



Modular bicompartamental knee arthroplasty : Indications, technique, prosthetic design, and results

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The shifting demographics of patients with localized knee arthritis, including younger, more active patients, is a chief motivation for mounting interest in tissue preserving surgical substitutes for total knee arthroplasty (TKA). Unlinked, modular bicompartamental knee arthroplasty (MBKA) is an emerging knee-resurfacing approach that provides a conservative alternative to TKA. Arthritis involving both patellofemoral and either medial or lateral tibiofemoral compartments, with no significant deformity or bone deficiency, preserved motion, and intact cruciate ligaments, can be effectively managed with MBKA. It is tailored to treat the pathologic areas of knees with bicompartamental arthritis with the benefit of improved function and tissue conservation. MBKA done in appropriate patients, using precise technique, with appropriate implants has shown to give good short and long term functional results. Long term results using modern MBKA implants are awaited and may further establish the durability and success of the procedure.

Key words : bicompartamental knee arthroplasty ; unicompartamental knee arthroplasty ; patellofemoral arthroplasty ; patellofemoral arthritis ; trochlear prosthesis ; bicompartamental arthritis.

INTRODUCTION

Rolston et al (65) showed that at least 73 of 100 osteoarthritic patients of age > 40 years had involvement of both the medial tibiofemoral

(TF) and patellofemoral (PF) compartments, but with no lateral TF involvement. Goodfellow et al (25) suggested a link between medial PF facet osteoarthritis (OA) and medial TF disease. Severe bicompartamental arthritis (BA) of the knee involving the PF and one of the TF compartments is often managed with total knee arthroplasty (TKA) (68). The changing patients profile with localized knee arthritis, including younger, more active patients, is a major impetus for growing interest in conservative surgical alternatives for TKA (18).

Unlinked, modular bicompartamental knee arthroplasty (MBKA) is an evolving knee-resurfacing approach that provides a conservative alternative to TKA. Heekin et al (27) showed that 28% of the patients who underwent TKA had BA and infrequent impairment of cruciate ligaments, indicating that between one-fourth and one-third of patients undergoing TKA could be considered for bone and tissue preserving MBKA. To adequately serve the population with such mid-term arthritis, TKA

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*No benefits or funds were received in support of this study.
The authors report no conflict of interests.*

should not be the first option. Patient satisfaction is crucial to the arthritic population and should be considered when determining the course of treatment (65). Hawker et al (26) found that no more than 15% of eligible patients with arthritis would consider arthroplasty. The major reasons patients refused TKA were postoperative pain and disability.

Indications and contraindications

Patients with a) pain limited to PF and one of the TF compartments, b) OA (Kellgren-Lawrence grade 2 or more) involving the PF and one of the TF compartments, c) OA not more than grade 1 disease of the other TF compartment, d) correctable varus or valgus deformity, e) less than 10° fixed flexion deformity, f) no significant bone loss, g) knee flexion more than 90°, and h) intact cruciate ligaments, can be effectively managed with MBKA. Clinical TF or PF instability, varus or valgus deformity more than 15°, inflammatory arthritis, patella alta or baja are contraindications for the procedure (36,45,62,68). Although several authors (16,67,69) have refuted the classic contraindication of body mass index (BMI) >30 kg/m² for UKA, obesity cannot be entirely overlooked. Recent studies have shown increased revision rates for UKA in obese patients (9,11,37). Similarly PFA literature has shown conflicting reports regarding the effect of obesity on revision rates (44,73). Therefore extreme caution is necessary before choosing a patient with BMI ≥ 30 kg/m² for MBKA.

Benefits of MBKA

In the recent years studies have shown multiple benefits of MBKA over TKA, done for BA. Parratte et al (62) showed that the likelihood of achieving forgotten knee status was four times higher after MBKA than after TKA. Yeo et al (80) and tan et al (70) showed in their studies that the blood loss and the post-surgery drop in serum hemoglobin was significantly less in the MBKA group compared to the TKA group. Further, Wang et al (76) showed that patients with medial MBKA exhibited good frontal plane knee mechanics with the same level of knee extensor moment as healthy control limbs during walking and concluded that these patients

largely exhibited normal gait patterns. On the other hand, biomechanical studies on TKA have yielded results far from the kinematics of a normal knee (17). Compared to TKA, MBKA potentially has the other established advantages of bone and tissue sparing minimally invasive surgeries such as shorter recovery time, reduced hospital stay, less effort for rehabilitation, a lower chance of infection (41) and deep vein thrombosis (2), better patient satisfaction, and higher preference (78). Heyse et al (30) reported that out of nine patients treated with medial MBKA all patients were satisfied or very satisfied.

Technique and prosthetic design

The technique of MBKA is challenging and in principle, the UKA or the PFA parts of the MBKA is no different from the isolated UKA or PFA and so, the technical considerations and recommendations for limb alignment remains the same. Hence merely the key technical steps and the crucial points to be considered before choosing the implants are discussed below.

Medial MBKA

A mini medial parapatellar or mini-midvastus arthrotomy is used and the exposure is typically 1–3 cm longer than that used for a UKA but a little less than for a TKA. Minimal resection of the tibial plateau and restoration of the natural posterior slope of the tibia which is usually between 5° and 7° are essential to avoid medial tibial collapse (1,49). The femoral components must be placed more laterally i.e. closer to the intercondylar notch to avoid edge loading (54) and at the same time it should be kept in mind that excessive lateralization may cause the femoral component to override the trochlear component. For medial UKA, neutral correction or slight under correction has been recommended because, overcorrection may increase the risk of OA in the opposite TF compartment whereas, marked under correction may accelerate polyethylene wear and recurrence of deformity (24,29,39,64).

Although PFA had remained controversial because of high failure rates seen with early inlay-style trochlear prosthesis designs, the contemporary onlay-style and some of the inlay-style trochlear

implants have shown high success rates and good functional outcomes (19,47). Unlike with the inlay prosthesis where the local anatomy (trochlea itself and the anterior distal femur immediately adjacent to it) determines the rotation, the rotational alignment of onlay prosthesis is based on the regional anatomy (posterior condyles, epicondylar axis, and Whiteside's line) (23), which facilitate patellar tracking and eliminate the effect of native trochlear rotation seen with inlay type prosthesis. To conclude, the advantages of onlay prostheses are a) they replace the entire anterior trochlear surface, alleviating many of the issues like component malpositioning, proximal catching and subluxation seen with inlay prostheses, when having to accept the constraints of native anatomic aberrations common in this population, b) they are wider and less constraining than inlay designs, thus allowing greater excursion of the patella throughout the arc of motion (47).

For trochlear preparation, the key points, to avoid implant mal positioning, patella catching and clunk (23) are worth mentioning. Firstly, all osteophytes should be removed from the intercondylar notch and trochlear ridge so as to appreciate its true bony anatomy. Secondly, trochlear component sizing is done based on the proximal extent of the implant rather than its medio lateral coverage. The proximal extent of the trial implant should allow the patella to be engaged in the trochlear implant during full extension of the knee with activated quadriceps (traction applied to duplicate this in surgery). Thirdly for neutral patellar tracking the valgus/varus positioning of the trochlear component is determined by aligning its proximal trochlea groove with the entry of natural trochlea or in case of severe dysplasia, lateral to midline of the femur. Fourthly, the distal tip of the implant should sit two to three millimetres proximal to the apex of the intercondylar notch and not overhang, to avoid ACL impingement. Finally, for the inlay prostheses, bone is removed to allow the implant to sit flush distally with the articular cartilage both medially and laterally. But proximally, the lateral cartilage takes precedence over the medial congruity in light of the lateral to medial tracking of the patella during flexion.

The patellar resection is carried out just as for a TKA, and the patellar button placement is medialized, so as to restore the peak height of the native patella and to allow symmetric tracking (75). Remember that the quadriceps tendon articulates with the trochlear groove, and an increase in the length of the arc of the groove can increase tension in the tendon with knee flexion and ultimately decrease postoperative flexion. Therefore, the thickness of the trochlear groove or the patella must not be increased during the procedure (75). With trial implants on, lateral subluxation of the patella, if it is still present, a titrated lateral release may be necessary intraoperatively for lateral tilt and/or lateral riding of the patella implant. Equally important, is to start vastus medialis oblique exercise from day one after surgery, which is essential for better patellar tracking (23).

Lateral MBKA

A lateral parapatellar approach is used for the lateral MBKA and the PFA part is technically similar to that of the medial MBKA. For the lateral UKA, firstly, the tibial resection should be minimal (2–4 mm maximum), because the disease more often affects the femoral side and the natural slope (which is around 0° on the lateral compartment) should be reproduced. Secondly, due to “screw-home” phenomenon, a good femoral implant position in flexion may lead to an excessive internal rotation in extension, causing impingement on the tibial spine. Therefore, the positioning of femoral component in flexion should exaggerate the lateral rotation and the lateral positioning (almost on the lateral osteophytes) (59) and for the same reason, osteophytes on the lateral femoral condyle should not be removed (7). Thirdly, to compensate for the “screw home” mechanism, the tibial component is placed in 10° to 15° internal rotation as described by Pennington et al (63). Finally, at the time of implant positioning, excessive lateral placement in extension should be avoided as this may lead to an overload of the lateral part of the tibial plateau when the knee is flexed to 30° (14,58). For lateral UKAs, the main risk is overcorrection, which is more common when compared to medial UKA. To avoid

the same a 2 mm laxity must be left in the lateral compartment at the end of surgery (40,49).

Short and long term results

Clinical and functional outcome

Although complications with bicompartamental knee arthroplasty using linked (monolithic) femoral component have been reported, arising from femoral component malpositioning or malrotation, use of unlinked (modular) implants allows independent placement of the prostheses, optimized sizing and orientation with superior results (55,71). Yeo et al (80) in their study of 22 patients who underwent medial MBKA using inlay trochlea implants showed that the Knee Society Scores (KSS) (32) and Oxford knee score (OKS) (20) improved significantly at one, two and five years post-surgery compared to respective preoperative scores. Similarly, Kamath et al (36) showed that in 29 patients who underwent MBKA and followed for a minimum of two years, the post-surgery KSS and the Western Ontario and McMaster Universities (WOMAC) score (8) improved significantly compared to the respective preoperative scores. Also, Parratte et al (62) compared the preoperative KSS of 34 patients who underwent MBKA with those recorded after a mean follow up of 3.8 ± 1.7 years post-surgery and showed that the scores improved significantly after surgery. Further, Shah et al (68) showed that in 16 patients who underwent medial MBKA, the KSS and the WOMAC pain scores improved significantly at six months, one and two years post-surgery compared to the respective scores before surgery.

Knee flexion

Various studies have established that the knee flexion improves significantly after MBKA. Kamath et al (36) in their study of 29 MBKA patients showed that the mean flexion improved significantly from $122^\circ \pm 7.3^\circ$ preoperatively to $133^\circ \pm 6.7^\circ$ at a minimum follow-up of two years after surgery. Similarly, Parratte et al (62) showed that in 34 patients who underwent MBKA, the mean knee flexion increased from $116^\circ \pm 12.5^\circ$ before surgery to $130^\circ \pm 6^\circ$ after surgery. Further, Tan et al

(70) in their study of 15 MBKA patients showed that the mean knee flexion improved significantly post-surgery in comparison to the mean flexion before surgery (i.e., $125^\circ \pm 12^\circ$ vs. $109^\circ \pm 21^\circ$).

Outcome compared to TKA

Recent studies on patients who underwent MBKA with contemporary implants have shown equivalent (68) or superior (62) short-term functional outcome compared to that of TKA. Yeo et al (80) showed that the clinical and functional outcomes of patients who underwent MBKA were similar to those who underwent TKA at five years follow up. Although the authors hypothesized that MBKA would result in a superior outcome compared to TKA, it was found to be statistically equivalent. They postulated that this may be due to the significant ceiling effect of the OKS, KSS and SF-36 scores utilised in their study (13,33,56). Although well accepted and widely used, these scoring systems have inherent limited discriminating power between patients with higher scores (80).

Literature suggests that knee flexion $>90^\circ$ may be limited following TKA (66). Recent studies show that improvements in TKA designs and surgical procedures now allow patients to reach higher flexions (approximately 120°) after TKA (5,28,38,79). However many daily activities require a knee flexion $>90^\circ$ and special activities, such as squatting and kneeling require much greater knee flexion ($>120^\circ$ and $>135^\circ$ respectively) (23,35,77). Parratte et al (62) compared the knee flexion of 34 patients who underwent MBKA with those who underwent TKA matched for age, gender, BMI, study centre, operating surgeon and preoperative flexion and showed that the postoperative flexion was significantly better in the MBKA group compared to the TKA group ($130^\circ \pm 6^\circ$ vs. $125^\circ \pm 8^\circ$). Similarly Shah et al (68) and Tan et al (70) showed that the improvement in knee flexion after surgery was significantly greater in the MBKA group compared to the TKA group. Better knee flexion seen after MBKA is a potential advantage for BA patients with higher preoperative knee flexion who choose to undergo MBKA rather than TKA because following TKA, those with higher preoperative knee flexion may actually lose it (66).

Survivorship of MBKA

While the survival period for the MBKA with new generation implants is not known it is expected to last for a time interval comparable to or longer than that of the modern UKA /PFA. This is for the reason that the combined procedure is likely to answer the most common mode of failure of PFA i.e. progression of OA in the TF compartments (21,47) and one of the primary failure modes of UKA i.e. PF arthritis (1,4,10). Various studies have substantiated the successful long term outcome of isolated PFA (15,42,47,73), and studies on isolated fixed bearing medial (31,50,61) and lateral UKA (6,31,59,61,63) using either metal backed (3,6,31) or all polyethylene (12,31,49,50) implants have shown good to excellent long term results.

Bicompartmental arthroplasty performed with modular components has shown good to excellent results at \pm 10 years follow-up (71). In the series by Heyse et al (30) out of the nine patients who underwent medial MBKA, none required revision surgery at a mean follow-up of 12 years (range, 4–17 years), although one asymptomatic patient had substantial progression of lateral OA. Recent short term studies on MBKA (62, 68, 70) using contemporary modular implants have shown 100% implant survival with no serious complications in any of the patient either intraoperatively or post-surgery until the final follow up. In yet another recent study by Yeo et al (80) on 22 medial MBKA patients using modern implants one patient sustained a post-traumatic medial tibial plateau periprosthetic fracture one year after surgery which was revised to a TKA. But none of the other patients required revision surgery until five years follow up. Bicompartmental knee arthroplasty using the linked (monolithic) femoral component has gone out of favour because of the limited success with a relatively high incidence of PF complications and need for revision surgery (52, 60, 72).

Revision of MBKA to TKA

A failed MBKA may be technically easier to revise with TKA as a fallback option (30), unlike a revision TKA that can be technically difficult. In the series by Kamath et al (36) 29 patients underwent

MBKA and were followed for a minimum of two years (mean follow up -31 months ; range - 24 to 46 months). One patient required conversion of a medial MBKA to TKA after three years, without the need for stems or metal augments for TF instability, in the absence of loosening or wear. UKA has the theoretical advantage of being technically easy to revise, with limited bone loss and without ligament insufficiency, which enables conversion to TKA with conventional implants (53). Advocates of UKA have described its revision as less complicated than revision of TKA (51,57) with acceptable survivorship following revision (22,34,43,51). Similarly revision of PFA to TKA is relatively straight forward and PFA does not appear to have a negative effect on the outcome of later TKA (15,46,48,74). A likely advantage of inlay prosthesis is that it resurfaces only a minimum area, conserving the femur bone stock when compared to the onlay trochlear component, perhaps making revision surgery relatively straight forward.

CONCLUSION

The typical OA patient is no longer elderly with low activity levels. Patients suffering from arthritic knees are demanding devices that can meet higher expectations in regard to a normal feel, and the elimination of pain regardless of activity. MBKA is tailored to treat the pathologic areas of the mid-stage arthritis with the benefit of improved function and ligament and bone conservation. MBKA done in suitable patients, using precise technique, with appropriate implants has shown good short and long term results. Long term studies using modern MBKA implants are awaited and may further establish the durability and success of MBKA. The active patient provided with earlier intervention may someday be an elderly inactive patient with need of revision to a TKA. The bone conservation of the combined MBKA will provide for this transition should the need arise.

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