Early results of Oxford mobile bearing Medial Unicompartmental Knee Replacement (UKR) with the Microplasty instrumentation: An Indian experience.

ABSTRACT

Object: Oxford medial unicompartmental knee replacement (UKR) is indicated in patients with anteromedial osteoarthritis (AMOA) of the knee. Microplasty (MP) instrumentation was introduced in 2012 as an improvement over phase 3 instrumentation. Advantages of this instrumentation include conservative tibial cut, decreased tibial re-cut rate and improved component alignment. We report the results of UKR with the new instrumentation in a consecutive series with a minimum follow-up of 2 years.

Materials and Methods: A prospective study of 115 cemented medial Oxford UKRs implanted in 89 patients was done. Post-operative alignment of the tibial and femoral components was analysed. Patient reported outcome measures were recorded using Oxford Knee Score (OKS) and the American Knee Society Score (KSS). Tegner Activity Scale (TAS) was used to record the activity level.

Results: 115 consecutive medial Oxford UKRs were studied. All patients were followed up annually in this prospective ethically approved study. The mean follow-up was 36 months and the minimum follow-up was 25 months. No patient died and none were lost to follow-up. At the final follow-up, the average OKS of the cohort was 39.5 (SD: 5.7). 91.2 % of the patients had good or excellent OKS with only 3.5 % reporting poor OKS. The overall limb alignment was 4.8^0 varus ($0 – 14^0$ varus). Tibia was recut in 5.2 % of cases. Median bearing size was 3 (range: 3 to 6). There was one case of bearing dislocation and one case of aseptic tibial loosening.

Conclusion: This is the first study to report results of MP instrumentation at a minimum follow-up of 2 years. Our study indicates that the new instrumentation results in reliable and accurate implantation of femoral and tibial components in majority of the cases, with a decrease in number of alignment outliers, and also a reduced rate of bearing dislocation.

KEYWORDS: Anteromedial osteoarthritis (AMOA), unicompartmental knee replacement (UKR), Microplasty instrumentation, mobile bearing.

INTRODUCTION

Anteromedial osteoarthritis (AMOA) of the knee as a distinct clinical, pathological, and radiological entity was first described by White et al in 1991 (1). The characteristic features of this entity include a correctable varus deformity, and varus which disappears on flexion. AMOA manifests as erosion of anterior tibial cartilage with intact anterior and posterior cruciate ligaments. Although initially developed as a bicompartmental implant for knee osteoarthritis (2,3), the Oxford Unicompartmental Knee Replacement (UKR), (Zimmer Biomet, Warsaw, Indiana, USA) has been used to treat AMOA over the past 35 years with recognition of AMOA as a distinct entity. The instrumentation and surgical technique have also evolved (2-5). The net result has been excellent clinical outcomes and long term survivorship similar to total knee replacement (TRK) (6–8). Multiple studies have shown lower rate of complications, lower mortality rates, higher percentage of highly satisfied patients, faster and less painful rehabilitation, and a reduced hospital stay in UKR compared to TKR (6–9).

The implant has the certain unique features – a single radius (spherical) twin peg femoral component and a mobile meniscal bearing which articulates with a flat tibial surface and a fully congruent femoral surface (2). These help reduce wear, restores normal kinematics and minimise bone resection. It is implanted through a minimally invasive approach which maintains integrity of the extensor mechanism, limits soft tissue damage and helps in rapid recovery.

Microplasty (MP) instrumentation (Zimmer Biomet, Warsaw, Indiana, USA) was introduced in 2012 with the aim of improving alignment and preserving bone. The key advantages of the new instrumentation include minimizing tibial bone resection, reducing tibial recut rate, and a

more reliable positioning of the femoral component. Few studies have compared the Microplasty instrumentation with Phase 3 (P3) instrumentation (10–15). Although three studies have shown superior results with Microplasty instrumentation in terms of alignment and bearing dislocation rate, one study did not show any benefit of the new instrumentation (10–13,15). Whether the Microplasty instrumentation improves short term survival rates is not yet clear. This study aims at describing the surgical technique and elucidate the clinical and radiological results at a minimum follow-up of 2 years.

MATERIALS AND METHODS

Prospectively collected clinical data and radiographs of 115 consecutive cemented medial Oxford UKRs implanted in 89 patients from August, 2013 to July, 2015 were analysed in this study. Ethical clearance was obtained from institutional ethics committee. Informed consent was obtained from all participants. The surgeries were performed by a single senior surgeon using the new Microplasty (MP) instrumentation for recommended indications which was followed by the standard physiotherapy and rehabilitation protocol. The inclusion criteria for Oxford UKR was the presence of Anteromedial osteoarthritis (AMOA). Patients with lateral compartment osteoarthritis, inflammatory arthritis and flexion deformity more than 15^0 were excluded. The patellofemoral (PF) compartment osteoarthritis was not considered as an exclusion criterion unless there was severe lateral facet OA with subluxation, grooving and/or bone loss.

All the patients were clinically followed up at 0, 3, 6 and 12 months post-surgery and then annually and patient reported outcome measures were recorded using Oxford Knee Score (OKS) and the American Knee Society Score (KSS). Tegner Activity Scale (TAS) was used to

record the activity level. Short leg antero-posterior and lateral radiographs of the knee were taken under fluoroscopic guidance using the recommended method (16) at 6 months, 1 year and then at the latest follow-up. Long leg standing antero-posterior view of both lower limbs was taken preoperatively and at 6 months post-surgery.

Radiographic assessment of implant positioning

Orientation of femoral and tibial implants in the sagittal and coronal planes was measured on short leg radiographs and for the values lying outside the recommended guidelines, the knee was considered an outlier for that measurement (14).

Femur flexion/extension: The acute angle subtended between femoral diaphyseal axis and a line parallel to the femoral peg was measured on lateral radiographs. Implants lying outside 0^0 to 15^0 of flexion were considered outliers. A value of 5^0 was added to the measured flexion/ extension angle to compensate for the 5^0 distal femoral anterior bowing.

Femoral component varus/valgus: The acute angle subtended between the femoral component and diaphyseal axis in the coronal plane was measured on AP view. A 7^0 subtraction was made to compensate for the normal physiological valgus of femur. Implants with more than 10^0 of varus or valgus were considered outliers.

Posterior tibial slope: The angle subtended between a line parallel to tibial tray and perpendicular to the tibial diaphyseal axis was measured on lateral radiographs. Implants lying outside $7^0 \pm 5^0$ were considered as outliers.

Tibial component varus/valgus: The angle subtended between a line parallel to tibial tray and the tibial diaphyseal axis was measured on AP radiographs. Implants more than 5^0 of varus or 5^0 of valgus were considered as outliers

Lower limb alignment: Alignment was measured on standing long leg AP radiographs of patients as the acute angle subtended between the mechanical axis of femur and tibia.

Radiolucent lines: The observed radiolucent lines (RLLs) were recorded and classified into physiological and pathological (17) and their relation to clinical outcome was analysed

Surgical Technique (Oxford Medial cemented UKR with MP instrumentation) (Figures 1 – 7): The patient was placed supine on the operating table with the leg to be operated placed on a padded leg holder and ipsilateral hip abducted to allow the leg to hang free. The knee should be free to flex to at least 120^0. Skin incision extends from superomedial pole of patella to the medial border of tibia tuberosity. Medial parapatellar arthrotomy is performed, and the proximal part of arthrotomy is angled superomedially into the fibres of Vastus medialis. The lateral compartment is carefully inspected for cartilage loss and the integrity of anterior cruciate ligament (ACL) is verified by giving a tug with hook. Anvil osteophyte just anterior to the tibial insertion of ACL is removed if present. Osteophytes on the margin of medial femoral condyle and the intercondylar notch are removed. No medial release is done. Femoral sizing stylus (available in 1 mm, 2 mm, 3 mm options for each femoral size) is used to determine the size of femoral component as well as tense the medial collateral ligament (MCL). On pulling the stylus anterior, so that the stylus hugs the posterior condyle, there should a 3-5 mm gap present anteriorly between anterior lip of stylus and eburnated femur. Usually 1 mm stylus does the job. Occasionally in the presence of a very deep tibial defect or medial laxity, a 2 or 3 mm stylus may be required. When a 3 mm stylus is used, less bone is removed from tibia. In our series, the most commonly used stylus in males was small, and for females extra small. Other methods of determining size include pre-operative templating (less accurate), and height and gender based guidelines.

Now, the anteroposterior axis (flexion-extension axis) of the vertical tibial cut is marked. This axis should be pointing towards the anterior superior iliac spine (ASIS). An easy way of marking is to insert a straight narrow osteotome or chisel into the intercondylar notch abutting the lateral wall of medial femoral condyle. The knee is then flexed and extended to identify the flexion-extension axis. A marking pen is used to mark the axis on the articular surface of tibia. Femoral sizing stylus and extramedullary tibial cutting guide (with a size zero golden shim on top) are linked together with a G-clamp (3G or 4G), depending on what thickness bearing insert (size 3 or 4) the surgeon wants to use later on. Vertical tibial cut is taken along the marked axis with a reciprocating saw. The vertical cut must pass just medial to ACL, and ideally include a part of the medial tibial spine. A medial cut would undersize the tibia and increase chances of overhang, while a lateral cut may damage the ACL.

The golden shim is replaced by a slotted size zero silver shim and the horizontal cut is taken. MCL must be protected at all times by a Z shaped retractor. The tibial sizing is done by laying the tibial cut flat on the tibial base plates of opposite side. The femoral canal is opened with a drill bit and awl (1 cm superior to the anteromedial corner of notch), and femoral intramedullary rod is inserted. Centre of the femoral condyle is marked with a pen. Femoral drill guide (set at 3 or 4 depending on what size G-clamp was used) is inserted and IM (intramedullary) link used to connect it with the rod. The IM link helps set the femoral component flexion and rotation (5). With the drill holes in line with the central mark, 4 mm and 6 mm holes are drilled. The posterior femoral resection guide is inserted into the holes and posterior cut taken. The tibial cut and the posterior femoral cut create the flexion gap. Next, extension gap is created by milling the femoral condyle.

Zero spigot is inserted into 6 mm hole and gently hammered in, followed by milling. Then, tibial base plate and femoral trial (single peg) are inserted to measure flexion (in 110^0 flexion) and extension (in 20^0 flexion) gaps with gap gauges. If even the smallest gauge (size 1) is tight

in extension, extension gap is considered zero. The difference of the two gaps is calculated, and milling repeated with the corresponding size spigot. Again trial is done to confirm that the gaps are equal. Anti-impingement guide is inserted and milling done to remove part of anterior condyle. Through the same guide, posterior osteophytes can be removed by using a bespoke chisel. Next, tibial preparation is completed. Trial is repeated with twin peg femoral trial component, keeled tibia, and meniscus. Knee is moved through flexion-extension to check stability and ensure that the bearing does not impinge. Final implant is cemented and wound closed in layers after inserting drain.

RESULTS

A total of 115 medial Oxford UKRs were performed on 89 patients suffering from AMOA by a single senior surgeon over the study period. The mean follow-up was 36 months and the minimum follow-up was 25 months (range: 25 – 48 months). None of the patients were lost to follow-up.

The mean age for the entire cohort was 58.2 years (SD: 7.99, range: 44 – 79 years) with an average BMI of 28.34 (SD: 3.11, range: 22.5 – 36.6). Males constituted 21% of the total cohort (Table 1).

Clinical outcome (Table 2)

At the latest follow-up, the average OKS of the cohort was 39.5 (SD: 5.7, range: 11 – 48). 46.9 % of the patients had excellent OKS (OKS > 41), 44.3 % had good OKS (OKS 34-41), while only 3.5% had poor OKS (OKS<27). KSS satisfaction score was 33.1 (SD: 4.4, range: 12 – 40), KSS expectation was 11.6 (SD: 1.5, range: 5-15) and KSS function was 71.1 (SD: 8.9,

range: 13 – 84). Median Tegner activity level was 3 (range: 0 to 4). All scores improved significantly when compared to the pre-operative scores (Table 2).

Tibial recut (Horizontal) and Bearing Size

Tibia was recut in 6 cases (5.2 %). Median bearing size was 3 (range: 3 to 6). Bearing size 3 or 4 was used in 93% of the cases.

Radiological outcome (Table 3)

The mean overall limb alignment was 4.8^0 varus (SD: 3.1^0, range: 0 to 14). None of the patients had valgus alignment of the knee. Mean inclination of femoral component in the coronal plane was 0.4^0 varus (SD: 3.93, range: 7^0 varus to 8^0 valgus). No implant was outside the recommended range of 10^0 varus to 10^0 valgus.

In sagittal plane, average inclination was 6.8^0 flexion (SD: 4.49, range: 0^0 to 18^0 flexion) with 5 knees (4.3 %) lying outside the recommended range of 0^0 to 15^0 flexion.

Mean inclination of tibial component in the coronal plane was 1.2^0 varus (SD: 3.89, range: 10^0 varus to 6^0 valgus) with 13 knees (11.3 %) lying outside the recommended range of 5^0 varus to 5^0 valgus

Mean posterior tibial slope was 6.4^0 (SD: 3.17, range: 0^0 to 14^0) with none of the implant having anteriorly sloping tibia and 5 knees (4.3 %) lying outside the recommended range of 2^0 to 12^0 of posterior slope.

Radiological lucencies

57% of knees had physiological radiolucent line around tibial component and 1 knee (0.9 %) had pathological radiolucency due to aseptic loosening of the implant.

Complications

There was one meniscal bearing dislocation (Figures 8 and 9) 6 months after surgery. The patient complained of sudden pain and swelling over her left knee while walking. She was diagnosed as having an anteriorly dislocated the meniscal bearing. The bearing was removed and a thicker sized bearing (3 mm size replaced by 5 mm size) was inserted. The lateral compartment and patellofemoral compartment did not show any signs of osteoarthritis. ACL was intact, and the femoral and tibial components were not loose.

There was one aseptic loosening (Figure 10) which happened 2 years after surgery and the patient is awaiting revision surgery. No case of infection was seen.

DISCUSSION

This is the first prospective clinical and radiological study of Microplasty instrumentation reporting short term results at a minimum follow-up of two years (range 25-48 months) in Indian patients. Strengths of the study include a prospective study design, single centre consecutive series of patients, no patient lost to follow-up and a minimum follow-up of 25 months. The study confirms the safety and efficacy of the system in Indian patients.

Although the first Oxford knee replacement (bicompartmental) was performed in 1976, the Oxford medial UKR was first implanted in 1982 as a unicompartmental device (4). The phase 1 Oxford UKR had one femur size (corresponding to the present day medium size) and five tibial sizes (non-anatomic, same for right and left side). The femoral preparation included three bony cuts. The femoral component was single pegged. Phase 2 was introduced in 1987, which included a modification in femoral design (flat posterior surface and a spherical inferior surface on the non-articular side) and introduction of a spherical mill to match the extension gap to the flexion gap. Milling could be done in 1 mm increments by varying the length of the spigot,

which allowed for accurate gap balancing. Both phase 1 and 2 Oxford UKR were implanted via an open approach similar to TKR. Phase 3 prosthesis was introduced in 1998 with a focus on minimally invasive approach. The implant inventory was expanded to include five femoral component sizes (extra small, small, medium, large, extra-large), side specific anatomic tibial base plate, and a modified polyethylene bearing to reduce the risk of impingement. The results of phase 3 have been significantly better compared to phases 1 and 2 (18). To improve femoral component stability, a twin-peg design was introduced in 2003 (19). Apart from improving fixation of the component, the newer design had a 15^0 extended arc (19), allowing for an increased knee flexion, which is particularly beneficial in the Asian population. The twin-peg design has been shown to improve survivorship (20). Microplasty instrumentation was then introduced in 2012 with the addition of a femoral sizing spoon (stylus), a G-clamp, and an IM linker.

The meniscus in a mobile bearing UKR follows the path of the femoral component. Hence, a laterally placed femoral component may lead to impingement of the lateral wall of the bearing with the lateral wall of the tibial tray. This point has been studied in detail by Inui et al (15). They observed lateral tilting of meniscus in post-operative radiographs in 10 % of MP patients, while none of the phase 3 cases depicted this. To avoid this, they stressed that the positioning of the drill holes (4 mm and 6 mm) must be in the centre of the medial femoral condyle. We ensured this in every case by marking the centre with a marking pen before positioning the femoral drill guide. Also, we checked for impingement of meniscus on tibial tray in every case during trial and before tibial keel preparation. Ideally, at least 1 mm distance must be maintained (15). Hence, we did not encounter such a problem in any of our cases. Although Inui et al (15) did not find this tilting to be consequential in terms of clinical scores in their short follow-up of one year, it would not be wrong to conclude that this impingement might contribute to polyethylene wear and hence a higher risk of revision later on. If impingement is

discovered during trial, one can extend the vertical tibial cut more laterally (21) and then proceed with tibial preparation.

Hurst et al (14), Walker et al (12) and Jang et al (13) compared the component alignment of P3 with MP instrumentation. Two studies (12,14) showed significantly improved alignment with MP, whilst one study did not show any difference between the two in terms of alignment (13). Koh et al (10) and Tu et al (11) compared the component alignment as well as the clinical outcome between MP and P3. They reported a significantly better positioning of femoral component; while the clinical scores, overall limb alignment and tibial component alignment were similar in the two groups.

Another advantage of MP has been a reduced risk of bearing dislocation (10,12,13). This also reflects better positioning of components with respect to each other (10). A reduction in tibial re-cut rate is also one of the advantages of MP instrumentation, although none of the previous comparative studies (10–15) have compared the rate in MP and P3. The tibial re-cut rate in our series was 5.2 %.

Due to the conservative tibial cut, the MP instrumentation typically leads to a higher percentage of cases with a thinner bearing size. In our series, size 3 or 4 bearing were used in 93 % of the knees; mean bearing size was 3.5 (median 3). In the study by Walker et al (12), mean size was 4.2 in MP group while it was 4.6 in P3 group, the difference being statistically significant. However, in the study by Jang et al (13) size 3 or 4 bearing was used in 81.9 % in P3 and 80.6 % in MP group, and the difference was statistically insignificant.

A review of published comparative studies is given in table 4, and the outliers are compared in table 5.

In our study, incidence of physiological radiolucent lines (RLL) beneath the tibial component was 57.4% at the final follow-up. Pathological RLL was found in one patient, due to aseptic

loosening. As detection of these lines is highly dependent on positioning of the limb (17), fluoroscopic imaging was used to specifically look for RLL in all cases at final follow-up. The presence of these lines did not correlate with poor clinical score ($p = 0.59$ for OKS). A study by Gulati et al also showed that 63 % knees with cemented Oxford medial UKR had RLL at five-years follow-up (17). They reported that presence of RLL did not correlate with age, BMI (body mass index), gender, post-operative limb alignment, state of the ACL, clinical score and pain score. Our study also affirms this. Another series of 688 Oxford cemented medial phase 3 UKR's reported RLL in 70 % cases (22). Non-progressive, 1 mm-2 mm wide and separated from underlying bone by a radiodense line are the three features necessary to label a RLL as physiological (17). It is important to differentiate physiological from pathological lucencies as misinterpretation may lead to unnecessary revision (23). Interestingly, Pandit et al have shown the incidence of RLL to be much less (7 %) in uncemented medial oxford UKR, although this did not translate into better clinical scores (24). The long term implication of this finding remains to be understood.

The limitations of this study include a short follow-up and lack of a comparative P3 group. Our group was one of the first to adopt MP instrumentation in India and this is first ever report of the new system. It is versatile, easy to use and reproducible. It improves component alignment and reduces the need for tibial recut, which in turn weakens the bone increasing the fracture risk. Long-term follow up is needed to ensure that the short-term outcomes are maintained in the long-term.

CONCLUSION

Our study indicates that the new instrumentation results in reliable and accurate implantation of femoral and tibial components in majority of the cases, with a decrease in number of alignment outliers. The early clinical results have been good to excellent with a low incidence of complications. The influence of the improved alignment on overall medium and long term survival remains to be studied.

SOURCE OF FUNDING: Nil

CONFLICT OF INTEREST: One of the authors is a paid consultant with Zimmer-Biomet, and has received grants from Governments of India and UK.

FIGURE LEGENDS:

Figure 1: Intra-operative photograph showing intact cartilage in lateral compartment and an intact ACL.

Figure 2: Method of marking flexion-extension axis on tibia using an osteotome. The vertical tibial cut should be parallel to this mark.

Figure 3: Femoral sizing stylus (Extra small) in place showing 5 mm space between condyle and stylus due to eburnated bone.

Figure 4: Tibial assembly in place showing the G clamp connecting the extramedullary tibial jig with the stylus.

Figure 5: Marking the centre of medial femoral condyle.

Figure 6: Intramedullary rod and femoral cutting guide linked with the IM linker. The drill slots in the guide must line up with the central mark on medial femoral condyle.

Figure 7: Final components and bearing in place. Ideally, a thin osteotome must easily pass between the bearing and the tibial tray. This ensures that bearing will not impinge on the tibial tray.

Figure 8: AP and lateral radiographs of a case showing meniscal dislocation. The dislocation was a result of trauma. Arrow points towards the bearing location.

Figure 9: Intra-operative photograph of the dislocated bearing lying medially in the suprapatellar space. The bearing was a size 3, and was replaced by a size 5 bearing based on stability during trial.

Figure 10: AP and lateral radiographs of a patient with aseptic loosening of the tibia.

TABLE LEGENDS:

Table 1: Demographic data of the patients.

Table 2: Clinical assessment.

Table 3: Radiographic assessment.

Table 4: A review of comparative studies between Microplasty (MP) and Phase 3 (P3) Oxford medial UKR.

Table 5: Outliers in component positioning.

REFERRENCES

1. White SH, Ludkowski PF, Goodfellow JW. Anteromedial osteoarthritis of the knee. J Bone Joint Surg Br 1991;73(4):582–6.

2. Jackson WFM, Berend KR, Spruijt S. 40 years of the Oxford Knee. Bone Joint J 2016;98–B(10 Supple B):1–2.

3. Goodfellow JW, O'Connor J. Clinical results of the Oxford knee. Surface arthroplasty of the tibiofemoral joint with a meniscal bearing prosthesis. Clin Orthop Relat Res 1986;(205):21–42.

4. Price AJ, O'Connor JJ, Murray DW, Dodd CA, Goodfellow JW. A History of Oxford Unicompartmental Knee Arthroplasty. Orthopedics 2007;30(5 Suppl):7-10.

5. Hurst JM, Berend KR. Mobile-bearing unicondylar knee arthroplasty: the Oxford experience. Orthop Clin North Am 2015;46(1):113–24.

6. Price AJ, Svard U. A second decade lifetable survival analysis of the Oxford unicompartmental knee arthroplasty. Clin Orthop Relat Res 2011;469(1):174–9.

7. Price AJ, Waite JC, Svard U. Long-term clinical results of the medial Oxford unicompartmental knee arthroplasty. Clin Orthop Relat Res 2005;(435):171–80.

8. Pandit H, Hamilton TW, Jenkins C, Mellon SJ, Dodd CA, Murray DW. The clinical outcome of minimally invasive Phase 3 Oxford unicompartmental knee arthroplasty: a 15-year follow-up of 1000 UKAs. Bone Joint J 2015;97–B(11):1493–500.

9. Berger RA, Meneghini RM, Jacobs JJ, Sheinkop MB, Della Valle CJ, Rosenberg AG, Galante JO. Results of unicompartmental knee arthroplasty at a minimum of ten years of follow-up. J Bone Joint Surg Am 2005;87(5):999–1006.

10. Koh IJ, Kim JH, Jang SW, Kim MS, Kim C, In Y. Are the Oxford(®) medial unicompartmental knee arthroplasty new instruments reducing the bearing dislocation risk while improving components relationships? A case control study. Orthop Traumatol Surg Res 2016;102(2):183–7.

11. Tu Y, Xue H, Ma T, Wen T, Yang T, Zhang H, Cai M. Superior femoral component alignment can be achieved with Oxford microplasty instrumentation after minimally invasive unicompartmental knee arthroplasty. Knee Surg Sports Traumatol Arthrosc 2017;25(3):729–35.

12. Walker T, Heinemann P, Bruckner T, Streit MR, Kinkel S, Gotterbarm T. The influence of different sets of surgical instrumentation in Oxford UKA on bearing size and component position. Arch Orthop Trauma Surg 2017;137(7):895–902.

13. Jang KM, Lim HC, Han SB, Jeong C, Kim SG, Bae JH. Does new instrumentation improve radiologic alignment of the Oxford® medial unicompartmental knee arthroplasty? Knee 2017;24(3):641–50.

14. Hurst JM, Berend KR, Adams JB, Lombardi AV. Radiographic comparison of mobile-bearing partial knee single-peg versus twin-peg design. J Arthroplasty 2015;30(3):475–8.

15. Inui H, Taketomi S, Yamagami R, Sanada T, Shirakawa N, Tanaka S. Impingement of the Mobile Bearing on the Lateral Wall of the Tibial Tray in Unicompartmental Knee Arthroplasty. J Arthroplasty 2016;31(7):1459–64.

16. Mukherjee K, Pandit H, Dodd CA, Ostlere S, Murray DW. The Oxford unicompartmental knee arthroplasty: a radiological perspective. Clin Radiol 2008;63(10):1169–76.

17. Gulati A, Chau R, Pandit HG, Gray H, Price AJ, Dodd CA, Murray DW. The incidence of physiological radiolucency following Oxford unicompartmental knee replacement and its relationship to outcome. J Bone Joint Surg Br 2009;91–B(7):896–902.

18. Price AJ, Webb J, Topf H, Dodd CA, Goodfellow JW, Murray DW. Rapid recovery after oxford unicompartmental arthroplasty through a short incision. J Arthroplasty 2001;16(8):970–6.

19. White SH, Roberts S, Jones PW. The Twin Peg Oxford partial knee replacement: the first 100 cases. Knee 2012;19(1):36–40.

20. White SH, Roberts S, Kuiper JH. The cemented twin-peg Oxford partial knee replacement survivorship: a cohort study. Knee 2015;22(4):333–7.

21. Goodfellow J, O'Connor J, Pandit H, Dodd C, Murray D. Unicompartmental Arthroplasty with the Oxford Knee 2015. Goodfellow Publishers Limited.

22. Pandit H, Jenkins C, Barker K, Dodd CA, Murray DW. The Oxford medial unicompartmental knee replacement using a minimally-invasive approach. J Bone Joint Surg Br 2006;88(1):54–60.

23. Panzram B, Bertlich I, Reiner T, Walker T, Hagmann S, Weber M-A, Gotterbarm T. Results after Cementless Medial Oxford Unicompartmental Knee Replacement - Incidence of Radiolucent Lines. PLoS One 2017;12(1): e0170324.

24. Pandit H, Jenkins C, Beard DJ, Gallagher J, Price AJ, Dodd CA, Goodfellow JW, Murray DW. Cementless Oxford unicompartmental knee replacement shows reduced radiolucency at one year. J Bone Joint Surg Br 2009;91(2):185–9.