of subsidence or osteolysis.

Polyzoides et al.[132] performed a retrospective study involving 170 knees (161 patients) who received a Rotaglide total knee. The results of the 170 cemented knees with a 2-5 year follow-up period were excellent or good in 95% of knees, based on the British Orthopaedic Association knee assessment system. Poor results were seen only in revision cases. There were no mechanical implant failures and no platform bearing dislocations. The platforms continue to move as documented by postoperative roentgenograms, which show the metal markers of the platforms moving anteriorly in flexion and posteriorly in extension.

Rotating Platform Devices

Callaghan et al.[29] performed 119 consecutive cemented LCS rotating-platform TKAs in 86 patients. Of 114 knees for whom final outcome was known, 0 required reoperation and 0 had a dislocation, which has been reported as a problem in some mobile bearing designs.

Periprosthetic osteolysis has also been reported as a complication in some designs, however there was no lysis found on any of the knees, on radiograph, in this study. No implant loosening was reported at final follow-up. Avoidance of a loose flexion gap may account for the absence of platform dislocation and osteolysis from backside wear, but also for the average range of flexion, at final F/U of 0 to 102 degrees.

Grodzki et al.[62] in an article written in German with an English abstract reported on 38 patients (12 PFC and 26 LCS) followed for 1 year. Knee Society scores (0-200) for the PFC group and LCS group, at 1 year, were 130 and 160 respectively. The number of revisions and complications were not available for review because that information was not provided in the English abstract.

Sorrells[157] presented his results of 521 LCS rotating platform patients (665 knees) followed for 1-11 years. Sorrells reported 98% good to excellent results at 11 years. Survivorship of patients was 94.7% at 11 years with failure defined as revision for any reason. The study reported a 2% revision rate (13 revisions: 6 for malpositioning, 2 for pain, 1 due to laxity, 1 because of poly wear, 1 due to septic loosening, 1 subluxation, 1 for subsidence).

Sorrells[159], in a second study reviewed 99 patients (117 knees) with LCS rotating platform implants. Of those cases, 74 patients (91 knees) with a mean follow up of 8.5 years were available for evaluation with 85% of those patients demonstrating good to excellent results. Survivorship, defined as revision for any reason was 88.1% at 14 years. Sorrells reported a 6.8% revision rate (8 revisions: 4 for malpositioning, 1 for osteolysis, 2 due to dislocation/poly wear, and 1 for infection).

Meniscal Bearing Devices

Bert[9] reported on 43 consecutive TKAs performed from October 1985 to April 1986, using a mobile-bearing Low Contact Stress (LCS) implant. Ninety-one percent of the patients had good to excellent results at 1year follow-up; four patients experienced dislocation and/or subluxation of the meniscal bearing elements. Three of these occurred within 2 weeks post-op, while the fourth occurred 6 months after surgery. All 4 cases of dislocation/subluxation were treated with revision surgery. Because of the requirement for additional stability between the femoral and tibial components, it was the opinion of the author that proper measurement of the flexion-tension of the tibiofemoral gap was critical in preventing dislocation/subluxation of the meniscal bearing elements.

Hartford et al.[68] evaluated 139 mobile bearing knees in 104 patients at a mean follow-up of 7.8 years. There were 80 cemented, 50 uncemented and 9 hybrid (cemented tibia, uncemented femur). Five uncemented knees were revised for aseptic loosening. No cemented knees were revised for mechanical loosening. 1 knee was revised for recurrent bearing dislocation. Ninety-two knees were evaluated clinically and radiographically. There was a 27% incident of radiolucency for the femur and 31% for the tibia. The survivorship of the knee was 93% at an average of 7.8 years. Aseptic loosening was statistically higher in the uncemented components (P=.0051).

Jordan et al.[79] performed a study on mobile bearing patellas using the LCS knee system. He prospectively reviewed and reported on 160 knees in 141 patients. Patients had a mean age of 68 with most diagnosed with osteoarthritis. At an average follow-up time of 12 years, survivorship was reported to be 99.5% with only 2 revisions.

Jordan et al.[80] reported the results of 375 patients (473 knees) who received cementless LCS mobile meniscal bearing knees followed for 2-10 years. Of those cases, 410 knees were followed from 2 years with an average of 4.7 years. The average follow-up postoperative Knee Society function score was 92 with a knee score of 93. Survivorship, defined as revisions for any mechanical reason was 94.6% at the 8-year level (18 Revisions: 7 for fracture, 4 subluxations, 2 subsidence, 5 infections.) KM survivorship analysis for mechanical loosening of fixation was 99% when including bone graft resorption.

Kim et al.[90] reviewed 120 simultaneous bilateral patients (116 followed for an average of 7.4 years). An LCS mobile bearing knee was implanted in 1 knee and an AMK fixed bearing knee was implanted in the other. Clinical results thus far have been similar for the LCS and AMK groups (Knee Society Score (0-100) 94.4 and 93.3; ROM scores 123 and 121 respectively). There have been 2 revisions from each group. In the AMK group, both revisions were due to polyethylene wear. In the LCS group 1 revision was due to the dislocation of the medial polyethylene, and 1 was due to medial polyethylene wear. Survivorship with revision for any reason in this series was calculated to be 98% for both groups at 7.4 years.

Minns[114] reported on the first 165 cases of the Minns meniscal knee prosthesis. 43% were diagnosed with rheumatoid arthritis while 57% were diagnosed with osteoarthritis. Follow-up was up to five years. Preoperatively, flexion was 89.65º and at six months post-op 103.1º. Fixed flexion deformity improved from 16º to 5.38º while instability decreased from 11.48º to 5.6º. Eight revisions were performed due to dislocation caused by instability and were revised using a sliding plateau. 75% were rated as Excellent, 13% good and 9% fair.

Muller et al.[119] studied 436 cases of LCS knees, with unresurfaced patellas to show the improvement of patella function with mobile bearing designs over the traditional hinge like TKA devices. The NJOHS score improved consistently from 83 at 2 years post-op to 90 at 5 years post-op. This showed that deterioration cannot be contributed to patellar behavior, and unresurfacing the patella is possible if: 1. the kinematics of the device allows physiological rotation; 2. the prosthesis is anatomic; 3. the alignment is correct; 4. the anatomy of the decelerator/extensor mechanism is respected by approach; and 5. ligamentous stability is good.

Rosenberg and Henderson[146] presented a study on 27 patients with 35 cementless LCS mobile meniscal bearing PCR total knees. 4 patients were lost to follow-up, 3 patients died 2-3 years after surgery and one prosthesis failed due to infection. Outcomes were scored using either the Hospital for Special Surgery scoring system or the Oxford scoring system. The survival rate was 97.1% with 14 patients (20 knees) showing favorable outcomes with a mean score of 83, 5 patients scored “fair” at a mean of 60.

Combination of Rotating Platform and Meniscal Bearing in Same Study

Buechel et al.[20] performed a twenty-year evaluation of the initial series of 373 NJLCS knee replacements in 282 patients who survived at least 10 years. The patients were analyzed using the strict knee scoring scale resulting in excellent, good, or fair results in 68.1%, 29.8%, and 2.1% of the primary PCR meniscal bearing knees, 46.7%, 53.3%, 0% results in primary cemented rotating platform knees and 68.1%, 29.8%, 2.1% results in primary cementless rotating platform knee replacements, respectively. Osteolysis occurred in 1.8% (3) cases requiring bearing exchange and bone grafting.

Buechel and Pappas[23] performed multiple evaluations on the New Jersey Low Contact Stress-Knee Replacement system. 357 knees including 149 cemented and 208 uncemented were examined. Average follow-up was 91.2 months for the cemented and 52.4 for the noncemented group. Overall, results for the cemented cases were 85.2% good to excellent, 3.4% fair and 11.4% poor using a strict knee scoring scale. Primary cemented cases resulted in 95.1% good to excellent. Overall, results in the cementless cases were good to excellent 91.8%, fair 2.4%, poor 5.8%. For both cemented and noncemented groups, the fair and poor results were predominantly in the MO group and revision cases. 140 meniscal bearing implants were used in the series with a 0.7% dislocation occurrence. 217 rotating platform bearing implants were used with a 3.2% dislocation outcome, predominately in revision cases.

Callaghan et al.[28] reports on 8 different studies conducted over the past several years with a follow-up ranging from 5-11 years. The most common complication reported was on bearing dislocation. The most promising note of this report shows the mobile bearing designs have improved functional performance over the fixed bearing designs. The mobile bearing designs studied in this report did not show superior prevention of mechanical failure over fixed bearing designs. The results of the Oxford and LCS knees, after 10 years show comparable results of the fixed bearing design. Future designs of mobile bearing knees should include better control of bearing mobility patterns to reduce the prevalence of abnormal kinematic motions.

Keblish et al.[82] reported results from two samples, one being a multicenter study and the other being from his own personal experience both using the LCS system. In the multicenter study, Keblish reports on 918 patients (963 knees) with follow-up between 2-8 years. Regarding his personal experience, he reports on 275 knees at 2-8 years of follow-up. The cemented LCS multicenter group had 95.8% good to excellent results, the uncemented LCS multicenter group had 96.9% good to excellent results, and the sample from Keblish's personal experience had 97.4% good to excellent results. Revisions from the multicenter trial were not reported, but the personal experience sample had 9 revisions: 4 due to subsidence/loosening, 2 from patellar fractures, and 3 due to patellar wear.

Keblish et al.[86] performed a prospective study of patients with patellofemoral problems. 52 patients (104 knees) had bilateral arthroplasty and had the patella resurfaced on one side and not on the others. A movable-bearing prosthesis with an anatomical femoral groove was implanted on both sides by the same surgeon using an otherwise identical technique. The mean follow-up was 5.24 years. The components were uncemented, porous-coated in 88 knees and cemented in 16 knees. 51 patellae were resurfaced using an LCS metal-backed, anatomical, rotating-bearing

patellar component. One patella was resurfaced with a cemented non-metal backed dome component because other patella was too small to accommodate the rectangular base plate of the LCS patellar replacement. There were 52 patellae which were not resurfaced. Preoperative and postoperative evaluation was performed by an independent examiner. Knee rating scores were 89.9 for the whole series, 89.2 for bicompartmental TKA and 90.1 for tricompartmental TKA group. It was concluded that if the prosthesis is suitable, and if technical and radiological criteria are met, the non-resurfaced patella performs as well as the resurfaced patella.

Munzinger et al.[120] evaluated 235 cases of LCS TKA using a metal-backed rotating PE patella. These were performed in a large joint replacement center (>2750 cases since 1988) which normally (95%) does not resurface the patella. Cases with < 2 years F/U were not analyzed for function but were included in complications. Of 105 cases, 94.7% scored excellent or good on a modified 100-pt HSS score @ 4.2 years. The mean pre-op score of 53 improved to 84 at the latest postop scoring. Of the 235 cases, revision rate was 3%.

Papachristou[129] from 1976-1987, performed 160 knee arthroplasties using 5 different knee designs. Of these, 2 were mobile bearing: the Oxford knee (9 patients) and the Endo-Model (18 patients). Three revisions occurred in these two groups: 2 Oxford knees were revised due to aseptic loosening and 1 Endo-Model was revised due to infection. The author stated that acceptable results were obtained with all models with special reference to the degree of stability and the amount of pain relief.

Results of 101 patients with an LCS device at an average 5.2 years of follow up are presented by Sanchez-Sotelo et al.[148] Using the Knee Society scoring system the average final follow up knee score was 93 and the average final follow up function score was 78. There were 8 complications leading to revision: 2 for meniscal dislocation, 2 due to progressive osteolysis, 1 for infection, 1 for supracondylar femoral fracture, 1 due to patellar loosening, and 1 for poly wear.

Stiehl et al.[169] ran a prospective nonrandomized study on a consecutive series of 250 patients, 290 knees. They report on 191 knees with clinical and radiographic follow-up. 147 knees were implanted with the LCS meniscal-bearing device and 44 knees received the LCS rotating-platform design. The 7 year overall survivorship rate for the meniscal-bearing knee was 97.5% with the rotating platform knees reporting 100% survivorship. Survival analysis favored the rotating-platform device. They report that with careful IM alignment and flexion-extension gap balancing should eliminate most bearing failures.

Thompson et al.[175] implanted and evaluated 33 LCS knees that did not undergo patellar resurfacing in 31 patients with an average follow-up of 20 months. Range of motion decreased from 108° to 104°, pain also decreased from all patients suffering from pain to 21 pain free and 12 with occasional pain. Complications were as follows: one superficial infection, one atrial fibrillation and one lower respiratory tract infection.

Weissinger et al.[190] reported results on 41 patients (42 knees) of LCS knee joint implants at the general hospital in Zwettel. The average age was 65.8 years and mean follow-up was 21 months.

The results for pain, stability, mobility, axis of the extremity and ability to walk were rated as very good and good. The authors did not observe loosening of cement-free components. The summary was in English but the article was in German so further details were unascertainable.

Unicondylar Meniscal Bearing

Barrett et al.[7] presented a study of 67 Oxford bicompartmental TKAs on 62 patients. The average follow-up was 4.5 years. 46.3% were diagnosed with Rheumatoid arthritis and 53.7% osteoarthritis. ROM preoperatively for both groups was 93º. Postoperatively, the RA group scored 103º and the OA group 73º. Overall average flexion was 95º. Fixed flexion deformity preoperatively was 12.8º for the RA group and 10.2º for the OA group. Postoperatively, the RA group scored 8.1º and the OA 10.0º. 83% had significant pain relief. Revision rate was 7%. Four cases of deep venous thrombosis (one which progressed to a pulmonary embolism) were reported. No deaths were observed, 2 cases of aseptic loosening and 2 dislocations.

Bourne et al.[13] reported on 67 consecutive Oxford meniscal TKAs and were compared prospectively with 66 Kinematic I TKAs. At an average follow-up of 5.5 years, 20 (30%) of the Oxford knees had been revised (9 due to aseptic loosening, 7 to aseptic loosening and patellofemoral syndrome, 2 to patellofemoral syndrome, 1 to meniscal bearing dislocation, and 1 for sepsis). This compares to 3 Kinematic I revisions (1 for anterior dislocation, 1 for a loose patellar component, and 1 for sepsis) that took place during the same time interval. The remaining cases demonstrated good to excellent knee ratings (Oxford, 82 $\pm$ 11; Kinematic I, 88 $\pm$ 6; Hospital for Special Surgery).

Carr et al.[31] implanted 121 Oxford meniscal knees in 96 patients. Their mean age was 69 years (SD, 6.5 years). There were 25 bilateral procedures. Seventy-four took place in women and 47 in men. The indication for surgery was osteoarthritis of the medial compartment only. Strict selection criteria was adhered to: 1) Intact cruciate ligaments, 2) Fully correctable varus deformity, and 3) Presence of full-thickness articular cartilage in the lateral compartment. Average follow-up time since surgery was 44.4 months. One patient died 14 days after having bilateral arthroplasty performed under one anesthetic. Infection did not occur among the patients of this study. One patient was revised who had had bilateral arthroplasty under one anesthetic. The patient had loosening of the tibial component and secondary displacement of the meniscal bearing 5 months after surgery. Seventy-five percent of patients reported no pain with activity after surgery, 22% of knees had mild pain, and 3% had moderate pain. Flexion increased from 95 degrees preoperatively to 106 degrees at last follow-up. At 9 years, survivorship was reported to be 99.1%.

Cohen et al.[34] over a ten year period performed 21 meniscal-bearing UKAs on 20 patients. Of the UKAs followed for at least 2+ years, 7 lateral and 11 medial, good to excellent clinical results (NJOHS) were found in 16 (89%). The scores represented significant improvement over preoperative scores. No statistical differences were noted between the lateral and medial, nor the cemented and uncemented knees.

Goodfellow et al.[55] implanted 103 Oxford unicompartmental meniscal bearing knees in 85 consecutive patients. Twenty-six were men and 77 in women, with a mean age of 70 years. There were 76 medial and 27 lateral compartment replacements and the diagnosis was osteoarthritis in all 85 patients. Five cases were lost-to-follow-up and an additional 5 patients died. Mean follow-up was 36 months (range, 21-56 months). In 96% of cases the pain on activity was reduced, 92% having little or no pain on activity and 67% had similar pain at rest. Maximum flexion showed an increase from 104 to 105 degrees. There were nine re-operations that occurred during the conduct of the study. Seven of the medial compartment arthroplasties failed (4 aseptic loosening, 2 lysis, and 1 for bearing dislocation). For those with lateral compartments, 2 failed (1 for dislocation and 1 for recurrent subluxation). The authors report that the absence of the ACL was associated with a significantly greater incidence of failure.

Goodfellow and O'Connor[56] utilized the Oxford method in 107 patients replacing 125 knees. Patients were followed for 24-72 months with a mean of 49 months. 89% of patients were pain free of had mild pain with activity. 91% were pain free or mild pain at rest. 4 patients were lost to follow-up, 1 death, 8 revisions. Mean flexion limit at preoperation was 104º and was 99º at follow-up with a 7º mean flexion deformity.

Goodfellow et al.[57] reported on the first 25 unicompartmental knee replacements in 22 patients (17 women and 5 men). Twenty implants were done in the medial compartment and 5 in the lateral compartment. Mean patient age was 67 years (range, 50-84 years). Diagnosis was osteoarthritis in 20 knees, 2 osteonecrosis, 2 for failed menisectomy, and 1 for arthritis secondary to tibial plateau fracture. The mean follow-up was 21 months (range, 12-54 months). One failure occurred in one grossly obese patient in which the tibial component became loose 10 months after surgery. After operation, 92% of patients reported mild to no pain during activity and at rest. Postoperative flexion was slightly worse after surgery: Preoperative 104 degrees vs. 101 degrees postoperatively. No other complications were reported other than the one revision due to tibial component loosening.

Gunther et al.[63] in a study of the lateral compartment implanted 53 knees in 51 patients with an Oxford unicompartmental knee replacement. Fifty-three percent of patients reported pain with activity at an average of 5.2 year follow-up. Eleven revisions occurred with a majority caused by bearing dislocation. Gunther found that the risk of bearing dislocation was greater in the lateral compartment when compared with the medial compartment.

Harding et al.[66] reviewed 50 knees (Oxford Phase I 35 patients, Oxford II 15 patients) with osteoarthritis. Phase I implants had a survival rate of 66% and Phase II implants had a survival rate of 86%. When the authors went back and critiqued the selection criteria used, they found that for patients who met all implant indications survival was 100%. Implanting the Oxford knee in patients with a deficient ACL resulted in a poor outcome.

Keys et al.[88], in a prospective, controlled study using strict selection criteria found 97.5% good to excellent results for 41 knees implanted with a replacement of the medial compartment using an Oxford unicompartmental device. The survival rate at 5 years was 100% with no revisions or patients lost to follow-up.

Kumar et al.[93] found in a retrospective review of 100 knees (average age 71 with OA in 91% of patients) receiving an Oxford uni had a survival rate of 85% at the eleven year interval. Knee scores also improved from pre-op: knee score 62; function score 45 to post-op: knee score 91; function score 71. Eighty-six percent of patients were pleased with the result, 12% were satisfied, 1% were unsure, and 1% was unsatisfied. Seven revisions occurred during the study period, most for aseptic loosening.

McLardy-Smith et al.[109] reviewed 475 knees in a study that compared those less than 60 years of age with those 60 and older. In the young group, (mean age 55) survivorship was 94% at 10 years. For the older group, (mean age 73) survivorship was 95% at 10 years. This study demonstrated that the Oxford uni performed well in both young and older cohorts. No data were reported on revisions or complications.

Murray et al.[122] reviewed 143 knees (114 patients) with anteromedial osteoarthritis, and Norman anterior cruciate ligaments treated by unicompartmental arthroplasty using fully congruous mobile polyethylene bearings. The mean age was 70 years with an average follow-up of 7.6 years. There were five revision operations giving a cumulative prosthetic survival rate of ten years of 98%. No failures were due to polyethylene wear or aseptic loosening of the tibial component. One bearing which dislocated at four years was reduced by closed manipulation.

Price et al.[135] performed a prospective randomized study of 40 Oxford medial unicompartmental arthroplasties (UCAs) performed through a short incision medial to the patellar tendon, without dislocation of the patella with 20 Oxford UCAs performed through an open approach with dislocation of the patella. These patients were chosen using a random number generator to include a similar proportion of bilateral and unilateral subjects. Both groups were compared with 40 ABD total knee arthroplasties performed for osteoarthritis during the same time period. The same strict criteria for patient selection was used as were described for the open technique reserving the procedure for the treatment of knees with anteromedial osteoarthritis, in which both cruciate ligaments are intact. On preoperative clinical assessment, all the knees could flex >90° and had <15° fixed flexion deformity. One patient (TKA) suffered a subendocardial infarct in the early postoperative period.

Rees et al.[140] performed a retrospective nonrandomized study of 631 knees (507) patients which had medical unicompartmental replacement, 613 were primary procedures and 18 were for a failed HTO. The mean follow-up times of the two groups were similar. 19 of the primary procedures and 5 of those undertaken for a failed HTO had been revised to total knee replacement. Survival analysis revealed the ten-year cumulative survivals to be 96% for the primary group and 66% for the failed HTO group. It was recommended that the Oxford UCA should not be used in knees which have previously undergone an HTO.

Sherman et al.[155] reported on 32 patients who underwent bilateral bicompartmental Oxford meniscal knee arthroplasty. Patients were followed prospectively for a mean time of 51 months from the time of surgery. Patients had a mean age of 63 years (range, 43-85) with 25 being women and 7 men. Five revisions occurred during the course of the study: one for infection,

three for aseptic loosening, and one for bearing dislocation. Significant pain relief was obtained in all but one knee, and in no case was pain increased at time of follow-up. There were no improvements in range of motion. Walking ability improved in 72% of patients.

Svard et al.[173] performed a retrospective review of 124 Oxford Meniscal-bearing unicompartmental arthroplasties carried out for osteoarthritis of the medical compartment. All knees had an intact ACL, a correctable varus deformity, and full-thickness cartilage in the lateral compartment. The mean time at follow-up was 12.5 years. Six knees were revised because of dislocation of the bearing in three of the six. There were no patients lost to follow-up. The 10 year cumulative survival rate was 95%. The result of the review confirms that the use of a meniscal-bearing prosthesis can provide good long-term results of unicompartmental replacement, probably by avoiding failure from polyethylene wear. It was concluded that the Oxford unicompartmental meniscal-bearing arthroplasty is a reliable treatment for anteromedial osteoarthritis of the knee, when correct indications are applied and appropriate surgical experience is available.

Vorlat et al.[180] performed a prospective study of the Oxford Unicompartmental knee prosthesis for unicompartmental osteoarthritis. A total of 41 knees (39 patients) were studied (38 medial, 3 lateral) with a mean follow-up of 5 years. The mean HSS score at the 5 year follow-up was 87. There were 3 revisions, one post-op infection and 4 other complications.

Weale et al.[185] discussed 31 consecutive Oxford medial knee arthroplasties in 28 patients. A validated functional score (Oxford 12-item) test showed a mean score of 36.5 (maximum possible, 48). There were 2 revisions due to aseptic loosening.

Weale et al.[187] reported on 56 Oxford Unicompartmental replacements performed for anteromedial osteoarthritis of the knee between 1982 and 1987. Of these 56, 24 were in patients who had died without revision; one was lost to follow-up and two have been revised. Of the remaining 29 knees, 26 were examined clinically, and radiographically, two were examined clinically and one patient was contacted by telephone, leaving 28 patients clinically reviewed. The mean age was 80.3 years, with the mean follow-up of 1.4 years. The late AKS and HSS scores showed that 25 of the 28 knees examined clinically were graded as either excellent or good by both systems. The results found no clinical or radiological evidence of deterioration of the patellofemoral compartment during the ensuing ten years. This concurs with the general experience that failure of unicompartmental arthroplasty for patellofemoral causes is rare and suggests that the changes so commonly seen in that joint at surgery are secondary to varus deformity. When limb alignment is restored to neutral, overloading of the medial facet of the patella is relieved and the process of deterioration ceases.

Witvoet et al.[193] in an article written in French with an English abstract, treated lateralized gonarthrosis in 135 knees with the Lotus type single compartment prosthesis. Follow-up average was 4.6 years. 71.9% of the knees scored good with 28.1% scoring poor. There was a 19% revision rate. Poly wear and radiolucencies evolved over time and were significantly correlated to failures and poor results. Failures were multifactorial with this rate being attributed to poor technique and poor indications.

Review Articles

Callaghan et al.[27] reviewed the literature to determine published survivorship of medial unicompartmental knee replacements, meniscal bearing knees, and rotating platform knees. 144 cases in 114 patients with medial uni knees reviewed by the designer's group, had a ten year survivorship of 98%. 378 knees, in 378 patients evaluated by independent reviewers on uni knees, had a 10 yr survivorship of 95%. 57 knees with meniscal bearing had a six year survivorship of 98% in the designer's series and 473 knees in 375 patients by independent review had an 8 year survivorship of 94.6%. The designers of the LCS rotating platform knee had 108 patients with 10 year survivorship of 97.5% cemented and 6 year survivorship of 98.1% uncemented. 665 knees in 521 patients cementless and 119 in 86 patients cemented had 11 and 12 year survivorship results of 95% and 100% respectively.

The Norwegian Arthroplasty Register with reporting by Furnes et al.[51] replaced 7,174 primary total knees. Of these, 982 were LCS mobile bearing design and 23 were Interax mobile bearing. Four of the LCS were revised, with a 97.2% survival after 5 years. Compared to all types of knee devices, the mobile bearing knees reported similar rates of survivorship and complications. There were no statistically different rates among any of the fixed bearing and mobile bearing designs.

Heim et al.[69] presented a review article on assessing mobile-bearing knee designs on their mobility and constraints. The study classifies nine (LCS Deep Dish Rotating Platform, T.A.C.K, SAL, TRAC, Genesis II, Interax I.S.A., MBK, Profix and Rotaglide) non-hinged contemporary mobile bearing designs in terms of the force generated during a prescribed displacement. A dynamic testing system applied biaxial loads to assess intrinsic performance of the implants. Anterior, posterior, medial, lateral and rotational constraints were determined for each total knee design under a compressive load consistent with normal walking gait of an average sixty-year-old male, weighing 163 pounds. Testing concluded that it is important to understand the actual mobility that is being offered by each design. While all the designs tested permitted uninhibited physiologic rotation of the tibial plateau, the amount of displacement permitted in the anterior-posterior and medial-lateral directions were highly variable. These evaluations are intended to aid surgeons in device selection as well as providing manufacturers with design criteria and assist RA's in determining the safety and efficacy of specific knee designs. Clinical longevity of a total knee prosthesis can only be attained with a correct balance between the intrinsic characteristics of the device and the patient's presenting pathology.

Lewold et al.[100] performed a review of all Oxford knee arthroplasties done in Sweden. There were 699 Oxford knees identified with 50 first-time revisions. The project had no control over the participants who applied their own indications for arthroplasty, choice of prosthesis, and indications for revision. All but 5 of the 50 revisions occurred in the medial compartment. Sixteen knees were revised due to dislocation of the meniscal bearing, 14 revisions were due to aseptic loosening, contralateral arthrosis in 10, infection in 4, and 6 due to technical failure with instability, pain, and/or impingement of the meniscal bearing. No component with substantial wear were reported in the medical files.

Liow et al.[103] published a review of the 37 total knee systems on the market in the UK at the time of data collection (Sep 1996), with a discussion of the amount of published data on the knee systems, as well as date of release, average selling price, design features and estimated market share (as stated by the manufacturers). There was observed to be a steady increase in number of implants introduced into the UK between 1980 and 1997. Seven of the implants were unicompartmental; only one implant (DePuy's LCS knee) was mobile bearing. Twenty of the implants possessed no published functional or survival results in peer-reviewed journals. Five implants had published survival analyses of 10 years or more (Biomet's AGC was shown to have >98% survival at 10 years); five others (including the LCS) had published 5-year survival rates. Because of this relative lack of clinical outcome studies, the conclusion was drawn by the authors that other factors appeared to be more important to the average UK surgeon when selecting a knee implant.

Robertsson et al.[143] reported on 27,372 knees operated on between 1981 and 1995 in Sweden. During a validation process of the Swedish register, patients were sent a questionnaire which focused on patient satisfaction. The answers of patients operated on were analyzed and found that only 8% of the patients were dissatisfied regarding their knee arthroplasty, 2-17 years postoperatively. The proportion of satisfied patients was affected by the preoperative diagnosis, patients operated on for a long-standing disease more often being satisfied than those with short disease duration. There was no difference in proportions of satisfied patients whether they had primarily been operated on with a TKA or UKA. Unrevised knees had a higher proportion of satisfied patients than knees that had been subject to revision, and among patients revised for medial UKA, the proportion of satisfied patients was higher than among patients revised for TKA. It was concluded that satisfaction after knee arthroplasty is stable and long-lasting in unrevised cases and that even after revision most patients are satisfied.

Robertsson et al.[144] reported on 4,381 primary operations performed 1985-1995 for rheumatoid arthritis. Of these, 192 were performed with unicompartmental and 4,143 with tricompartmental. There were 126 first, 20 second and 1 third revision in tricompartmental arthroplasties, mainly for loosening, infection and patellar problems. There were 38 first, 3 second, and 1 third revision in unicompartmental arthroplasties, mainly for progression of RA and loosening. Cemented tibial components resulted in lower revisions rates than uncemented ones. There was no significant difference in revision rates between patellar replaced and unreplaced knees.

Stiehl[162] published an article that reviews recent data regarding the LCS mobile bearing total knee prosthesis. Overall, the article summarizes the clinical performance of the LCS TKS as documented by many long-term studies. The studies primarily include the initial experience of the original study group (Buechel, Sorrells, Keblish, and Jordan) who participated in the FDA exemption study that began in 1984. The incidence of bearing complications remains low in these studies, especially with the PCL-sacrificing rotating platform implant. Sorrels noted that nearly 50% of the mechanical failures in his study were related to early surgeon error in malalignment and ligament imbalance that can be eliminated with improved technique and a greater range of implant sizes. Bearing dislocation is most likely related to flexion gap instability or imbalance necessitating the need for overall ligament balancing early on in the case before creating the flexion gap. Comparing to a general total knee procedure, the occurrence of osteolysis and patellar complications are minimal thus, favoring the LCS implant. Improved

polyethylene wear related to the high conformity and low surface contact stresses have lead to improved performance of the mobile bearing knee and has been documented in long-term clinical follow-up with the occurrence of overt osteolysis virtually “nonexistent”.

Vertullo et al.[179] discussed the various types of mobile bearing knee designs. Mobile bearing knee arthroplasty (MBKA) has potential advantages compared to conventional fixed bearing TKA. By allowing axial rotation, MBKA can offer greater articular conformity without an increased probability of loosening due to increased axial torque. Increased articular conformity minimizes polyethylene contact stresses, thereby reducing linear wear and subsurface fatigue failure. Axial rotation of the platform also enables self correction of tibial component malrotation. Despite these advantages, MBKA results are similar to those obtained in well-designed fixed bearing TKAs, with no data suggesting superiority. The disadvantages include: bearing dislocation/breakage, soft-tissue impingement, steep learning curve, and concerns about volumetric wear. Hypothetically, longer-term follow-up of MBKA results may reveal a significant difference from fixed bearing TKA as the fatigue failure threshold of incongruent polyethylene is exceeded.

Meta-analysis: Patient Outcomes Following Mobile Bearing Knee Replacement

The complete report of this meta-analysis is presented in Appendix 4.

The goals of this meta-analysis were to provide more precise estimates of patient outcomes for the class of mbks (mbks of different design and surgical technique) than could be assessed from individual clinical studies, and to compare those estimates with the meta-analysis estimates provided by Callahan et al.[30] for tricompartmental fixed bearing knee replacement.

English-language articles were identified through a computerized MEDLINE literature search and bibliography review. Studies were included if they enrolled 10 or more patients at the time of initial knee replacement and measured patient outcomes using a global knee-rating scale. Callahan et al.[30] included both cemented and uncemented knees, as well as, all PCL treatments in the literature search, and the current study remained consistent with this method. In order to include a sufficient number of mobile bearing knee articles for the meta-analysis, the bearing type, and number of compartments replaced was not used to exclude articles. Each study was then subjected to a qualitative assessment and abstraction of patient characteristics, PCL treatment, and outcomes.

A total of 21 studies reporting patient outcomes on 22 cohorts satisfied inclusion criteria. The total number of enrolled knees was 2,870 (2,490 patients) with a mean enrollment of 138 patients. The mean follow-up was 6.0 years. The mean patient age was 66.1 years, 62.3% of patients were women, 82.3% had osteoarthritis, and 13% underwent bilateral replacement.

Table 3, below, shows the comparison of outcome values between mobile vs. fixed bearing meta-analysis results. Callahan et al.[30] reported on far more knees (9,879 versus 2,870). The raw, weighted mean percentage of patients with good or excellent outcomes following mobile bearing knee replacement was 90.3%. The weighted mean percentage of patients with good to excellent outcomes following fixed bearing total knee replacement reported by Callahan et al.[30] was 89.3%.

The comparison of percent improvement in global rating scale score showed similar results for mbk versus fixed bearing knees: mbk in current analysis, 91.4%, Callahan et al.[30], 100%.

Comparing the revision rate of mobile bearing studies versus fixed bearing studies initially revealed a difference of 2.4%: mbk, 6.4% vs. fixed bearing, 3.8%. However, a high revision rate (30%) in two of the mobile bearing studies [13, 44] strongly influenced the mean. These two studies reported on the Oxford unicompartmental phase I knee replacement[13] and the Accord total knee replacement[44]. Both of these designs are no longer used. After exclusion of these two studies, the revision rate comparison is more similar: 5.1% for mobile bearing knees and 3.8% for fixed bearing knees (difference of 1.3%).

Table 3 - Comparison of mobile versus fixed meta analysis results

	Mobile bearing knee outcome result (Current study)	**Mobile bearing knee outcome result excluding Oxford phase I[13] and Accord Knee[44]**	**Tricompartmental fixed bearing knee outcome result (Callahan et al.[30])**
No. of knees	2870	2729	9879
Weighted mean years of follow-up	6.0	6.4	4.1
No. of cohorts analyzed	22	20	154
Weighted mean % good or excellent	90.3*	93.4*	89.3
% improvement in global rating scale	91.4*	91.4*	100
Weighted mean postoperative global rating scale score	87.8	89.0	86.6
Weighted mean % knees with any revision	6.4	5.1	3.8

*Based on raw data, (imputed values not included)

The average mobile bearing knee replacement was a safe and effective procedure for the patients reported in these studies. Furthermore, these mobile bearing meta-analysis estimates are similar to the fixed bearing meta-analysis estimates reported by Callahan et al.[30] .

Meta-analysis: Mobile versus Fixed Bearing Total Knee Replacement Survival

The complete report of this meta-analysis is presented in Appendix 5.

A meta-analysis of knee implant survival was performed based on published survival estimates from recent peer reviewed literature. Mobile bearing knee articles were selected using the methods from the previous meta-analysis with the additional selection criteria that the article included a survival estimate. Fixed bearing knee articles were included if: they reported long-term follow-up (greater than 10 years); were cited at least twice in peer-reviewed journals as having high durability and clinical success; and included a survival estimate.

Estimates of implant survival were extracted from a total of 37 articles published between the years 1989 and 2002. Types of implants were grouped into mutually exclusive categories (i.e., mobile bearing or fixed bearing) prior to summarization. There were 21 articles which summarized survival for devices which were grouped into a mobile bearing category and 16 grouped into a fixed bearing category. From these, a total of 111 survival estimates were extracted, 40 were mobile bearing, and 71 were fixed bearing.

Since the number of survival estimates appearing in a given publication ranged from 1 to 30, data were reduced allowing only one estimate for each unique device (or set of similar devices within the mobile or fixed bearing group) from each article. When multiple survival estimates were provided for a unique device, data was reduced retaining the estimate with the most consistent definition of "revision" and the longest length of follow-up. This resulted in 26 observations in the mobile bearing group and 30 in fixed bearing group.

Weighted least squares (WLS) was performed on the survival estimates using the natural logarithmic transformation of the product of the number of cases (knees) and the mean length of follow-up as the weighting variable (log knee-years). A bootstrap procedure was performed 1,000 times to generate 95% confidence intervals and to estimate the P-value for the differences between mobile and fixed bearing device survival.

The maximum mean years of follow-up differed by 4.7 years between the two device groups. Follow-up of fixed bearing devices extended to 17.2 years while mobile bearing device follow-up extended to 12.5 years. Also, there were more fixed bearing cases followed-up, where a maximum of 665 implants were followed-up for the largest unique mobile bearing device considered and a maximum of 4,583 for the largest fixed bearing device considered.

The results are summarized in Table 6, below. Overall, implant survival was approximately 92 percent. Mobile bearing survival probability was approximately 93 percent, fixed bearing survival was approximately 91 percent. However, this difference is not statistically significant (P-value 0.966). The meta-analysis does not suggest mobile bearing device survival differs from fixed bearing survival (two-sided P-value 0.966). Both mobile and fixed bearing knees have a similar, satisfactory, long-term survivorship of greater than 90%.

Table 4 - Comparison of mobile bearing and fixed bearing implant survival

	Overall Survival %	**MBK Survival %**	**FB Survival %**	**Difference in Survival† (FB-MBK)**
WLS Estimate	0.9198	0.9263	0.9133	-0.0130†
95% CI*	(0.8985, 0.9401)	(0.8937, 0.9535)	(0.8830, 0.9410)	(-0.0550, 0.03171)†
P-value**	N/A	N/A	N/A	0.966

* *Based on the 2.5th and 97.5th percentiles of the distribution of (2-stage) bootstrap estimates*

** *Based on twice the minimum of the empirical probability of the two-stage bootstrap estimate being less than/equal to (or greater than/ equal to) the WLS estimate.*

† *Computed as two times the estimate of the between-device group difference*