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Tissue-sparing surgery with the bi-unicompartmental knee prosthesis: retrospective study with minimum follow-up of 36 months

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Abstract Despite its theoretical advantages in terms of less invasive surgery, bi-unicompartmental knee replacement still represents a controversial knee reconstructive procedure. Many orthopaedic surgeons are skeptical about this demanding procedure despite the possibility of maximally preserving anatomy, with benefits for functional aspects such as gait, muscle activity and proprioception. Presently, no results of bi-unicompartmental knee replacement have been reported in the literature, even if several surgeons use it in selected cases. We present a retrospective analysis of our experience with this implant at a minimum follow-up of 36 months. At the latest follow-up, the mean Knee Society score was 80.58, the mean functional score was 83.5 and the mean postoperative GIUM score was 78. No implant has been revised and all patients are satisfied with the outcome. We consider bi-unicompartmental knee replacement to be a reasonable, less invasive option for the treatment of knee arthritis in selected cases.

Key words Knee • Bi-unicompartmental • Replacement

Introduction

One of the main debates in modern knee reconstructive surgery regards mini-invasive replacement, often defined as the use of smaller skin incisions and "keyhole" surgical instruments for implanting a total prosthesis that sacrifices both cruciate ligaments [1–3]. Likewise the "bi-unicompartmental replacement philosophy" has always advocated a more conservative surgical approach to the joint: minimal tibial bone removal, femoral cartilage resurfacing, conservation of the knee ligaments and minor procedures on the patellofemoral joint. Despite not yet well-defined indications, technique and results there is an increasing interest towards this surgical solution for bicompartmental knee arthritis even for the influence of unicompartmental knee replacement results [4–6].

Compared to a total joint replacement, use of a bi-unicompartmental prostheses can correct joint deformity three-dimensionally, without harming the ligamental apparatus or having to use intra-medullary instrumentation with a minor risk of bone loss, unsolvable joint infection, and practical benefits both for the patient and the surgeon, including:

- Reduced blood loss even in simultaneous bilateral implants
- Lower risk of vein thrombosis and sepsis
- Decreased use of general anaesthesia
- Minor lateral compartment lift-off because of the presence of the anterior cruciate ligament
- The chance to use all-polyethylene tibial components
- No wear on posteromedial polyethylene (edge-loading), due to the presence of an intact anterior cruciate ligament (ACL) that prevents posterior subluxation of the femur

- No effect on articular muscle sensitivity and proprioception
- Shorter hospital stays with more complete and faster articular recovery.

Moreover, these advantages indirectly reduce medical costs, permitting better economic resource management.

Clear indications for UKR have been reported in the literature, although clear protocols for bi-unicompartmental implants have not yet been published [4–6]. In Italy in 1995, an association of orthopaedic surgeons with particular interest in UKR (the Italian UKR Users Group) was founded to address, among other things, bi-unicompartmental implant indications. Using similar indications for UKR, this group has identified typical selection criteria for bi-UKR:

- Bi-unicompartmental arthrosis
- Asymptomatic patellofemoral joint
- Range of motion greater than 90°
- Axis deviation less than 10°
- No major anterior or posterior laxity
- No systemic articular disease (e.g. rheumatoid arthritis, hemophilia)
- No severe postural deficiency.

Originally indicated for selected young patients (for example, with intra-articular bicompartmental deformity following fracture of the tibial plateau), bi-UKR slowly began to be used as a treatment for atraumatic arthritis of the knee in older patients. Although not recommended for obese patients, bi-UKR can be performed in patients who are overweight, if they have the will and capacity to lose weight. The operation often helps patients return to physical activities that had been interrupted previously by pain or limb malfunction.

Because of its lesser invasiveness, even in selected patients with mild ACL insufficiency and an incomplete range of motion of the knee, a bi-UKR implant can be considered as a practical solution. However there are also absolute contraindications to bi-UKR:

- The “terrible trio”: obesity with varus in osteoporosis (OVO)
- Inflammatory rheumatism
- Symptomatic patellofemoral arthritis
- Serious combined laxity
- Flexion deformity more than 10°.

Here, we present a retrospective analysis of our experience with this technique after a minimum follow-up of 36 months.

Materials and methods

From January 1999 to January 2003, we treated 23 patients (24 knees: 17 right, 7 left) with bicompartmental arthritis of the knee with bi-unicompartmental knee replacement. There were 15 women and 8 men of mean age 66.1 years (range, 56–78 years). The diagnosis in all cases was bi-compartmental (medial and lateral) arthritis, graded according to the classification of Älback [7]. Arthritic change did not exceed grade IV in the medial-lateral compartment or grade III in the patellofemoral compartment. All patients had an asymptomatic patellofemoral joint. All patients had mild varus deformity less than 8° and a body mass index less than 30 kg/m^2. No patient had any clinical evidence of ACL laxity or flexion deformity and all had a preoperative range of motion of a least 110°. Ten knees were referred to us with a history of tibial plateau fractures and one case after failure of a high tibial osteotomy. All the patients had previously undergone surgical procedures (mean number of procedures, 2.3; range, 1–6). The unicompartmental implant used in both compartments, starting always from the most damaged, was the UC-Plus Solution (Endoprothetik, Rotkreuz, Switzerland) with an all-polyethylene tibial plateau.

An approximately 12-cm midpatellar approach with an anteromedial arthrotomy and lateral patellar retraction was used. Both components in all patients were cemented with the same technique. Full weight bearing was allowed as soon as tolerated in all patients.

At a minimum follow-up of 36 months, the clinical outcome was evaluated using both the Knee Society score [8] and a dedicated UKR score developed by the Italian Orthopaedic UKR Users Group (GIUM) [9]. The GIUM score is based on a sum of positive and negative values and indicates normal, almost normal, abnormal and poor results. Two independent orthopaedic surgeons not involved in the original surgery evaluated all patients. The hip-knee-ankle (HKA) angle and the frontal tibial component (FTC) angle were measured on long leg standing anteroposterior radiographs. Furthermore, the sagittal orientation (slope) of the lateral tibial component angle (LTC) was measured. FTC angle is that between the mechanical axis of the tibia and the medial transverse axis of the tibial component. Radiological assessment was done independently by a radiologist not involved in the study. Surgical time, hospital stay and patient satisfaction at the latest follow-up were recorded.

Preoperative planning

We approached the knee as a two-compartment problem. We first restored the most damaged compartment that was responsible for the deformity, by implanting a uni-compartmental prosthesis. The thickness of the prosthesis was chosen to correct the joint deformity. Therefore, for an implant to be successful, we needed to know the deviation angle of the lower limb and the minimum thickness of the prosthetic components (femoral + tibial, all polyethylene or polyethylene with a metal back), i.e. generally 11 or 12 mm. To do this, we radiographed the lower limbs in standing position, preferably with the patella centered on the femur and with the ankle at right angles to the radiographic plate. This was done to avoid intra- or extrarotation that could falsify the image. The axial deviation angle was calculated in varus or valgus, and subtracted from the minimum thickness (expressed in millimeters) of the prosthesis to determine the minimum bone cut (MBC):

MBC (minimum bone cut) = TP (thickness of the prosthesis) – ADA (axial deviation angle)

Therefore, with a valgus arthrosis of 8° (ADA) and a prosthesis thickness (TP) of 11 mm, the MBC for lateral bone resection is 3 mm. This value indicated how to cut the tibia, medially or laterally (varus or valgus), to bring the femoral-tibial axis back to 180°, with the minimum bone resection and with the purest respect for minimal invasiveness.

Surgical technique

We always positioned a metal marker, over the skin in correspondence of the head of the femur having a reference point during all the surgical procedure. We generally used an acetabular hip component to control the limb alignment and components position.

We prepared the surgical field as we would for a total knee replacement. The patient was in the dorsal position, at the bottom of the bed with the feet outside, so that resting the foot in question on a wedge, the knee was flexed 90° on the bed. We placed a support by the side of the thigh to keep the lower limb in position, with the knee flexed. In this way, the surgeon operated in front of the patient and could therefore check the mechanical axis constantly.

Before making an incision, we checked the anaesthetized limb carefully to evaluate how the deformity could be best corrected. As this form of treatment is not generally used for serious cases, the deformity should always be corrected. Radiographs of the hip were used to determine the position of the metal locator. We normally used a tourniquet because it is more practical, safer in terms of infectious diseases, and more reliable while the prosthesis is being cemented. As far as we know, no published data are contrary to the use of a tourniquet.

The skin incision, with the limb flexed 90°, did not exceed 14 cm, in a median or paramedian medial direction, but never a lateral one, as the bi-unicompartmental prosthesis is not suitable for cases of serious valgus. The patella was moved but not turned over, as no major surgery is involved given that this treatment is not recommended for patellofemoral problems. We removed the meniscus from the compartment with the deformity, leaving the posterior wall intact and being careful not to section the collateral ligament.

Considering the indications of the bi-monocompartmental knee replacement, the deformity should always be reducible. However, in case it should not, one could proceed with a slight release of the ligaments. We positioned the tibial cut guide. Since the height of the resection is based on pre-operation calculations, its orientation (varus-valgus) and slope were almost normal, i.e. 5°. (Remember that with the present crossed ligaments, the articular space is reduced in flexion. Therefore, it has to be enhanced by the slope and the cut of the posterior femoral condyle).

After fixing the guide, we continued to use an oscillating horizontal blade for the vertical cut, near the LCA insertion point, moving in an anteroposterior direction. We then changed to a “lamellate” blade for the sideways cut. The bone “block” was removed. Often the posterior osteophytes knock against the posterior femoral condyle when flexed or the adherence to the surrounding soft tissue causes difficulties when removing the bone. Therefore, we extended the limb and held it in traction using a pair of strong pincers while detaching the tissues from the block using a long-handled scalpel.

At this point, the tibial trial component was inserted. The size of the component was equal to that of the surface of the resected bone; the height depended on the deviation axis correction, in terms of flexion or extension of the entire inferior limb in motion. This was checked with a long metal rod, using the metal marker positioned at the head of the femur. With the knee extended, we marked the front edge of the tibial trial component on the femoral condyle, to check the size of the femoral prosthesis.

Then, we moved on to the femoral condyle with the knee flexed or extended, regardless of the cutting guide that was already used (it is better if this is based on the thickness of the tibial component, so that it can be positioned automatically at right angles to the tibia cut at least in one plane). Perpendiculars are important here, in relation to the tibial component and the mechanical femur axis (evaluated, here too, with a metal rod, to find the metal marker at the head of the femur). This should be the case on the frontal plane so that the two components have the largest contact surface for the whole knee flexion-extension movement, and do not have edges that would cause the polyethylene to wear. On the sagittal plane, the correct position is shown by how far the curve of the cutting guide fits the condyle, with the knee flexed and the tibial trial component in place.

The femoral condylar cartilage was removed, make chamfer cuts in the bone and holes for the pegs and the prosthesis fitting. The trial components were positioned, checking the mechanical axis and the ligament balance. After correcting the deformity and the ligament balance with the trial prosthesis, we now moved on to the contralateral compartment. We positioned the tibial cut guide and checked the articular space. Now in the realigned knee we choose the height of the cut on the basis of space (in terms of flexion and extension).

If necessary, distractors may be used to tighten the ligaments and open the articulation. In flexion, the space is reduced; we

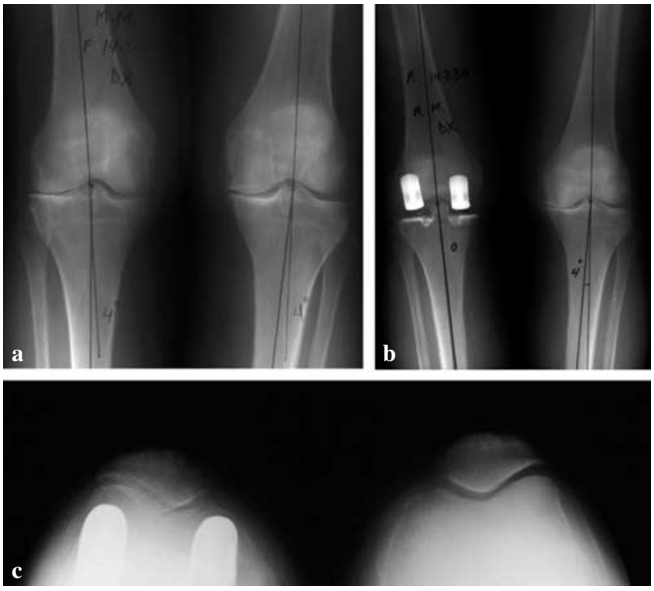

Fig. 1a-c a Preoperative AP radiographs of a patient suffering of a bicompartimental knee arthritis on the right side. **b** Postoperative AP radiographs. **c** Well balance patello femoral joint after the implant

could calculate and obtain it by acting upon the posterior slope and the osseous resection of the posterior femoral condyle.

We continued in exactly the same way as with the bone resection and when creating space for the prosthetic components. We positioned the femoral trial components and selected the definitive tibial thickness, based on the optimum ligament balance in terms of extension and flexion and the mechanical axis, almost 180°, without pro or recurvation. We always cemented both the components in a single operation, using cement loaded with antibiotic. We first implanted the two tibial components and then the femoral one. The limb was extended and compressed securely against the chest of the operator to complete the operation (Fig. 1). Then, we released the tourniquet, ensured hemostasis, drained and stitched in layers, and applied a vascular elastic bandage.

Postoperative care

The vacuum drain was removed 24 h after surgery and on day 2, patient began a continuos passive mobilitation (CPM). Starting on day 3, patients began a partial weight-bearing with crutches. On day 5, they were discharged from hospital and transferred to a rehabilitation center. The postoperative protocol was the same as for total knee replacement. After 30 days, patients were advised to leave their crutches and for usual daily activities.

Results

The mean pre-operative flexion was 120° (range, 110°–130°) and the mean pre-operative HKA angle was 174.5° (range, 171°–178°). Pre-operatively, the mean Knee Society score was 45.1 (range, 39–50) and the pre-operative functional score was 49.7 (range, 44–56).

The mean surgical time was 118.8 min (range, 90–132 min). Intra-operatively in 3 cases (12.5%), we caused the detachment of the tibial spine bone block because of excessive ACL tension. In all 3 cases, this complication was successfully managed with internal fixation, a long brace hinged in extension and avoidance of weight bearing for the first 4 weeks postoperatively. This intra-operative complication had no influence on the outcome at the latest follow-up (40.2 months).

The mean hospital staying was 8.2 days (range, 4–16 days). Two patients (8.7%) required postoperative blood transfusions. The mean follow-up period was 57 months (range, 36–86 months). In this period, no implant required revision.

At the latest follow-up, the mean Knee Society score was 80.58 (range, 70–100) and the mean functional score was 83.5 (range, 73–100). The mean post-operative GIUM score was 78 (range, 67–90). All knees had a range of motion greater than 120° and 20 patients (87%) were able to walk for more than 1 km. According to the GIUM score, there were no poor or abnormal results. All knees were stable at clinical testing (data not shown). The mean HKA angle was 177.4° (range. 175°–182°). The mean FTC angle was 87.4° (range, 84°–91°) and the LTC angle was 4.8° (range, 2°–7°). No major signs of radiological loosening were observed.

All patients were satisfied with the outcomes and all declared that would have the same procedure again, if necessary.

Discussion

Some surgeons have been experimenting with tissue-sparing joint replacement despite an only recent interest by the international orthopaedic community in less invasive surgical procedures [1–3]. The literature does not contain reports showing results of a series of bi-UKR. However, recently, several biomechanical studies have demonstrated that maintenance of the anterior cruciate ligament and its mechanoreceptors may result in a better functional result [10–13]. Furthermore knee kinematics during flexion following bi-UKR more closely resembles the intact knee while TKR leads to results far from that of a normal knee [14].

There are some practical advantages for this implant, such as less blood loss, tissue sparing, shorter hospital stay, and faster recovery. These benefits emphasise the less invasive nature of this procedure.

This is the first series to report the results of bi-UKR, at a minimum follow-up of 36 months. There were no revisions and all the clinical scores were improved to similar values for TKR. All patients were satisfied with the results and would undergo the same procedure again, if necessary.

The most common complication occurred intra-operatively. We experienced in 3 cases (12.5%) of bone block tibial spine detachment due to unbalanced anterior cruciate ligament tension. Even if this complication was always managed successfully with internal fixation, without influence on the final outcome, we recognise that in these cases the recommended postoperative immobilisation and avoidance of weight bearing do cancel the theoretical advantages of this procedure. Therefore, in 2003, we introduced a computer-assisted technique for bi-UKR to overcome this complication, resulting in better balanced and aligned implants [15].

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