

Bicompartmental knee arthroplasty

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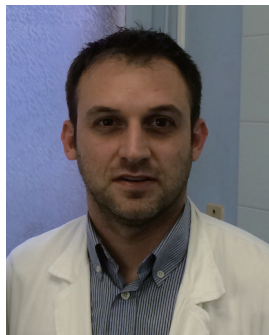
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Abstract: Total knee arthroplasty (TKA) is the most worldwide practiced surgery for knee osteoarthritis and its efficacy is mightily described by literature. Concerns about the invasiveness of TKA let the introduction of segmental resurfacing of the joint for younger patients with localized osteoarthritis. Bone stock sparing and ligaments preservation are the essence of both unicompartmental knee arthroplasty (UKA) and bicompartmental knee arthroplasty (BKA). Advantages related to BKA are the respect of knee biomechanics, lower complications rates, shorter hospital stay, faster rehabilitation. Moreover, in case of failure of the first implant the conversion to TKA is undemanding and can be compared to a standard prosthesis. Our experience suggest that BKA is a reliable technique in selected cases and especially younger people with higher functional requests can favourably profit from it. Although those results are encouraging, we still need further prospective, randomized, long-term studies to finally assess BKA indications and outcomes.

Keywords: Bicompartamental knee arthroplasty (BKA); patello femoral arthroplasty; medial unicompartmental knee arthroplasty (UKA); lateral unicompartmental knee arthroplasty

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Total knee arthroplasty (TKA) is the treatment of choice in case of advanced osteoarthritis (OA) affecting the three compartments of the knee. Although the effectiveness and high reproducibility of this surgery are responsible of its worldwide success, there are some worries about certain sub-groups of patients. In particular younger people with localized arthritis can be negatively affected by both bone stock waste and ligaments demolition related to TKA procedure.

If OA involves two of the three compartments, the treatment of choice becomes more controversial.

In these cases surgical treatments proposed include high tibial osteotomy—with or without tibial tubercle transposition, UKA without patella resurfacing, TKA or bicompartamental knee arthroplasty (BKA).

Young patients with higher functional demand and higher risk of potential revision can benefit by the implant of unicompartmental knee arthroplasty (UKA), patellofemoral arthroplasty (PFA) or the combination of the two, which are considered an effective solution for localized arthritis (1-4).

BKA has become in the last years a convincing alternative treatment to TKA due to improved techniques, prosthesis design enhancement and better clinical results achievements (5,6).

The rationale of performing a segmental resurfacing of the joint originates from the observation of normal age-related cartilage wear in cadaveric and radiographic studies. Structural changes typically progress from condyles to patellofemoral compartment (7,8). The Oxford group also observed a significant incidence of patellofemoral cartilage erosion in patients undergoing UKA; an overall rate of full thickness cartilage loss was recorded in 13% of the knees, with 9% involving the medial facet and 4% the lateral facet of the patella (9-12). Ledingham *et al.* reported a 58% incidence of bicompartamental OA in their population of patients referred to hospital and a relatively small number of tricompartmental OA. Medial and patellofemoral compartment involvement was the dominant pattern and was observed in 50% of the knees, while lateral and patellofemoral was found in 8% of patients (13). Beside

this, Heekin *et al.* demonstrated that a significant subset of candidates for TKA had intact cruciate ligaments. They subsequently established that a relevant group of patients (28%) could benefit from cruciate ligaments preservation and bone sparing BKA (14). The same authors found that women are more likely to be candidate for bicompartamental knee replacement if compared with men of the same age group.

The preservation of ligaments and the minimal impact on bone stock are the main advantages related to UKA or BKA and the keys to comprehend the functional advantages related to these procedures (15,16). The principal aim of bicompartamental arthroplasty is to restore a better functionality of the knee with a less invasive surgery if compared to TKA. This target is essentially achieved by preserving the ligaments and the bone stock (16-21). The deriving enhanced stability and maintenance of joint proprioception increase functional results as far as the better kinematic of the operated knee reduces shear stress at the implant-bone interface (22-24). Bone and ligaments sparing is considered a minimally invasive surgery, more than dimensions of skin incision (16-21).

Historically two types of femoral design have been used in bicompartamental arthroplasty; the older monolithic architecture with a fixed position of tibiofemoral and patellofemoral components, or the more recent modular unlinked design where the two parts are split and placed independently (16,22,25,26). The implant of monolithic femoral component forces the surgeon to compromise the final placement on the coronal plane to best resurface medial and patellofemoral compartments. Poor results were recorded with this design (27,28). The high incidence of persistent knee pain and reduced function made the rate of failure and subsequent conversion to TKA unacceptable, so that monolithic BKA is not suggested anymore. On the other hand, a modular unlinked trochlear and condylar prosthesis allows the individual compartmental resurfacing to be performed almost independently. The orientation and alignment of each component can be precisely adjusted relatively to the axial and rotational axes of the distal femur

to best suit any individual morphology (29).

Best results for bicompartamental arthroplasty are achieved if accurate indication is given; inclusion criteria aside from OA grade and extension were established by Kozinn and Scott: minimum of 90° flexion arc and less than 5° of flexion contracture, angular deformity of no more than 10° of varus and 15° of valgus and intact anterior cruciate ligament (ACL) (30). No limitations of weight and age are recommended, although BKA is especially suitable for young and active patients with body mass index (BMI) <32 and high functional expectations (1,2,4,16,25).

Early results for the less invasive procedure of BKA showed excellent pain relief and knee function, lower complications rate (fat embolism, blood loss, infection and venous thromboembolism), shorter hospital stay, allows faster rehabilitation and return to daily activities, if compared to TKA (4,5,15,16,31). The possible future surgery for conversion to TKA is undemanding, although revision is uncommon due to the high survival rate of the implant (21,25,29,32-34).

The great amount of existing literature states that TKA produces predictable and durable results (32). Nevertheless TKA unavoidably alters knee biomechanics and loads distribution of the joint. The preservation of a more physiological biomechanics as it happens in BKA should theoretically protect the implant and limit the stresses acting on it. The bicompartamental prosthesis should have at least the same potential survivorship capability of its more invasive alternative, however, few long-term studies are available.

In a 17-year follow up analysis Parratte *et al.* found a 54% of BKA revisions, radiographic loosening or disease progression (31). Among the 27 aseptic loosening cases, 20 knees had an isolated loosening of the patellofemoral component, 7 knees had loosening of the medial component related to PE wear and failure of the tibial plateau. An interesting aspect was that 15 of the 20 patellofemoral loosening were uncemented implant, performed before 1989; cemented components produced a significant superior long-term outcome and thus are recommended. The same authors continue to advocate for modular BKA, recognizing that cementless trochlear component fixation, crude instrumentation and techniques, and poor polyethylene quality were responsible for aseptic loosening. Other papers reported no surgical revisions after a mean follow up of approximately 12 years (35).

Revision, if required, is often carried out without difficulty and performed with the utilization of primary implant TKA. Occasionally the employment of augments

and stems is required, and the use of revision TKA is generally not necessary.

Since BKA is a relatively new procedure, strong mid-term and long-term outcomes have still to be established. Further studies should determine whether long-term durability of the implant compares to that of TKA or single compartment arthroplasty for bicompartamental disease. A characterization of the un-resurfaced compartment response to BKA and its disease-free survivorship has yet to be done.

Radiological findings in follow up for BKA show generally good implant stability. Minor cases of small radiolucencies are reported but mostly stable over the years, except for the cases needing revision as mentioned before.

Although generally considered a more complicated procedure than TKA, BKA provides the same advantages as UKA over TKA. Preservation of the intercondylar eminence with both of the cruciate ligaments, restoration of normal kinematic and gait, preservation of bone stock, maintenance of the rotational axis, maintenance of normal leg morphology, normal patella level and tracking and conservation of proprioception are the fundamental characteristics supporting partial resurfacing procedures (36-41).

UKA patients showed better functional outcomes and increased likelihood of returning to normal functional activity and to low impact sports (37). Studies regarding BKA are less powerful to assess clear benefits of this surgery over the worldwide spread TKA, although bicompartamental resurfacing concept is actually much more comparable to UKA than to TKA.

The importance of ACL and posterior cruciate ligament (PCL) retaining in knee arthroplasty has both biological and biomechanical explanation. The deriving enhanced stability of the joint is given by the less altered tibiofemoral kinematics and the preservation of proprioception. As the native biomechanics are maintained the stresses acting on prosthetic components are reduced, and shear forces between implant and bone minimized. ACL action on the resurfaced knee may be different from the native knee. Some clinical findings support it, although no *in vitro* data are available to biomechanically evaluate the ability of the ACL to maintain knee joint kinematics after bicruciate retaining BKA (15,31,35). Some authors simulated weight bearing knee flexion to investigate the role of cruciate ligaments in BKA and TKA with posterior cruciate retaining. They tested BKA with both ligaments preserved, ACL-resected BKA and the previously mentioned TKA for translational and rotational joint kinematics. They found that the translational and rotational knee joint kinematics

resemble that of the native knee in bi-cruciate retaining BKA; the PCL-retaining TKA reached similar translational characteristics but resulted in loss of rotation (22). If both ligaments are conserved femoral rollback and tibial internal rotation with flexion are maintained (19,42,43). Ultimately, though, the sparing of cruciate ligaments in BKA may be advantageous in terms of implant survivorship, stair-climb ability, joint kinematics and patient satisfaction (16,21,42-47).

The small amount of studies concerning articulation after BKA implantation generally reported a satisfactory range of motion (ROM) recovery. Most of the patients reached a complete flexion greater than 120° with no pain and complete extension (5,23).

Current studies show a trend towards common complications in line with other popular lower limb surgeries. Deep venous thromboembolism and deep infections are rare, in accordance with literature. Some cases of post-operative stiffness have been reported, however it is unclear if this is a coincidental finding or if the procedure has a tendency to provoke stiffness (48). Furthermore, there isn't any report of knee instability with walking. Some patient suffered light anterior pain, especially standing up from seated position. An exceptional case of patellar instability has been reported, treated successfully with lateral release.

Some group experienced a higher rate of complications, but it is not clear if this can be ascribed to technique, choice of implant, or patient selection.

Both BKA and TKA effectively reduce pain and improve physical function compared to pre-operative scores. Whether other advantages can be ascribed to the less invasive BKA, is not completely clear.

Firstly BKA resulted in less intra-operative blood loss, due to the minimization of tissue damage and bone sparing (49).

Parratte *et al.* found that after at least 2 years, contemporary unlinked BKA was associated with greater comfort during everyday activities (forgotten knee) and better functional outcomes, compared to TKA. These short-term results require validation in randomised trials with longer follow-ups (50).

Other authors found that BKA lead to a greater knee extension in the early post-operative period. It seem, however, that these advantages over TKA do not persist past 1 year after surgery; when adjusting for age, sex, BMI and baseline status, the early advantages offered by BKA appear to vanish. The only significant difference they observed was that in the early

post-operative period patients experience a more rapid and drastic reduction in stiffness in favour of BKA (28).

Engel recorded that 2 years postoperatively the BKA and TKA groups achieved equivalent results in clinical scores and functional testing (51).

Yeo *et al.* said that unlinked, modular BCA results in similar clinical and functional scores as TKA for medial and patellofemoral arthritis in the mid-term. Intra-operative blood loss was significantly lower in the BCA group compared to the TKA group. BCA is a viable option for a select group of young and active patients with the advantage of reduced intra-operative blood loss and equivalent functional outcomes as TKA (52).

Other groups found general clinical and functional better outcomes for BKA compared with TKA but no statistical significance was produced. In terms of KSS-function, KOOS stiffness and ADL scores, the BKA group was consistently better than TKA. The better function in the BKA group may be the result of bone and ligaments preserving nature. Postoperative knee ROM and its improvement were again greater in the bicompartmental group (53).

The knee muscles strength recovery seems to be equivalent between BKA and TKA. The less-invasive procedure however gives better results in isokinetic quadriceps strength, which is related to better performance during strenuous activities such as jogging or stair climbing (54).

In our experience we performed BKA in selected cases with bicompartmental OA, both medial unicompartmental and patellofemoral arthroplasty (*Figure 1*) and lateral unicompartmental and patellofemoral replacement (*Figure 2*); we prefer this surgical technique in young active people and our surgical results confirm very good patients satisfaction in short and medium term follow up without complications.

In conclusion, BKA shows undoubtedly important advantages such as bone-stock and ligaments sparing. Overall results of this surgery are at least comparable to that of TKA, the gold standard treatment for diffused knee OA. For its features of less-invasive surgery, BKA find its ideal indication in young patients affected by medial or lateral tibiofemoral OA, plus patellofemoral compartment involvement. Active and high-demanding patients can also benefit from BKA.

Although encouraging results are emerging from recent studies, further prospective, randomized, long-term analysis comparing BKA and TKA have to be performed before definitive treatment recommendation can be done.

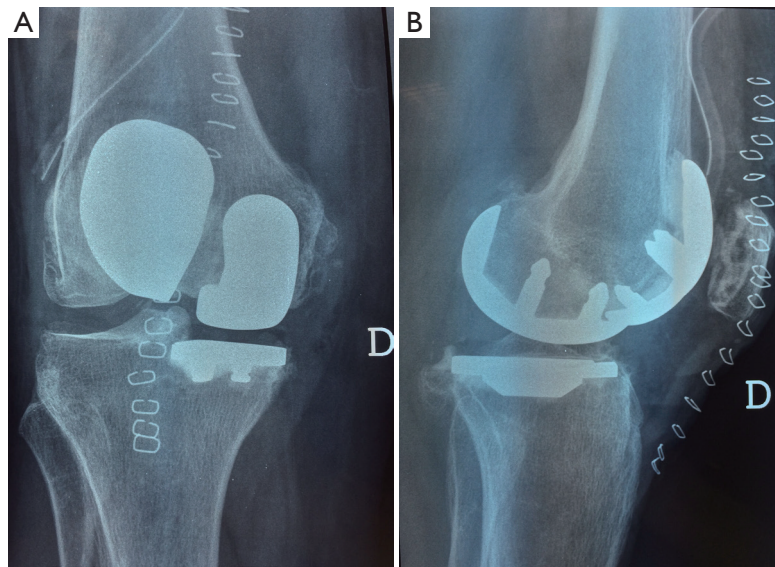


Figure 1 A case of medial unicompartmental and patellofemoral bicompartmental knee arthroplasty.

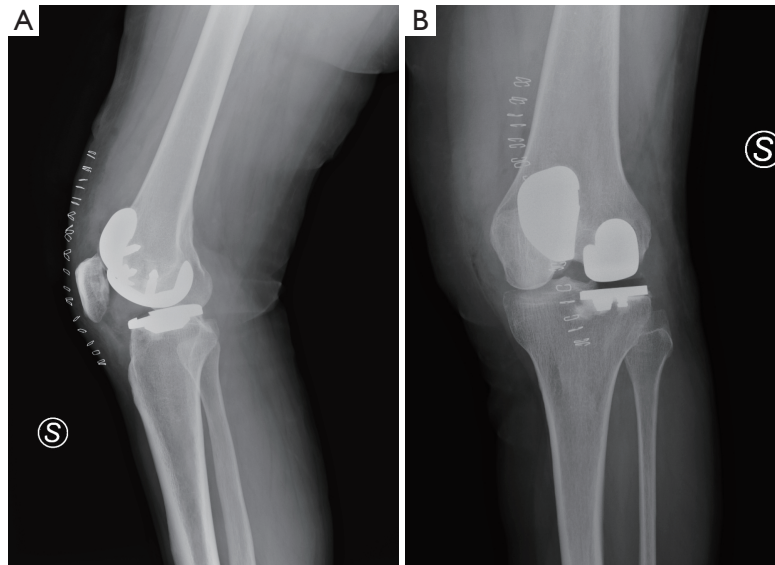


Figure 2 A case of lateral unicompartmental and patellofemoral bicompartmental knee arthroplasty.

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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