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ORIGINAL PAPER

# Anterior cruciate ligament reconstruction in association with medial unicompartmental knee replacement: a retrospective study comparing clinical and radiological outcomes of two different implant design

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## Abstract

**Purpose** Unicompartmental knee arthroplasty (UKA) combined with anterior cruciate ligament (ACL) reconstruction has recently been suggested as a feasible treatment option for young and active patients with medial compartment osteoarthritis (OA) and ACL deficiency. The aim of this study is to evaluate retrospectively the outcomes of two different implant designs in patients with medial OA secondary to traumatic ACL rupture, who underwent combined ACL reconstruction and unicompartmental knee replacement.

**Methods** From January 2007, to December 2013, 24 patients with medial OA secondary to ACL rupture underwent medial unicompartmental knee arthroplasty (UKA) and ACL reconstruction. Nine patients received a mobile bearing UKA (Group 1) and fifteen a fixed-bearing one (Group 2). The mean follow-up was 53 ± 8.3 months for Group 1 and 42 ± 6.7 months for Group 2. Knee Society Score (KSS), Western Ontario and McMaster Index of Osteoarthritis (WOMAC) index and radiological evaluation used to assess the implant loosening alignment of the knee joint and tibial slope were recorded pre-operatively and at the last follow-up.

**Results** At the final follow-up, all patients showed statistically significant clinical improvements with respect to the pre-operative values ($p < 0.05$). No significant difference was observed in WOMAC index and KSS both objective and functional between groups at the last follow-up (KSS obj. 73.4 ± 9.3 vs 77.3 ± 10.5; KSS funct. 86.2 ± 6.2 vs 84.7 ± 5.9; WOMAC 79.3 ± 7.3 vs 81.3 ± 7.6 for Group 1 and 2, respectively). No differences in radiolucent lines were found between the groups.

**Conclusion** The use of different prosthesis design (fixed- or mobile-bearing) during a combined procedure of ACL reconstruction and medial unicompartmental arthroplasty does not affect the middle-term clinical and radiological outcomes.

**Keywords** ACL reconstruction · Unicompartmental knee replacement · Fixed bearing · Mobile bearing · Medial osteoarthritis

## Introduction

Medial compartment knee osteoarthritis (OA) is a common degenerative joint disease and cause of disability in people over 50 years of age [1]. Biomechanical stressors [2, 3], varus knee alignment [4], knee adduction moment (KAM) [5] and rupture of the anterior cruciate ligament (ACL) [6, 7] are among the major factors responsible for the onset of medial

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compartment OA. Knee joint instability due to ACL insufficiency leads to various degenerative alterations of the joint, such as cartilage lesions, meniscal tears and worsening of varus morphometry, leading to a gradual thinning of the medial articular rim eventually resulting in posteromedial OA [8–10].

In the case of younger and more active patients affected by medial OA and ACL deficiency, it is common to observe a posteromedial OA consequent to an untreated ACL rupture; differently, in older patients, an ACL failure is the consequence of the arthritic phenomenon especially located in the anteromedial part of the knee [11–13].

There are numerous options of treatment that include isolated ACL reconstruction with biological chondral treatments, high tibial valgus osteotomy (HTO) with or without ACL reconstruction, unicompartmental knee replacement with or without ACL reconstruction in one or two stages or total knee replacement (TKR) [14–16].

Unicompartmental knee arthroplasty (UKA) combined with ACL reconstruction has been recently suggested as a feasible treatment option for young and active patients with medial compartment OA and ACL deficiency [17, 18]; however, a limited experience exists in this field.

When ACL reconstruction is associated with partial knee replacement, the bearing modularity (fixed or mobile) of the UKA continues to be discussed even though the design concept is fundamentally different but both bearings generate similar outcomes [19, 20].

The aim of this study is to retrospectively evaluate the mid-term clinical and radiological outcomes of two different bearing partial knee arthroplasty designs in young and active patients with medial OA secondary to traumatic ACL rupture who underwent a single-stage procedure combining ACL reconstruction and medial unicompartmental knee replacement.

## Materials and methods

From January 2007, to December 2013, a total of 24 patients (20 male and four female) with diagnosis of medial OA secondary to untreated ACL rupture underwent medial unicompartmental knee arthroplasty and ACL reconstruction and were enrolled in the present study. All the surgeries were performed in a single-stage procedure by a single experienced senior surgeon in a high volume Orthopaedic Surgery Department.

The patients involved in the study were young and active with a symptomatic bone-on-bone knee OA (Kellgler-Lawrence grade 4 [21], Type IA–PMOA in accordance with varus knee classification of Thienpont and Parvizi [22]) occurred years after an untreated complete ACL rupture identified as the possible cause of the early OA onset. ACL tear was diagnosed by clinical test (Anterior drawer test, Lachman test and Pivot shift test) and MRI; cartilage lesions in other compartment of the knee, meniscal tears and other knee ligaments injury were also detected, if present. Pre-operative anteroposterior (AP) and lateral weight-bearing, axial views of the patella, Rosenberg view, full-length (hip-knee-ankle) weight-bearing and varus-valgus stress radiographic studies were obtained in order to confirm the osteoarthritic pattern, lower limb alignment, reducibility of the deformity and to exclude lateral compartment narrowing.

All the patients included in this retrospective study met also the following inclusion criteria: BMI $< 30$ Kg/m$^2$, isolated medial compartmental OA, reducible varus knee deformity $< 10°$, and no patellofemoral pain. The patients who presented history of previous surgery on either knee, detection of cartilage lesions or osteoarthritic changes of lateral compartment or lateral aspect of patello-femoral joint, multiligamentous involvement (posterior cruciate ligament (PCL), lateral collateral ligament (LCL), medial collateral ligament (MCL), posteromedial or posterolateral corner), concomitant ipsilateral leg fracture and cardiovascular or neurological disease were excluded from the study.

On a total of 24 patients, nine received a mobile bearing UKA (Oxford UKA, Biomet China, Bridgend, UK) (Group 1) and 15 a fixed-bearing one (SIGMA HP, DePuy Synthes Inc., Warsaw, IN) (Group 2). As routinely done for all patients that undergo replacement surgery in our Department, objective and functional Knee Society Score (KSS), Western Ontario and McMaster Index of Osteoarthritis (WOMAC) index and radiological evaluations were recorded pre-operatively. The same clinical and radiological evaluation was then performed at an average follow-up of $53 \pm 8.3$ months for Group 1 and $42 \pm 6.7$ months for Group 2. Written informed consent was obtained from all patients before the beginning of the retrospective study in order to obtain the permission of recording sensible data. The study was conducted upon approval of the Institutional Review Board of our Institute (Prot. “UNIACL_ComEt CBM 42/18 OSS”).

### Surgical technique

All patients underwent combined UKA and ACL reconstruction in the same surgery session. All procedures were carried out under spinal anaesthesia using a minimally invasive technique with autologous semitendinosus tendon used as graft for all ACL reconstructions. With the patient in supine position and using tourniquet, a diagnostic arthroscopy was used to confirm the diagnosis. Then, the intercondylar notch was cleaned from ACL stump and a minimal notchplasty was performed. A femoral tunnel (7 or 8 mm in diameter and 20 mm in length) was arthroscopically performed through the anteromedial portal. A central knee skin incision with mini-invasive midvastus approach of the extensor mechanism was then performed. The same skin incision was extended some centimetres distally on the tibia to allow harvesting of the semitendinosus tendon. The harvested tendon diameter was measured and looped in a four-stranded graft, locking the ends with a non-absorbable hig-resistance suture. The femoral tunnel was then arranged according to the diameter and length of the measured graft.

Then, standard UKA was performed with some precautions: differently to UKA without ACL reconstruction in an ACL-deficient knee, the tibial slope was not reduced and the anatomic slope was recreated; the tibial resection was performed few millimetres medial to the ACL stump to allow correct positioning of the tibial tunnel. The femoral cuts were made in a standard manner for UKA guided by specific instrumentation. The tibial tunnel was made with tibial ACL guide (Acufex, Smith & Nephew Inc. Andover, MA, USA) set to 55° angle in the horizontal plane and positioned more laterally than a standard procedure in order to avoid weakening of the medial tibial plateau and any conflicts with the tibial component (Fig. 1).

During the cementation process, a reamer equal in size to the tunnel diameter was introduced into the tibial tunnel to avoid the cement from entering the tunnel and creating graft damaging (Fig. 2). The excess of cement was carefully removed and a sample of tibial insert was introduced to obtain the perfect ligament tensioning and balance. After the polymerisation of cement, the graft was passed through the tunnels (Fig. 3) and was fixed to the femur with an EndoButton® (Smith&Nephew, Memphis, TN, USA) and to the tibia with interference absorbable screw (Smith & Nephew Inc. Andover, MA, USA) 1 mm larger or the same diameter as the drill size of the tunnel and passive metallic screw positioned 1 cm distally to the tunnel used as a post with a non-absorbable high-resistance suture tied around. The last step was to put the definitive insert (mobile- or fixed-bearing) with the adequate thickness in order to restore the best ligaments tensioning in both flexion and extension. At the end of the procedure, two drains were placed into the knee joint.

## Post-operative care and rehabilitation protocol

Rehabilitation protocol was the same for both groups. After surgery the affected knee was flexed for four hours and drains were removed the day after the surgery. Walking with partial weight bearing was permitted with two crutches and brace with no limitation of range of motion (ROM) from the day after the surgery; at the same time, isometric muscle exercises and restoration of ROM were started. Flexion was allowed < 90° in the first week and as tolerated in the following weeks. From the fourth week, after restoring the complete ROM, proprioception exercises were added.

**Fig. 1** The tibial tunnel was made with tibial ACL guide set to 55° angle in the horizontal plane and positioned more laterally than a standard procedure in order to avoid weakening of the medial tibial plateau and any conflicts with the tibial component

## Follow-up assessment

Knee Society functional/objective Scores (KSS) [23] and Western Ontario and McMaster index of osteoarthritis (WOMAC) [24] were administered pre-operatively and at the final follow-up. At same time, radiological evaluation was conducted on AP and lateral weight-bearing X-ray, axial views of the patella and full-length (hip-knee-ankle) weight-bearing, all for the evaluation of the change in the posterior tibial slope degrees, alignment of knee joint and any presence of loosening of components. Patients' evaluations pre-

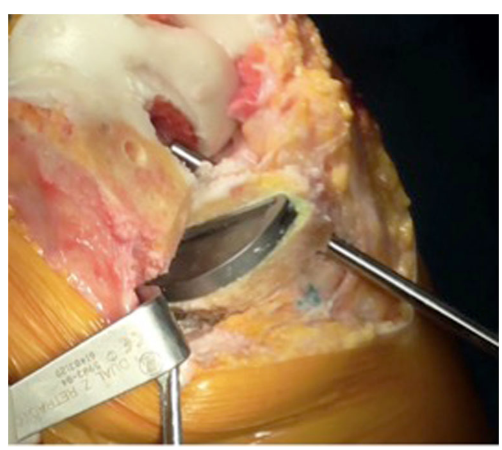

**Fig. 2** A reamer equal in size to the tunnel diameter was introduced into the tibial tunnel to avoid the cement from entering the tunnel and creating graft damaging

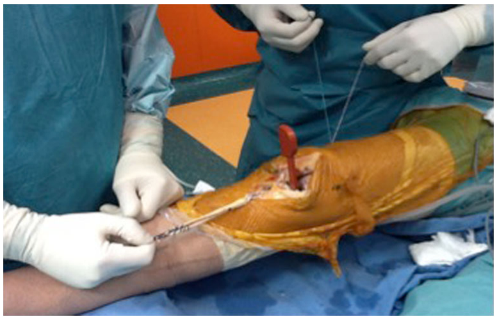

**Fig. 3** A sample of tibial insert was introduced to obtain the perfect ligament tensioning and balance, after the polymerisation of cement the graft was passed through the tunnels

operatively and at follow-up were performed by the same independent orthopaedic surgeon (FD) who was not involved directly in the present study.

### Statistical analysis

Data were reported as mean ± standard deviation. For intergroup and intragroup comparison of the two groups, Student's *t* test was performed on WOMAC, KSS and measured angles at baseline and at follow-up. A threshold of 0.05 was set as statistically significant. Furthermore, Fisher's test was used to compare the number of radiolucency positive patients in each group.

## Results

A total of 24 patients that met the inclusion and exclusion criteria underwent medial UKA associated to ACL reconstruction and were involved in the present study. The mean age at surgery was 47.8 years (range 41–53) for Group 1 and 48.4 years (range 43–54) for Group 2. The mean follow-up of those patients was 53 ± 8.3 months for Group 1 and 42 ± 6.7 months for Group 2.

No intra-operative or post-operative complication such as septic or DVT complications, component loosening or bearing dislocation were reported in any patients.

During the preliminary arthroscopic assessment, in 17 of 24 patients, a cartilage defect on the lateral tibial plateau next to the lateral spine was found (Fig. 4).

With respect to the pre-operative values, WOMAC index and functional and objective KSS improved significantly ($p < 0.05$), without any statistically significant differences between the two groups. The Lachman and anterior-drawer tests performed by an independent orthopaedic surgeon not directly involved in the present study confirmed the absence of residual laxity in all the patients.

The pre-operative and post-operative X-ray showed a significant change in terms of lower limb alignment in both groups, passing from a varus of 4.1° ± 1.05 to 2.5° ± 1.8 and from a varus of 4.4° ± 1.3 to 2.7° ± 0.9 for Group 1 and 2, respectively. However, no significant differences were found between the two groups.

Similarly, the post-operative posterior tibial slope significantly decreased in both groups with respect to the pre-operative level, but again without any significant difference between the two groups.

At the follow-up, no pathologic radiolucent line (> 1 mm) were reported; 4 patients in Group 1 and 3 patients in Group 2 reported < 1 mm radiolucency with no statistically significant difference between the groups.

All detailed results were summarised in Tables 1 and 2.

## Discussion

The most important finding of the present study was that medial unicompartmental arthroplasty combined with ACL reconstruction performed in one-stage is a viable option for the treatment of medial knee osteoarthritis related to an untreated ACL rupture in young and active people. No significant clinical and radiological differences between mobile- and fixed-bearing implant design were found.

In literature, to date there are only few original studies, systematic review and state-of-the-art about the issue (Table 3). To our best knowledge, this is the first study comparing the outcomes of these patients treated with two different bearing modularity implant designs.

The combined procedure has several advantages when compared with TKR, among all bone stock conservancy, less blood loss and better knee kinematics [25] and when compared with HTO in terms of post-operative recovery and participation in recreational and sports activities [26]. However, the procedure is high demanding [27] and should be performed by experienced surgeons following well-defined steps.

In addition, one of the most critical points concerning this procedure is the accurate selection of patients and the decision-making process before surgery [28].

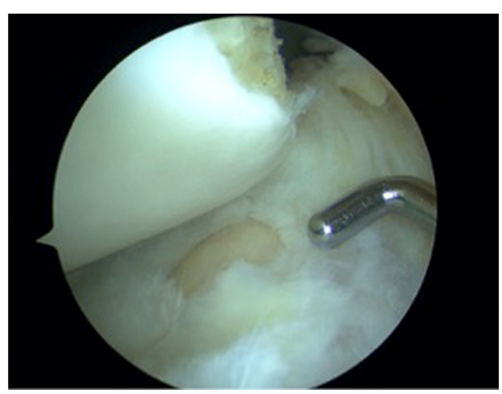

**Fig. 4** Cartilage defect on the lateral tibial plateau next to the lateral spine was found in 17 cases

**Table 1** Clinical outcomes

| | Mobile | Fixed | *p* |
|---|---|---|---|
| WOMAC pre | 55.78 ± 7.6 | 59 ± 8.1 | 0.35 |
| WOMAC post | 79.3 ± 7.3 | 81.3 ± 7.6 | 0.53 |
| *p* | < 0.05 | < 0.05 | |
| KSS funct pre | 71.2 ± 7.4 | 70.2 ± 6.4 | 0.74 |
| KSS func post | 86.2 ± 6.2 | 84.7 ± 5.9 | 0.54 |
| *p* | < 0.05 | < 0.05 | |
| KSS objec pre | 37.3 ± 4.3 | 38.6 ± 3.8 | 0.46 |
| KSS objec post | 73.4 ± 9.3 | 77.3 ± 10.5 | 0.37 |
| *p* | < 0.05 | < 0.05 | |

Mancuso et al. [29] proposed an algorithm of treatment based on joint stability, patient age and functional request. According to this algorithm, the preferred procedure for young and active patients with ACL rupture and bone-on-bone medial compartment OA is the combined one-step procedure.

Several differences were found between our personal surgical technique and that proposed by other surgeons. The first difference concerns the femoral tunnel: while some surgeons prefer to create the tunnel during arthrotomy to minimise the risk of infection, we prefer to create it arthroscopically through the anteromedial portal because this allow for a more accurate anatomical orientation [17]. Although we performed all the tunnels arthroscopically, no infections were observed in our patients.

Kendoff et al. [30] pointed out the importance of fixing the graft as the final step of the procedure because of the effects of valgus knee on the length of the ACL. In our experience, the last step is the selection of the insert thickness after the fixation of the neo-ligament to the tibia in order to avoid inadequate overcorrection with overloading of the lateral compartment of the knee.

Addressing the issues between fixed- and mobile-bearing UKA, in 4 studies [13, 31–33], fixed-bearing UKA was performed and reported good to excellent in subjective and objective clinical outcomes after combined surgery. Tinius et al. [32, 33], in two studies, showed the improvement of Knee Society Score (KSS) from pre-operative condition to the last follow-up. In their most recent study [33], they evaluated the score at an average follow-up of 53 months in 27 patients who underwent combined ACL and fixed-bearing medial UKA; the score improved significantly from 77.1 ± 11.6 to 166.0 ± 12.1 points. Similar clinical results were showed by Krishnan et al. [31] after an average follow-up of two years in nine patients (KSS = 196 points, Oxford knee score (OKS) = 11). Ventura et al. [13] also evaluated KOOS, OKS, WOMAC index and KSS that improved significantly after surgery with no clinical evidence of instability at KT-1000 test after an average follow-up of 26.7 months.

Quite similar results were obtained from 4 studies [34–37] that performed surgery with mobile-bearing UKA. Pandit et al. [35] reported the results of Oxford medial mobile-bearing UKA and ACL reconstruction in 15 ACL-deficient arthritic knee patients. After an average follow-up of 2.8 years, all the patients reported good to excellent clinical outcomes with increase in occupational and physical activity. The same excellent results were reported by Weston-Simons et al. [37] and Dervin et al. [34] on 52 and 10 patients with an average follow-up of five and 1.7 years, respectivelyTian et al. [36] in his study followed up his 28 patients for an average of 52 ± eight months and evaluated the Tegner activity score, OKS and both functional and subjective KSS; all patients reported, similarly to our study, good to excellent clinical outcomes from pre-operative to post-operative condition.

When the results of both fixed- and mobile-bearing prosthesis were compared as shown in the present study, no differences between the two different design prostheses were observed.

When radiographs were evaluated at the final follow-up, no patients in both groups showed component loosening or pathological radiolucency (< 1 mm). Tibrewal et al. [38], in his study, stressed the concept of physiological and pathological radiolucency. The first condition arises during the first year after surgery but no further progression or loosening will be observed, while the second is caused by a real aseptic loosening or infection. In our study, a total of seven

**Table 2** Radiological outcomes

| | Mobile | Fixed | *p* |
|---|---|---|---|
| Post-tibial slope pre | 4.9 ± 3.2° | 4.7 ± 2.9° | 0.9 |
| Post-tibial slope post | 2.3 ± 1.5° | 2.4 ± 0.9° | 0.89 |
| *p* | < 0.05 | < 0.05 | |
| Pre-op varus | 4.1 ± 1.05° | 4.4 ± 1.3° | 0.57 |
| Post-op varus | 2.5 ± 1.8° | 2.7 ± 0.9° | 0.75 |
| *p* | < 0.05 | < 0.05 | |
| | | | Fisher's test |
| Physiological radiolucency (< 1 mm) | *N* = 4 | *N* = 3 | *F* = 0.14 |

**Table 3** Available evidences about the combined procedure of UKA and ACL reconstruction

| Type of study | *N* of studies |
|---|---|
| Original study | 4 (mobile-bearing) [34–37] |
| | 4 (fixed-bearing) [13, 31–33] |
| Systematic review | 3 [16, 18, 29] |
| State-of-the-art | 1 [17] |

patients (29.2%) showed radiolucent lines on the tibial side which were defined physiological and thus without clinical relevance. Our radiolucency values were lower than those found in the literature, for example, Gulati et al. [39] reported 62% of patients with physiological radiolucency but similarly no clinical consequences were observed.

In the present study, the average posterior slope of the tibial component was 2.3° ± 1.5 for Group 1 and 2.4 ± 0.9 for Group 2. We perfectly agree with the opinion of Hernigou et al. [40] that recommended not exceeding 7° in the posterior tibial slope during this procedure. They also reported the significant correlation between the anterior translation and the posterior slope of the tibial component. On the other hand, in our experience, when ACL is not reconstructed in ACL-deficient arthritic knee, the slope should be abolished.

Although the clinical records shown in our study analyse a wider patient population among the most consistent currently available in literature on this topic, there are some limitations that, in our opinion, are not influenced the veracity of the data. First, despite the two groups being composed of a different number of patients, the demographic data of the two groups were comparable. Second, the follow-up of this study is heterogeneous between the two groups and relatively short, thus further long-term study would be needed.

## Conclusion

The results obtained in the present study allow us to conclude that combined medial UKA and ACL reconstruction performed in one-stage procedure is a viable and safe option for the treatment of medial osteoarthritis secondary to ACL deficiency in young and active patients. The use of different prosthesis designs (fixed- or mobile-bearing) did not affect clinical and radiological outcomes at middle-term follow-up.

### Compliance with ethical standards

Written informed consent was obtained from all patients before the beginning of the retrospective study in order to obtain the permission of recording sensible data. The study was conducted upon approval of the Institutional Review Board of our Institute (Prot. "UNIACL_ComEt CBM 42/18 OSS").

**Conflict of interest** The authors declare that they have no conflict of interest.

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