Bi-unicompartamental and combined uni plus patellofemoral replacement: indications and surgical technique

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Abstract

The anatomy and orientation of the condyles and the trochlea are not standard, but related to morphotype, gender and race. Consequently, the extreme variability in their dimension, and in the distance and angle between the axis of the condyles and of the trochlea, often necessitates a “custom-made” replacement. This may be achieved through the use of small implants. Bicompartamental osteoarthritis with intact ligaments should be addressed with bi-unicompartamental (bi-UKR) or UKR plus patellofemoral replacement (PFR). These options allow selective replacement of the worn compartments and a customised fit of the small implants to the native knee anatomy. Clinical consequences are restoration of the native knee kinematics and overall better function.

Key Words: bicompartamental, knee replacement, patellofemoral, replacement, unicompartamental.

Introduction

The aim of any treatment for knee osteoarthritis (OA) is to permit the patient to return to the desired level of physical activity without residual pain and with knee function that is as similar as possible to that of the native knee. In current clinical practice, the surgical options include tibial or femoral osteotomy, total knee replacement (TKR), unicompartamental knee replace-

ment (UKR), and patellofemoral replacement (PFR) (1-4). TKR is the most studied and widespread option. Many orthopaedic surgeons consider it the only reliable surgical option in advanced knee OA, even though it often fails to allow the patient to return to the desired level of physical activity (5, 6).

The development of unicompartamental and patellofemoral prosthesis designs and the evolution of the techniques led to excellent clinical and biomechanical results for UKR and PFR (3, 4, 7, 8). These are now well-accepted surgical procedures for addressing unicompartamental knee OA. Their benefits compared to TKR are tissue sparing, reduced surgical morbidity, faster recovery, better functional results and easier revision surgery. These goals are obtained by replacing only the damaged compartment, while preserving the others as well as the ligaments and the capsule; this approach makes it possible to respect the native knee kinematic and biomechanics (7, 8).

These excellent results extended the indications for small implants to bicompartamental OA, too (9, 10). Indeed, the versatility of these implants is such that they can be adapted to almost all knees, allowing the creation of “custom-made” prostheses that preserve, as much as possible, the intact parts of the native knee. In particular, preservation of the anterior and posterior cruciate ligaments is essential for normal proprioception and knee kinematics and constitutes the key point of bicompartamental replacement.

Indications for bi-unicompartamental replacement

Preoperative evaluation consists of clinical and radiological examination, but also a detailed anamnesis with particular attention to the patient's level of activ-

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Fig. 1. A 68-year-old woman with bi-compartmental tibiofemoral OA of both knees. Pre-operative radiographic evaluation includes: standing whole-limb AP view (A), PA Rosenberg's view (B), lateral view (C) and skyline view at 30° of knee flexion (D).

ity. Radiographic evaluation should include standing whole-limb anteroposterior (AP) view, posteroanterior (PA) Rosenberg's view, and lateral and skyline views at 30° of knee flexion (**Fig. 1**).

Our indications for a simultaneous bi-unicompartamental knee replacement are: medial and lateral tibiofemoral OA (Kellgren-Lawrence grade II or higher), absence of patellofemoral OA (or no symptoms), functional cruciate ligaments, range of movement >90°, flexion deformity <10°, varus-valgus deformity <15°, and tibial bone defect <12 mm.

Contraindications are: active inflammatory arthritis, knee instability, severe coronal or sagittal deformity, and tibial bone defect >12 mm (11, 12).

Patellofemoral OA is not a contraindication, but it should be no more than grade II according to Iwano et al. (13) and asymptomatic. Anterior knee pain with secondary patellofemoral joint degeneration should be excluded during patient selection.

We do not apply cut off values for patient age or weight, although this procedure is particularly recom-

mended in patients younger than 65 years with a BMI <32 and an adequate level of functional activity. In some carefully selected cases of active men younger than 60 with medial and lateral tibiofemoral OA and anterior cruciate ligament (ACL) deficiency, bi-UKR and simultaneous ACL reconstruction may be considered (11, 12).

Surgical technique for bi-unicompartamental replacement

Basically, bi-UKR uses the same surgical technique applied in UKR, but in both tibiofemoral compartments simultaneously. Two surgical approaches are possible: a single medial mini-mid-vastus incision or a double parapatellar mini-skin incision (11, 12) (**Fig. 2**).

The first option consists of a minimally-invasive medial parapatellar incision, 8-10 cm long. After a mini-mid-vastus arthrotomy, both the tibiofemoral compartments are exposed without patellar eversion. The

Fig. 2. A: Mini-invasive medial parapatellar incision in a left knee. **B:** Double parapatellar approach in a left knee.

second choice is a double parapatellar approach. This procedure starts with the compartment in the side of the deformity; after correction of the deformity by implant trial positioning, the other compartment is addressed. Essentially, it is like performing two successive UKRs. The main advantage of this approach is its capacity to further reduce damage to the extensor mechanism. Since the superomedial area of the knee is respected, the superomedial geniculate artery ensures patellar blood supply.

Once the chondral surfaces are exposed, bone cuts are performed starting from the tibia. The coronal orientation of the tibial cut must be perpendicular to the epiphyseal axis of the tibia, not to the whole axis of the tibia, in order to respect the height and obliquity of the joint line and avoid any subsequent release. In the sagittal plane, the orientation of the tibial cut (slope) should be 0 to 3° in the lateral compartment and 3 to 6° in the medial one. This reproduces the native slope and preserves ACL and posterior cruciate ligament (PCL) stability.

Once the tibial cuts have been made, attention should be paid to the different shapes of the medial and the lateral tibial plateau. The lateral one is more symmetric and semi-circular than the medial one. Therefore, it is recommended to use a semi-circular tibial component, which allows a better fit and better coverage of the lateral tibial surface. The thickness of the bone resected is between 3 and 7 mm, less in the compartment with the deformity.

The next step to check knee stability in extension using

spacers. It is useful to mark the anterior limit of the tibia on the femoral condyles in order to use this as reference for correct positioning of the femoral tray. The distal femoral cut is performed in extension, the posterior cut in flexion; cutting should be done using two different tensor guides that ensure the same amount of bone resection, so as to obtain a balanced flexion-extension gap. Only 2-3 mm of bone and cartilage, an amount corresponding to the thickness of the femoral component, is removed from the femur (resurfacing).

Moreover, no releases are performed and, indeed, should not be performed. The aim is to correct the deformity, not the morphotype (11, 12).

The position of the femoral components in the coronal plane should be lateralised as much as possible. This allows the femoral components to remain perpendicular to the tibial plateau throughout the arc of motion, both in extension and in flexion.

A great advantage of the bi-UKR is the possibility to choose different sizes of femoral component for the medial compartment and the lateral compartment, thus allowing a close fit of the UKR to the native knee (Fig.3). This “custom-made” knee replacement recreates knee motion and stability in every plane, also in rotation (7, 12).

Once stability and arc of motion have been checked with implant trials, the bone surfaces are prepared for cementing by drilling and removal of the sclerotic bone. Cementing starts from the lateral tibial side (less accessible), proceeds with the medial one and ends with the femoral components.

Fig. 3: A: Bi-UKR, by using different sizes and orientation of the lateral and medial components, allows a close fit to the native anatomy. B: Postoperative radiographic evaluation of the bi-UKR. The orientation of the components is different from medial to lateral to allow a close reproduction of the native anatomy.

When a concomitant ACL reconstruction is performed, the surgical procedure begins with graft harvesting. An autologous hamstring graft is recommended to reduce morbidity and skin incisions. Allografting is another viable option. Then, ACL bone tunnels are drilled, and the graft is placed and fixed on the femoral side. Surgery proceeds with bi-UKR as previously explained. After cementation, the graft is fixed on the tibial side (Fig.4).

Indications for combined uni and patellofemoral replacement

Simultaneous UKR and PFR follow the same philosophy as bi-UKR: preservation of the non-affected compartment of the knee, preservation of both cruciate ligaments, and implantation of a tailored prosthesis to maintain the native kinematics of the knee and allow the patient to “feel the knee as his own” even after surgery (7, 8).

Candidates for simultaneous UKR+PFR may be patients with symptomatic lateral or medial tibiofemoral OA (Kellgren Lawrence grade II or higher) and symptomatic patellofemoral OA; or with symptomatic patellofemoral OA (Iwano grade II or higher) and deviation of the mechanical axis of the knee (varus $>3^\circ$ and valgus $>5^\circ$) due to unicompartmental tibiofemoral wear. Other essential features are: ACL and PCL competence, range of movement $>90^\circ$, and flexion deformity $<10^\circ$. Older age and excessive weight are

not absolute contraindications (14-16). The radiographic evaluation is the same as described for bi-UKR. Nevertheless, indications for UKR+PFR are even more restrictive than those for bi-UKR and isolated unicompartmental tibiofemoral OA with symptomatic patellofemoral OA and functional ACL accounts for 15% of our patients (14, 15). For these reasons, the clinical and imaging assessment of the patellofemoral joint must be very accurate. We developed an algorithm allowing us to identify when performing PFR in association with UKR is useful. This algorithm is based on three main criteria and two secondary criteria.

The three main criteria are: patellofemoral pain; patellar malalignment or lateral patellofemoral wear on X-ray axial view; and intraoperative findings of grade 3-4 patellofemoral chondral degeneration. The two secondary criteria are: female gender and BMI >32 . If two of the main criteria or one main criterion and two secondary ones are present, isolated UKR will fail and UKR+PFR must be considered.

Surgical technique for combined uni and patellofemoral replacement

The skin incision is the same as for UKR but extended 1-2 cm proximally (14, 15). A medial parapatellar skin incision and a mini-mid-vastus approach are used for medial UKR; a lateral parapatellar skin incision and capsulotomy through the lateral intermuscular septum are used for lateral UKR. Both these approach-

Fig. 4. A 57-year-old man, ski-instructor, with bi-compartmental tibiofemoral OA and ACL insufficiency. The indication was bi-unicompartamental knee replacement with concomitant ACL reconstruction with allograft (A-D). Postoperative radiograph evaluation (E-F) showed correction of the mechanical axis and respect of the native joint line.

es aim to reduce quadriceps damage and enhance functional recovery.

The surgical procedure starts with UKR, using the tibia-first technique as previously explained in the bi-UKR section. After placement of the chosen component trials, patellofemoral replacement can start.

Patellofemoral “onlay” designs cover broader indications and are easier to implant than “inlay” designs. The latter are more anatomical and respect patellar tracking. However, in 78% of cases, patellofemoral OA is secondary to trochlear dysplasia, and the anatomy and the patellar tracking therefore have to be corrected. In these cases, only the onlay design can replace the hypoplastic lateral facet of the trochlea and provide the correct lateral trochlear inclination. The same applies in cases of patella alta, in which an onlay PRF extends more proximally than an inlay PFR and can improve patellar tracking in the first, fundamental, 30° of knee flexion. For all these reasons, the inlay design should be used only in selected patients with a non-dysplastic trochlea and no major deformity (**Fig. 5**).

After proper evaluation of any deformity and

trochlear dysplasia, the anterior femoral cut is performed. It should be perpendicular to the sagittal axis of the joint, represented by Whiteside’s line. In patients with a non-dysplastic trochlea, the amount of bone and cartilage removed should be determined by the amount of wear. In the presence of trochlear dysplasia, the lateral defect should be evaluated and corrected, re-orienting the new trochlea. In lateral facet aplasia, the bone defect must be corrected, but being careful to avoid lateral overstuffing and an excessive lateral release. Moreover, the anatomy and orientation of the condyles and the trochlea are not standard, but related to morphotype, gender and race. Consequently, the extreme variability in their dimension, and in the distance and angle between the axis of the condyles and of the trochlea, often necessitates a “custom-made” replacement (different and often non-proportional components between the two compartments). This “custom-made” bi-compartmental replacement is able to recreate the normal anatomy and kinematics (**Fig. 6**).

The guide for preparing the trochlear box is then placed. It should be centred with respect to the medio-

Fig. 5. Medial UKR + PFR. A: An "onlay" design PFR + medial UKR were used in the right knee. B: An "inlay" design PFR + medial UKR were used in the left knee.

Fig. 6. Variability of the orientation of the condyles and the trochlea requires independent replacements to reproduce the native anatomy. X-rays show two knees submitted to bi-compartmental replacement. To allow reproduction of the native anatomy, the orientation of the components differed between the patients.

lateral width and oriented according to the desired trochlear groove. After guide fixation with screws, the box for the trochlear component is created with a high-speed bur, which removes a minimal amount of bone and cartilage, corresponding to the thickness of

the prosthesis. Accurate preparation of this box is essential to avoid any damage to the transition zone between the prosthesis and the surrounding native cartilage. The distance between the trochlear component of the PFR and the femoral component of the UKR

Fig. 7. Careful positioning of the trochlear and condylar component should avoid any step or impediment to a smooth flexion-extension movement. The transition zone should be at least 3 mm wide.

should be at least 3 mm to guarantee a proper and smooth flexion-extension kinematics without patellar clunk or tilting (Fig. 7).

Patellar preparation should be done in extension to reduce patellar eversion and mechanical stress on the patellar and quadriceps tendon. The technique does not differ from the one used in TKR. The need for a lateral release is common, especially in PFR secondary to trochlear dysplasia due to consequent lateral retinaculum tightness.

References

1. O'Rourke MR, Gardner JJ, Callaghan JJ, et al. The John Insall Award: unicompartmental knee replacement: a minimum twenty-one-year followup, end-result study. *Clin Orthop Relat Res.* 2005;440:27-37.
2. Schallberger A, Jacobi M, Wahl P. High tibial valgus osteotomy in unicompartmental medial osteoarthritis of the knee: a retrospective follow-up study over 13-21 years. *Knee Surg Sports Traumatol Arthrosc.* 2011;19:122-127.
3. Pandit H, Jenkins C, Gill HS. Minimally invasive Oxford phase 3 unicompartmental knee replacement: results of 1000 cases. *J Bone Joint Surg Br.* 2011;93:198-204.
4. Lustig S, Magnussen RA, Dahm DL. Patellofemoral arthroplasty, where are we today? *Knee Surg Sports Traumatol Arthrosc.* 2012;20:1216-1226.
5. Newman J, Pydisetty RV, Ackroyd C. Unicompartmental or total knee replacement: the 15-year results of a prospective randomised controlled trial. *J Bone Joint Surg Br.* 2009;91:52-57.
6. Weale AE, Halabi OA, Jones PW. Perceptions of outcomes after unicompartmental and total knee replacements. *Clin Orthop Relat Res.* 2001;(382):143-153.
7. Banks SA, Frely BJ, Boniforti F, Reischmidt C, Romagnoli S. Comparing in vivo kinematics of unicondylar and bi-unicondylar knee replacement. *Knee Surg Sports Traumatol Arthrosc.* 2005;13:551-556.
8. Wünschel M, Lo J, Dilger T. Influence of bi- and tri-compartmental knee arthroplasty on the kinematics of the knee joint. *BMC Musculoskelet Disord.* 2011;12:29.
9. Heyse TJ, Khefacha A, Cartier P. UKA in combination with PFR at average 12-year follow-up. *Arch Orthop Trauma Surg.* 2010;130:1227-1230.
10. Paratte S, Pauly V, Aubaniac JM. Survival of bicompartamental knee arthroplasty at 5 to 23 years. *Clin Orthop Relat Res.* 2010;468:64-72.
11. Romagnoli S, Verde F, Bibbiani E. Bi-unicompartmental knee prostheses. In: Scuderi GR, Tria AJ (Eds) *Minimally Invasive Surgery in Orthopaedics.* Springer, Heidelberg. 2010;327-340.
12. Romagnoli S, Verde F, Corbella M, et al. The bi-unicompartmental knee prosthesis. In: Confalonieri N, Romagnoli S (Eds), *Small Implants in Knee Reconstructions.* Springer, Milan. 2013;81-93.
13. Iwano T, Kurosawa H, Tokuyama H, Hoshikawa Y. Roentgenographic and clinical findings of patellofemoral osteoarthritis. With special reference to its relationship to femorotibial osteoarthritis and etiologic factors. *Clin Orthop Relat Res.* 1990;(252):190-197.
14. Romagnoli S, Verde F, Bibbiani E, et al. Protesi femoro-rotulea isolate e mono + FR. *Minerva Ortopedica e Traumatologica.* 2008;59 (Suppl. 1).
15. Romagnoli S, Verde F, Corbella M, et al. Bicompartamental prosthesis. In: Confalonieri N, Romagnoli S (Eds), *Small implants in knee reconstructions.* Springer, Milan. 2013;105-116.
16. Romagnoli S, Verde F, Bibbiani E, et al. La protesi femoro-rotulea: a che punto siamo? *Archivio di Ortopedia e Reumatologia.* 2008;119:29-30.