Arch Orthop Trauma Surg (2009) 129:1157–1163
DOI 10.1007/s00402-008-0713-8

ORTHOPAEDIC SURGERY

Bi-unicompartmental versus total knee arthroplasty: a matched paired study with early clinical results

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Received: 10 April 2008 / Published online: 12 August 2008

Abstract
Introduction The authors performed a matched paired study between two groups: bi-unicompartmental (Bi-UKR) versus total knee replacements (TKR) for the treatment of isolated bicompartmental tibio-femoral knee arthritis with an asymptomatic patello-femoral joint. The Authors believe that Bi-UKR could achieve comparable outcomes than TKR, but with a real less invasive surgery and maintaining a higher joint function.
Materials and methods A total of 22 patients with bicompartmental tibio-femoral knee arthritis, who underwent Bi-UKR between January 1999 and March 2003, were included in the study (group A). In all the knees the arthritic changes were graded according to the classification of Älback. All patients had an asymptomatic patello-femoral joint. All patients had a varus deformity lower than 8°, a body-mass index lower than 34, no clinical evidence of ACL laxity or flexion deformity and a preoperative range of motion of a least 110°. At a minimum follow-up of 48 months, every single patient in group A was matched with a patient who had undergone a computer assisted TKR between August 1999 and September 2002 (group B). In the Bi-UKR group, in two cases we registered intraoperatively the avulsion of the treated tibial spines, requiring intra-operative internal fixation and without adverse effects on the final outcome. Statistical analysis of the results was performed.
Results At a minimum follow-up of 48 months there were no statistical significant differences in the surgical time while the hospital stay was statistically longer in TKR group. No statistically significant difference was seen for the Knee Society, Functional and GIUM scores between the two groups. Statistically significant better WOMAC Function and Stiffness indexes were registered for the Bi-UKR group. TKR implants were statistically better aligned with all the implants positioned within 4° of an ideal hip–knee–ankle (HKA) angle of 180°.
Conclusions The results of this 48 months follow-up study suggest that Bi-UKR is a viable option for bicompartmental tibio-femoral arthritis at least as well as TKR but maintaining a higher level of function.

Keywords Knee · Arthritis · Bi-unicompartmental · Replacement · Computer assisted

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Introduction

Unicompartmental knee replacement (UKR) is a well-accepted minimally invasive surgical procedure for the treatment of knee arthritis. Well-defined indications for using a UKR were first documented by Kozinn and Scott in 1989 and continue to be refined [17]. However, actual new designs and materials are resulting in a high success rates for the procedure similar to those reported for total knee replacement (TKR) [2, 5, 31, 35]. Even for lateral UKRs, despite a lower incidence, reliable results are being reported with implant using fixed bearing tibial plateau [2, 30, 33].

In comparison with TKR, UKR allows for smaller implants, shorter operative time, preservation of both cruciate ligaments, and minimal bone resection [24, 32]. Maintenance of the anterior cruciate ligament and its mechanoreceptors may produce a better functional result in UKR [3, 10, 11]. Knee kinematics during flexion following UKR more closely resembles those of the intact knee [3, 11]. Likewise, biomechanical studies of TKR have yielded results far from the kinematics of a normal knee. Weale et al. [36] documented a superior functional recovery with a higher performance in descending stairs and better patient satisfaction with UKR compared with TKR. In a cadaveric study in 2005, Patil et al. [28] demonstrated normal joint biomechanics gained after a UKR implantation in a knee. More recently, Isaac et al. [16] demonstrated how dynamic aspects of proprioception improve more consistently after UKR than after TKR, so explaining why UKR patients have superior functional outcome. Despite these advantages of UKR, in literature very few authors have presented case series using simultaneously two UKRs in the same arthritic knee affecting both the tibio-femoral compartments but with an intact ACL. In 1986, Goodfellow et al. [12] reported a low revision rate (4.8%) in 125 bicompartmental implants followed 2–6 years. In 1992, Stewart et al. [34] presented a long term follow-up with the Manchester knee with a cumulative success rate of 73% at 10 years. However, up to now no studies have compared the results of Bi-UKR with TKR.

The Authors of the present paper performed a matched paired study between two groups Bi-UKR or Computer Assisted TKR in the treatment of bicompartmental tibio-femoral knee arthritis. The authors hypothesized that Bi-UKR, in correct indications, can guarantee at least an equivalent clinical score and patient satisfaction than a traditional TKR, but offering a more conservative surgery sparing ACL with a better function.

Materials and methods

A total of 22 knees in 22 patients treated in our orthopaedic department from January 1999 to March 2003 with the simultaneous implant of 2 UKR (Bi-UKR), because of bicompartmental tibio-femoral arthritis, were included in the study (group A) (Figs. 1, 2a, b). All the patients were evaluated pre-operatively using the Knee Society score [15]. The diagnosis in all the cases was medial and lateral compartment knee arthritis. Arthritic change was graded according to the classification of Älback [1] and did not exceed grade IV in the medial or lateral compartment and grade II in the patello-femoral compartment. All patients had an asymptomatic patello-femoral joint. All patients had a varus deformity lower than 8° and a body-mass index lower than 35. No patient had any clinical evidence of ACL laxity or flexion deformity and all had a pre-operative range of motion of a least 110°.

Fig. 1 Pre-operative radiographs of a post-traumatic knee arthritis

At a minimum follow-up of 48 months, 22 patients in group A were successfully matched with patients who had undergone a computer assisted TKR for bicompartmental tibio-femoral knee arthritis between August 1999 and September 2002 in our orthopaedic department (group B). Even all patients included in the computer assisted TKR group had a stable knee, asymptomatic patello-femoral joint and range of motion of at least 110°. No patient in group B had a pre-operative flexion deformity or varus deformity greater than 8°. As with group A, all patients had a body-mass index less than 35. Every single patient was matched in terms of pre-operative arthritis grade, age, gender and pre-operative range of motion. Patients were matched with a maximum difference with respect to age of 3 years and motion of 10°. Pre-operatively all the knees were evaluated according to the Knee Society Score [13].

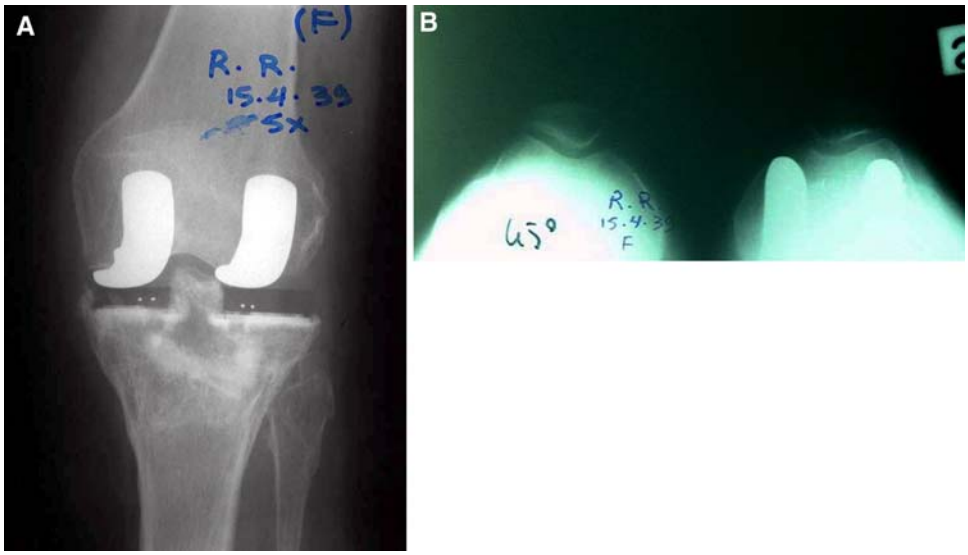

Fig. 2 **a**, **b** Follow-up radiographs following a Bi-UKR implant

There were 14 females and 8 males for each group, the mean pre-operative age was 60.4 years (range: 48–68) for the Bi-UKR group and 60.7 years (range: 48–68) for the TKR group. The mean pre-operative flexion was 118.86° (range: 110–130) and 119.45° (range: 110–135) for UKR group and TKR group, respectively. The mean pre-operative hip–knee–ankle angle (HKA) was 174.4° (range: 172–177) and 175.31° (range: 172–180) for UKR group and TKR group, respectively. Pre-operatively the mean Knee Society score was 43.95 (range: 39–50) in UKR group and 43.4 (range: 38–51) in the TKR group. The pre-operative Functional score was 47.95 (range: 44–55) for group A and 47.27 (range: 45–50) for group B. There were no statistically significant differences in all the pre-operative data for the two groups (Tables 1, 2).

Table 1 Patient demographic data, 22 cases are considered

	Group A (Bi-UKR)	Group B (TKR)
	14♀, 8♂	14♀, 8♂
Age (years)		
M	60.4	60.7
STD	6.06	5.96
R	48–68	48–68
Pre-op flexion (°)		
M	118.86	119.45
STD	5.96	5.93
R	110–130	110–135
Pre-op HKA angle (°)		
M	174.4	175.31
STD	1.56	2.64
R	172–177	172–180
Pre-op IKS score		
M	43.95	43.4
STD	3.31	2.98
R	39–50	38–51
Pre-op FUNCT score		
M	47.95	47.27
STD	3.33	2.54
R	44–55	45–50

Data are reported as mean value (M), standard deviation (STD) and range (R)

Surgical techniques

The unicompartmental implants used in the Bi-UKR group was the UC-Plus Solution (Smith and Nephew, Memphis, USA) with a fixed all poly tibial component. In group B a posterior cruciate retaining mobile bearing TKR (Search, Aesculap, Tuttelingen, Germany) was used. A total computer assisted CT-free alignment system (Orthopilot 3.0, Aesculap, Tuttelingen, Germany) was used for all TKR. In both the group we adopted a pre-drawn mid patellar approach ranging between 12 and 14 cm with an anteromedial para-patellar arthrotomy and a lateral patellar retraction was used. In the Bi-UKR group the medial UKR was performed first using an extramedullary tibial guide. This allowed for correct re-alignment of the limb by replacing the most severely damaged compartment. The amount of bone to be resected from the medial compartment of the tibia to correct the limb alignment was determined pre-operatively. This calculation was based on the amount of axial deformity on the pre-operative radiographs and the thickness of the implanted components. The minimum tibial bone cut was given by the difference between the prosthesis thickness and the axial deviation angle. For example if a patient had a varus deformity of 8° and assuming a total thickness of 11 mm for the prosthesis being used, the planned minimum medial tibial bone to be resected would be approximately 3 mm. Corrected the limb deformity with

Table 2 Post-operative results for the 2 groups, 22 cases are considered

	Group A (Bi-UKR) 14♀, 8 ♂	Group B (TKR) 14♀, 8 ♂	*P*
Surgical time (min)			
M	96.59	101.54	0.15902
STD	9.31	11.87	
R	86–120	86-123	
Hospital stay (days)			
M	6.31	7.9	0.00670
STD	1.64	2.11	
R	4–11	4–13	
Post-op HKA angle			
M	176.77	179.36	0.00008
STD	2.13	1.21	
R	174–182	177–1811	
Post-op IKS score			
M	80.04	77.86	0.18868
STD	5.29	4.54	
R	74–88	72–87	
Post-op FUNCT score			
M	82.27	77.32	0.06040
STD	8.91	8.02	
R	70–100	69–90	
Post-op GIUM score			
M	78.5	75.18	0.10281
STD	6.43	5.1	
R	67–90	63–83	
WOMAC pain			
M	4	4.22	0.68986
STD	1.69	1.57	
R	1–7	2–7	
WOMAC function			
M	7.77	9.18	0.04476
STD	1.9	2.08	
R	4–11	6–13	
WOMAC stiffness			
M	1.5	2.31	0.00917
STD	1.05	0.7	
R	0–4	1–4	

Data are reported as mean value (M), standard deviation (STD) and range (R). Non-parametric statistical analysis was performed (Mann–Whitney *U* test)

the medial implant, in the lateral compartment the thickness of the implant corresponds to the amount of bone to be resected. Furthermore in each case we tried to restore the original tibial slope of the different compartments.

All the components in both the groups were cemented and closed suction drainage was used for 24 h after surgery. The patella was not resurfaced in any patient. Full weight bearing was allowed as soon as tolerated in all patients.

At latest follow-up the clinical outcome was evaluated using the WOMAC Arthritis Index [4], the Knee Society Score and a dedicated UKR score developed by the Italian Orthopaedic UKR Users Group (GIUM) [8, 21, 22]. The GIUM score is based on a sum of positive and negative values and indicates normal, almost normal, abnormal and poor results. One Author (M.A.) not involved in the original surgery evaluated all patients. The HKA angle was measured at latest follow-up on long leg standing anterior–posterior radiographs and the mean values between the two surgeons assessments were used as final values. The surgical time and hospital stay was recorded and compared.

Statistical analysis of the results was performed and because of an abnormal data distribution non-parametric test (Mann–Whitney *U* test) was adopted using Statistica 7.0 (StatSoft Inc., Tulsa, OK, US). A statistically significant result was given as $P \leq 0.05$.

Results

There were no statistical significant differences in the follow-up and no implant was revised and no major signs of radiological loosening were seen in either group.

In the Bi-UKR group, an intra-operative fracture of the tibial spine bone block was seen in two cases (9%). This was thought to be an avulsion fracture as a result of excessive intra-operative traction on the anterior cruciate ligament despite different slopes of the tibial insert. In all cases the fracture happened during surgery and intra-operative internal fixation was performed. Implantation of the UKR components then proceeded as usual. These two patients were managed with partial weight bearing in an hinged knee brace locked in extension for the first 4 weeks after surgery and after the removal passive and active motion were gradually started. At the latest follow-up no adverse effect on the final outcome was seen as a result of the intra-operative fracture. No other complications including infection were seen.

There were no statistically significant differences in the surgical time between the two groups. The hospital staying was statistically shorter in the Bi-UKR group ($P < 0.007$) with a mean of 6.31 days compared to a mean of 7.9 in the TKR group (Fig. 3). Eight patients in each group required postoperative blood transfusions.

At the latest follow-up no statistical significant differences were seen in the Knee Society and Function scores between the two groups. Even for the GIUM score there were no significant differences and no poor or abnormal results were seen in either group (Fig. 4) The two groups

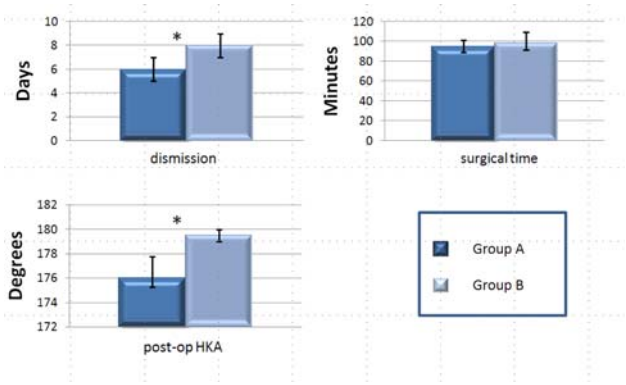

Fig. 3 Graphs of the number of hospitalization days (*upper left*), operation duration (*upper right*) and post-operative HKA angle (*bottom left*). *Asterisks* indicate that the statistical difference is significant

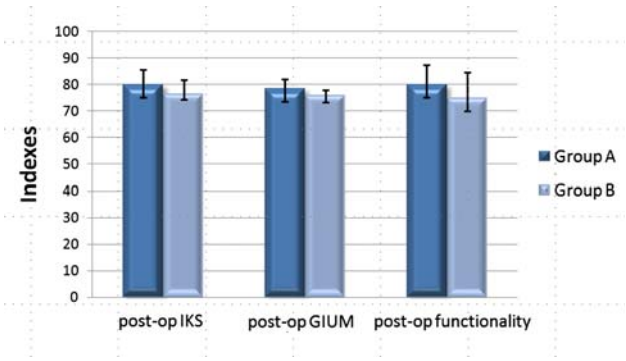

Fig. 4 Graphs showing values related to Knee Society and Function and values related to the GIUM scores

had similar percentages of knees considered normal according to the GIUM score.

According to the WOMAC Arthritis Index, there was no statistical difference between the two groups for the Pain index, while statistical differences were registered for the function ($P < 0.05$) and stiffness ($P < 0.01$) indexes, respectively, in favour of the Bi-UKR group (Fig. 5). All the knees in Bi-UKR group had a range of motion greater than 120° compared to only 15 knees (68.1%) in TKR group.

At latest follow-up the mean HKA angle was lower ($P < 0.00008$) for the Bi-UKR group (mean 176.8°) than for the TKR group (mean 179.4°) (Fig. 3). All TKA implants were positioned within 4° of an ideal hip–knee–ankle angle of 180°.

Discussion

Tissue sparing knee replacement surgery has been a focus for many surgeons well before the recent enthusiasm for minimally invasive TKR gripped the international orthopaedic community [19, 32]. Most of the attention given to

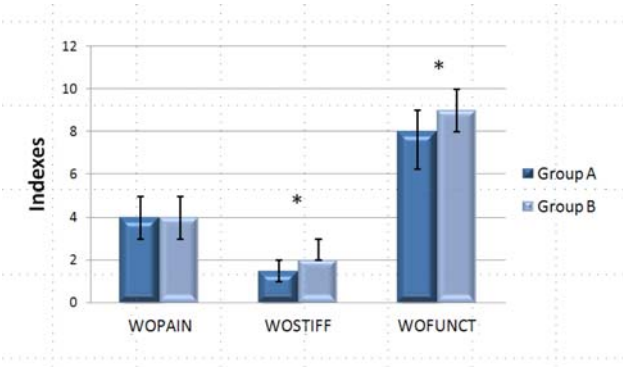

Fig. 5 Graphs showing values related to WOMAC Arthritis Index: pain, stiffness and function. *Asterisks* indicate that the statistical difference is significant

this area has involved dedicated instruments to reduce the required surgical exposure [6, 18, 25].

In comparison to minimal invasive TKR, UKR offers further tissue sparing advantages together with a kinematics which more closely resembles those of the intact knee [3, 10, 11, 28]. Unicompartmental prostheses are smaller, requiring less access and bone resection for implantation than total knee components [7, 23, 31]. In our experience, in the corrected indication UKR can even achieve better functional results compared to TKR [22], probably because of cruciate ligaments preserving compared to a routinely partly or wholly sacrificing in TKR [13]. Pandit et al. [26, 27] reported good short term results with combined ACL and medial UKR in young active patient achieving a normal kinematics. Fuchs et al. [11] emphasized that, by maintaining both the cruciate ligaments, a bicondylar sledge prostheses achieves functional results as good as TKR, avoiding the potential UKR complication of progressive arthritis in the contra-lateral compartment. In addition, Hollinghurst et al. [14] reported that, after fixed bearing UKR, the cruciate mechanism remains intact over time and the ligaments continue functioning as in a normal knee. Furthermore, recent studies with follow-up of more than 10 years showed comparable survivorship for total and unicompartmental knee replacements even if mainly dedicated to medial implants.

Up to now, medial and lateral tibio-femoral arthritis even in young patients has traditionally been addressed towards a total knee replacement [20, 25, 29] but in these cases, the simultaneous implant of two unicompartmental knee prostheses preserving the ACL could offer an attractive alternative solution. The benefits of this approach, when compared to TKR, include greater tissue sparing, reduced surgical morbidity and easier revision surgery. In addition it was demonstrated how even Bi-UKR resembles more closely the biomechanics of an intact knee with respect to a TKR matching our current patient expectations undergoing knee replacement surgery to achieve a

kinematics as closer as possible to a normal knee [10, 28]. Despite these potential advantages, only Goodfellow et al. [12] and Stewart et al. [34] reported series of bi-unicompartmental knee replacement sparing the ACL.

Since 1998, we performed Bi-UKR in very selected patients for less than 4–5% of the knee arthroplasty surgery at our institution each year. To our knowledge up to now none of these implants has been revised even if we believe that a Bi-UKR could be easily revised using a traditional TKR or even with another UKR if the initial loosening is clearly limited to one compartment.

All the patients undergoing Bi-UKR had an asymptomatic patello-femoral joint with arthritis less than or equal to Älback grade II. Contra-indications included obesity, osteopenia, a history of systematic articular disease, significant ligamentous laxity and limb deformity greater than 10°. The aetiology of the knee arthritis was post-traumatic in most cases in patients all younger than 70 years old.

At a minimum of 48 months after the surgical intervention, we performed a matched study comparing 22 Bi-UKRs to traditional TKRs implanted using a navigated technique. Despite our study owns some limitations (retrospective and not randomized, different implants, different alignment systems), we identified strict matching criteria (age, arthritis grade, gender, and pre-operative range of motion).

At the latest follow-up in both the groups no signs of implant loosening have been seen and no implants have been revised.

According to our results, we did not register any statistical significant difference in IKS, Functional and GIUM score between Bi-UKR and TKR. However, despite a less accurate limb alignment, significant differences were seen between the two groups in the WOMAC Index according to the function and stiffness scale. Furthermore, in the Bi-UKR group all the patients achieved a range of motion greater than 120°. No differences were seen for the pain. There were no differences in the surgical time but the hospital staying in the Bi-UKR group was statistically shorter.

In two cases (9%) of Bi-UKR, an intra-operative fracture of the tibial spines occurred during implantation of the prosthesis, possibly related to excessive tension on the anterior cruciate ligament. All fractures were managed successfully with intra-operative internal fixation. This fracture did not adversely affect the final result. In an attempt to overcome this complication a computer-assisted technique for Bi-UKR has been introduced since 2003 [9]. This allows accurate soft tissue balancing and bone resection during all phases of the surgery. However, despite of this we still recommend that this "not everydays procedure" should be performed only by trained joint replacement surgeons.

In conclusion, our study showed promising similar outcome using both Bi-UKR and TKR in the treatment of bicompartmental tibio-femoral knee arthritis at a short follow-up. Despite using a computer assisted alignment system for TKR to achieve more accurate implant positioning, the WOMAC stiffness and function indices were still lower than those ones for Bi-UKR.

The early results of this study suggest that Bi-UKR is a viable option for bicompartmental tibio-femoral arthritis in selected cases at least as well as TKR. Bi-UKR has the advantage of greater tissue and bone sparing compared to TKR and may more closely reflect normal knee biomechanics. Further investigation is required to assess the long-term results and precise indications for this surgery.

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