■ KNEE

Early outcomes of twin-peg mobile-bearing unicompartmental knee arthroplasty compared with primary total knee arthroplasty

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Aims

Since redesign of the Oxford phase III mobile-bearing unicompartmental knee arthroplasty (UKA) femoral component to a twin-peg design, there has not been a direct comparison to total knee arthroplasty (TKA). Thus, we explored differences between the two cohorts.

Patients and Methods

A total of 168 patients (201 knees) underwent medial UKA with the Oxford Partial Knee Twin-Peg. These patients were compared with a randomly selected group of 177 patients (189 knees) with primary Vanguard TKA. Patient demographics, Knee Society (KS) scores and range of movement (ROM) were compared between the two cohorts. Additionally, revision, re-operation and manipulation under anaesthesia rates were analysed.

Results

The mean follow-up for UKA and TKA groups was 5.4 and 5.5 years, respectively. Six TKA (3.2%) *versus* three UKAs (1.5%) were revised which was not significant (p = 0.269). Manipulation was more frequent after TKA (16; 8.5%) *versus* none in the UKA group (p < 0.001). UKA patients had higher post-operative KS function scores *versus* TKA patients (78 *versus* 66, p < 0.001) with a trend toward greater improvement, but there was no difference in ROM and KS clinical improvement (p = 0.382 and 0.420, respectively).

Conclusion

We found fewer manipulations, and higher functional outcomes for patients treated with medial mobile-bearing UKA compared with TKA. TKA had twice the revision rate as UKA although this did not reach statistical significance with the numbers available.

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Controversy exists about the benefits of unicompartmental knee arthroplasty (UKA) *versus* total knee arthroplasty (TKA) for the treatment of isolated arthritic degeneration of the medial compartment of the knee. Advocates of UKA cite it is less invasive compared with TKA,[1] with reduced mortality and fewer complications.[2] UKA preserves undamaged structures, including the cruciate mechanism, which provides more natural kinematics,[3] and the patellofemoral joint, which gives more normal contact force and pressures.[4] Studies have shown that patients achieve a greater range of movement (ROM) after UKA,[5-12] and better perceived feel and function, particularly with demanding activities such as stair climbing.[13-18] Advocates for TKA over UKA for treatment of isolated medial osteoarthritis cite higher revision rates for UKA in large registry studies.[19-21] Our centre has previously compared patients undergoing primary knee arthroplasty treated with the Oxford Phase III (Zimmer Biomet, Warsaw, Indiana) mobile-bearing UKA *versus* TKA with the Vanguard Complete Knee System (Zimmer Biomet) and found a faster return to a more functional level with UKA.[9]

The development of UKA has progressed significantly since its first inception in the 1970s.[22,23] The mobile-bearing concept, developed in Oxford, United Kingdom, and described by Goodfellow and O'Connor,[24] has been maintained throughout the years while technological advancements have been made through phases of the design. The earliest phase of the Oxford mobile-bearing UKA was implanted using cutting blocks, while the newest instrumentation employs a distal femur bone mill and allows precise bone removal to facilitate accurate balancing of flexion and extension gaps.[22,25] Subsequent design phases resulted in minimally invasive techniques, and improved rehabilitation and functional outcomes.[26] Recently, the Oxford Phase III femoral component (Zimmer Biomet) was redesigned.

Table I. Pre-operative demographics

Characteristic	UKA group	TKA group	p-value
Patients (n)	168	177	
Knees(n)	201	189	
Gender of patients (n, %)			0.136
Male	72 *(43)*	62 *(35)*	
Female	96 *(57)*	115 *(65)*	
Age (yrs)	63.3 (SD 9.0, 38 to 84)	65.7 (SD 8.2, 45 to 86)	0.008
Height (inches)	66.8 (SD 4.2, 59 to 77)	66.2 (SD 4.0, 58 to 79)	0.127
Weight (pounds)	205 (SD 43, 128 to 350)	215 (SD 59, 104 to 390)	0.065
Body mass index (kg/m^2)	32.2 (SD 5.9, 21 to 53)	34.5 (SD 9.1, 17 to 63)	0.004
Pre-operative range of movement (°)	115.1° (SD 11.2°, 20° to 130°)	106.7° (SD 14.0°, 60° to 130°)	< 0.001
Pre-operative Knee Society pain score (0 to 50 possible)	8.6 (SD 10.1, 0 to 50)	8.2 (SD 10.9, 0 to 50)	0.692
Pre-operative Knee Society clinical score (0 to 100 possible)	39.7 (SD 13.5, 18 to 100)	39.6 (SD 15.0, 8 to 84)	0.919
Pre-operative Knee Society function score (0 to 100 possible)	57.9 (SD 18.0, 0 to 100)	50.6 (SD 18.1, 0 to 100)	< 0.001

UKA, unicompartmental knee arthroplasty; TKA, total knee arthroplasty; SD, standard deviation

The current Oxford Partial Knee Twin-Peg incorporates an additional femoral peg for improved stability and an additional 15° of femoral articular surface for greater contact in deep flexion. The twin-peg design also includes a more rounded profile for enhanced fit into the milled surface.

Since the redesign of the Oxford Phase III mobile-bearing UKA to a twin-peg femoral implant, there has not been a direct comparison with TKA. We sought to revisit our previous comparison of UKA *versus* TKA,[9] this time comparing patients treated with the new UKA design to those treated with the same TKA system as before. We evaluated the revision rates, frequency of complications, requirements for manipulation and post-operative function.

Patients and Methods

A search of our practice registry revealed 184 patients (219 knees) who had signed a general research consent allowing retrospective review, who underwent medial UKA performed by one of two surgeons (AVL, KRB) with the Oxford Partial Knee Twin-Peg device between February and October 2009. Indications for medial mobile-bearing UKA are full thickness medial cartilage loss, anterior disease with preserved posterior bone, fully correctable varus deformity and intact full thickness lateral compartment articular cartilage, and an intact anterior cruciate ligament, while disregarding traditional limitations of age, weight, patellofemoral disease and anterior knee pain. Exclusion criteria included tricompartmental osteoarthritis confirmed by radiograph, arthroscopy or intra-operatively, failure of lateral stress radiographs, active infection and patients who had responded to initial conservative therapy. These patients were compared with a randomly selected group of 212 consented patients (228 knees) treated with primary TKA using the Vanguard Complete Knee System (Zimmer Biomet) by the same two surgeons between February and March 2009. Underlying diagnoses for TKA were osteoarthritis in 217 knees (95%), rheumatoid arthritis in eight, and post-traumatic arthritis in three. In the UKA group, five patients (five knees) died prior to returning for minimum two-year follow-up, and 11 presumed living patients (13 knees) who have not returned for minimum two-year follow-up and have been lost to contact, leaving a cohort of 168 patients (201 knees) available for review with minimum two-year follow-up. There were no patient deaths within 90 days of UKA. In the TKA group, 19 patients (20 knees) died prior to returning for minimum two-year follow-up, and 16 presumed living patients (19 knees) who have not returned for minimum two-year follow-up who have been lost to contact, leaving 177 patients (189 knees) available for review with minimum two-year follow-up. One patient, who was progressing satisfactorily at her six-week post-operative visit, died 73 days post-operatively, unrelated to her TKA. The characteristics of both groups of patients are presented in Table I.

A midline approach with medial parapatellar arthrotomy was used for both procedures. UKA was performed without extension to the vastus medialis obliquus and without patellar eversion. Subsequent to the current study, instrumentation incorporating intramedullary femoral alignment guide and an anti-impingement guide were developed to facilitate implantation of the new femoral component. However, instrumentation used for UKA in the current study was the earlier Phase III instrumentation. All components were cemented in both groups. All patellae were resurfaced in the TKA group. The Vanguard TKA femoral components were cruciate-retaining (CR) in 186 knees (98%) and posterior-stabilised in three knees. All patients underwent the same multimodal rapid recovery pre-operative and post-operative protocols as previously described.[27,28] Patients were seen initially at six weeks post-operatively and annually thereafter. Patient demographics, including height, weight, body mass index (BMI), and age were collected from the pre-operative records. Knee Society clinical score (KSC), pain score (KSP) and function score (KSF) were recorded. ROM was measured with an electric goniometer. Revision, re-operation and manipulation

Table II. Post-operative results

Characteristic	UKA group	TKA group	p-value
Follow-up (yrs)	5.4 (SD 0.8, 2 to 7)	5.5 (SD 1.2, 2 to 7)	0.503
Length of hospital stay (days)	1.4 (SD 0.7, 1 to 4)	2.1 (SD 1.0, 1 to 7)	< 0.001
Discharge disposition			< 0.001
Not available	7 *(4)*	0 *(0)*	
Home	183 *(91)*	150 *(79)*	
Extended care facility	11 *(6)*	39 *(21)*	
Post-operative range of movement (°)	118.7° (SD 9.2°, 85° to 140°)	111.6° (SD 12.4°, 70° to 140°)	< 0.001
Improvement in range of movement from pre-operative to most recent (°)	3.7° (SD 11.9°, -20° to 95°)	4.9° (SD 14.5°, -40° to 55°)	0.382
Post-operative Knee Society pain score (0 to 50 possible)	44.0 (SD 13.0, 0 to 50)	45.6 (SD 10.7, 0 to 50)	0.195
Improvement in Knee Society pain score from pre-operative to most recent	35.4 (SD 17.3, -20 to 50)	37.3 (SD 14.6, -20 to 50)	0.225
Post-operative Knee Society clinical score (0 to 100 possible)	90.3 (SD 15.5, 31 to 100)	88.6 (SD 14.2, 45 to 100)	0.265
Improvement in Knee Society clinical score from pre-operative to most recent	50.8 (SD 20.7, -35 to 81)	49.1 (SD 20.8, -11 to 81)	0.420
Post-operative Knee Society function score (0 to 100 possible)	77.6 (SD 24.3, 0 to 100)	66.0 (SD 27.8, 0 to 100)	< 0.001
Improvement in Knee Society function score from pre-operative to most recent	19.3 (SD 25.8, -55 to 100)	15.3 (SD 25.8, -55 to 90)	0.135

UKA, unicompartmental knee arthroplasty; TKA, total knee arthroplasty; UKA, SD, standard deviation

under anesthesia rates were all recorded. Post-operative radiographs were evaluated for signs of hardware loosening, osteolysis, and component positioning and alignment.

Statistical analysis. We compared differences in the continuous variables (age, follow-up duration, BMI, ROM, length of stay and clinical scores) between groups using mean values, ranges and standard deviations (SD) with non-paired, two-tailed Student *t*-tests. We compared differences in discharge disposition, revision, re-operation, manipulation requirement, and complication rates between the two groups using chi-squared analysis. We calculated 95% confidence intervals (CI) and significance was determined as a p-value < 0.05.

Results

The mean follow-up in the TKA group was 5.5 years and 5.4 years for the UKA group (2 to 7). Pre-operatively, patients in the UKA group were somewhat younger (mean 63.3 years *vs* 65.7 years, p = 0.008), had a lower mean BMI (32.2 kg/m^2 *vs* 34.5 kg/m^2, p = 0.004), higher pre-operative mean KS functional scores (57.9 *vs* 50.6, p < 0.001), and greater mean ROM (115° *vs* 107°, p < 0.001). Pre-operative mean KS clinical and pain scores were similar (Table I).

Post-operatively, the twin-peg UKA cohort demonstrated higher mean KS functional scores (78 *vs* 66, p < 0.001) and ROM (119° *vs* 112°, p < 0. 001) (Table II). When considering functional improvement from pre-operative levels to most recent evaluation, mean KS functional scores demonstrated a trend toward greater improvement in the UKA group compared with the TKA group that did not reach statistical significance (19.3 *vs* 15.3, p = 0.135). Mean improvement in the ROM from pre-operative levels was similar between the groups (3.7° for UKA *vs* 4.9° for TKA, p = 0.382). Mean post-operative Knee Society pain and clinical scores were similar between groups, as were improvements from pre-operative levels for these outcome measures.

Post-operative radiographs were available to review for signs of hardware loosening, osteolysis, and component alignment in 386 knees. In the TKA group, patella infera was noted in one patient. In the UKA group, an "anvil" osteophyte (osteophyte seen along the base of the anterior cruciate ligament) was noted in one patient after falling from a bicycle and fracturing his ipsilateral hip, an asymptomatic radiolucency medial to the tibial keel was noted in one patient, and asymptomatic osteoarthritic changes to the patellofemoral joint were noted in another patient. Satisfactory fixation, position and alignment were observed for the remainder of patients with no evidence of osteolysis.

Overall nine component revisions were performed in our study: three in the UKA group (3 of 201, 1.5%) compared with six in the TKA group (6 of 189, 3.2%, p = 0.269) (Table III). Reasons for UKA failure were arthritic progression in two knees and tibial collapse in one. In all three patients the UKA was revised to a Vanguard CR TKA, one with a standard CR bearing and two with anterior stabilised bearings. TKA failure modes were two full component exchanges to constrained condylar devices for two-stage treatment of infection, one full revision to a rotating hinge at six years for periprosthetic fracture, and three bearing only exchanges with one each for arthrofibrosis, instability and polyethylene wear. Manipulation for arthrofibrosis was required after 16 TKA (16 of 189, 8.5%) *versus* no UKA (p < 0.001). In the UKA group, in addition to the three knees revised there were four complications requiring re-operation: three arthroscopic debridements, with two for removal of a loose body and in one of these, lateral meniscectomy, and one for osteophyte removal and lysis of adhesions; and one open incision and debridement of a non-healing wound. In the TKA group, in addition to the three full component revisions and three bearing only revisions, there were three complications requiring further surgery: two incision and debridement procedures with one for superficial infection after a dental abscess and one for

Table III. Complications and revisions

Characteristic (n, %)	UKA group	TKA group	p-value
Manipulation	0 *(0.0)*	16 *(8.5)*	< 0.001
Any re-operation	7 *(3.5)*	9 *(4.8)*	0.524
Revision of any component	3 *(1.5)*	6 *(3.2)*	0.269

UKA, unicompartmental knee arthroplasty; TKA, total knee arthroplasty

wound dehiscence, and one excision of a prepatellar suture granuloma.

Discussion

In the current study, while the revision rate after primary TKA was twice that of medial mobile-bearing UKA at minimum two-year and mean 5.5- and 5.4-year follow-up, the difference was not significant with numbers available. Revision in all three failed UKAs was accomplished with a primary-type CR TKA, whereas the three full revisions in the TKA group required constrained condylar or rotating hinge devices. Survival with the Oxford Twin-Peg Partial Knee was 98.5% with an endpoint of implant revision. In a previous study from our centre of patients who underwent 1000 consecutive medial Oxford Phase III UKAs with minimum two-year follow-up (mean 3.7 years) reported survivorship was 95.2% with an endpoint of implant revision.[29] Good success and long-term survival for patients treated with mobile-bearing UKA has been demonstrated by other centres as well. Pandit et al[30] prospectively reported on their first 1000 Oxford Phase III UKAs with a 2.9% re-operation rate and 96% ten-year survival rate. Their experience at 15 years yielded 91% survivorship with an endpoint of all re-operations or 99% survivorship for an endpoint of revision for implant failure.[31] Price and Svärd[32] reported first and second decade survivorship of mobile-bearing UKA at 94% and 91%, respectively. White, Roberts and Kuiper[33] recently reported results of 248 patients (287 knees) implanted with the cemented Oxford Twin-Peg Partial Knee reviewed at a mean follow-up of 5.1 years (maximum 9.2), and observed 98% cumulative implant survival. They stated that survivorship of the twin-peg UKA was superior to that of the single-peg knee at their centre, although another study found little difference between the two.[34]

In contrast, other authors have demonstrated diminished results in direct comparison to TKA. Lyons et al[35] reported a 6.4% TKA revision rate *versus* 12.9% UKA revision rate at mean follow-ups of 6.5 and 7.1 years respectively. Niinimaki et al[20] evaluated the Finnish Arthroplasty Registry and reported 90.4% survivorship at five years for mobile-bearing UKA compared with 96.3% survivorship at five years for all TKA. Although these studies demonstrated inferior results to UKAs, both study periods included implants from 1978 and 1985, respectively. Newer technological designs may influence revision rates and survivorship analysis.

Many papers have ubiquitously shown patients receiving UKA have higher pre-operative and post-operative clinical function scores and ROM.[5,9,13,35-38] Critics comment that these papers do not demonstrate significance when looking for the change between pre- and post-operative outcomes. More recent studies have looked at this change. Walker et al[39] reported substantially better post-operative Oxford knee scores[40] (increase in 14.3 *vs* 9.6) and ROM (127 *vs* 107) in 22 matched pair knees for patients treated with UKA *versus* TKA for isolated lateral osteoarthritis at mean follow-ups of 22 and 19 months, respectively. They also found UKA patients to have more improved scores and ROM compared with TKA patients. Our analysis likewise demonstrated greater improvement in the Knee Society functional scores for medial UKA patients *versus* TKA patients that was significant at earlier follow-up intervals, but was less pronounced when only considering patients with minimum two-year follow-up.

In our study, manipulation rates in the TKA cohort were higher than the UKA cohort. Arthrofibrosis after TKA resulting in manipulation can range from 1% to 9%.[41] However, manipulation after UKA is exceedingly rare.[42] In addition, anaesthesia required for manipulation may carry risk. Although dependent on many factors, including American Society of Anesthesiologists (ASA) score,[43] comorbidities such as diabetes, heart disease and pulmonary disease, administration of general anaesthesia has an all-cause mortality risk associated with it. Bainbridge et al[44] reports all-cause mortality depending on ASA 1 to 3 as 0.48% and ASA 4 to 5 as 9.32%.

As technology improves, we have seen the indications for UKA expand. Relative contraindications, such as BMI greater than 32 kg/m^2, age younger than 60 years, weight greater than 82 kg, mild patellofemoral disease, and anterior knee pain have not yielded diminished results in recent studies.[45-48]

Although our follow-up results are early, our initial revision rates are comparable between UKA and TKA groups using the Oxford twin-peg medial mobile-bearing UKA. Other strengths of this paper include evaluation of the difference in changes between clinical outcome scores, single institution, same technique, and same implants.

There were some limitations to our study. First, it was retrospective and may be subject to selection bias. Pre-operative findings revealed that patients in the UKA group had higher functional scores, lower BMI, and lower age indicating a selection bias toward opting for the UKA procedure in healthier, more active patients.[49] Although a selection bias is commonly seen in comparison studies between UKA and TKA, analysis of the improvement between pre-operative and post-operative levels indicated benefits for the choice of UKA over TKA. Greater BMI may no longer be a risk factor for adverse events and increased failure in UKA surgery, as demonstrated by recent studies.[45,46,48] Some authors may argue younger, lower BMI patients are typically more active, resulting in higher functional scores, better outcomes and lower manipulations regardless of surgery. Although this may be true, our study looked at the specific change in functional score before and after surgery, which may mitigate that benefit. Howell et al[49] demonstrated that patients selected and planned for UKA but converted intra-operatively to TKA have outcomes similar to patients who received UKA and better results than patients originally planned and selected to receive TKA. An additional confounding factor is the inclusion of eight rheumatoid arthritic and three post-traumatic arthritis patients in the TKA cohort which may skew our results. Another limitation resulting from the retrospective nature is that 30 patients (31 knees) died during the study period, and 24 of those patients (24 knees) had not been seen for a two-year clinical follow-up visit. Only seven of the patients died before reaching two years post-operatively. We know that one patient had a revision before death. The other patients had no known complications or revisions at the time of last follow-up. Another weakness of the study is that in addition to the 24 patients who died before a two-year clinical assessment, minimum follow-up was not available for 32 knees in 27 presumed living patients. The Social Security Death Index and online obituaries were searched for all patients. Attempts were made to contact the patients at their last known address and telephone numbers, by contacting referring and family physicians listed, and by searching available free internet services. However, minimum two-year clinical follow-up was available for 87% of patients.

In conclusion, our study showed fewer manipulations, and higher functional outcomes for patients treated with medial mobile-bearing UKA compared with TKA. TKA had twice the revision rate as UKA although this did not reach significance with numbers available. Newer technology may improve the functional outcomes and durability of medial mobile-bearing UKA, with implant survival that may be comparable with TKA. Further study with longer follow-up will determine if medial mobile-bearing UKA with enhanced twin-peg design will continue to demonstrate equivalent or better long-term survivorship and functional outcome.

Take home message:

We have seen fewer manipulations and higher functional outcomes with the Oxford Partial Knee Twin-Peg mobile bearing unicompartmental knee arthroplasty compared with total knee arthroplasty in the short-term.

Author contributions:
Z. C. Lum: Writing the paper.
A. V. Lombardi: Performed surgery.
J. M. Hurst: Performed surgery.
M. J. Morris: Performed surgery.
J. B. Adams: Data analysis.
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