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ORIGINAL STUDY

Bi-unicompartmental versus total knee arthroplasty: long term results

Alessio Biazzo, Alfonso Manzotti, Norberto Confalonieri

From the Orthopaedic Department, ASST Gaetano Pini-CTO, Milano

The purpose is to demonstrate that Bi-Unicompartmental knee arthroplasty (Bi-Uni) can produce equivalent long-term outcomes to total knee arthroplasty (TKA) in patients with bicompartmental knee osteoarthritis involving both the medial and lateral tibio-femoral compartments.

A total of 37 patients with bicompartmental tibio-femoral osteoarthritis of the knee treated between January 1999 and March 2005 underwent either Bi-Uni or TKA. Nineteen patients who underwent simultaneous implantation of 2 unicompartmental knee arthroplasties (UKA) were matched and compared with 18 patients who had undergone a computer assisted TKA.

At latest follow-up no statistically significant differences were seen between the 2 patient groups for KSS, Function scores and WOMAC Arthritis Index (pain score). The patients undergoing Bi-Uni did showed a statistically significant superior outcome for function ($P < 0.05$) and stiffness ($P < 0.01$) WOMAC indexes compared with the TKA group.

The results of this study suggest that Bi-Uni is a valid alternative to address medial and lateral tibio-femoral osteoarthritis of the knee in selected cases. Bi-Uni replacement produces results equivalent TKA in patients with bicompartmental knee osteoarthritis involving both the medial and lateral tibio-femoral compartments and could represent a new frontier in modern knee reconstructive surgery.

Level of Evidence: Level IV, retrospective comparative study.

Keywords: unicompartmental arthroplasty ; total knee arthroplasty ; computer-assisted ; tissue-sparing surgery.

INTRODUCTION

The treatment of bicompartmental knee osteoarthritis involving both the medial and lateral tibio-femoral compartments, can be performed with simultaneous implantation of medial and lateral unicompartmental knee arthroplasties (Bi-Uni) or total knee arthroplasty (TKA). In contrast to TKA, Bi-Uni preserves the uninvolved compartment and cruciate ligaments theoretically leading to enhanced stability, improved proprioception and more physiological knee kinematics.

TKA offers high survival and high functional scores when arthritis affects all three compartments of the knee. However, TKA does not preserve bone stock and ligaments, and this may be particularly disadvantageous for young and high demanding patients potentially resulting in a higher risk of revision surgery *(5,11)*. Preservation of the knee ligaments and minimal bone excision are the main advantages of Bi-Uni. Therefore, bicompartmental

■ Alessio Biazzo[1].
■ Alfonso Manzotti[2].
■ Norberto Confalonieri[1].
[1]*Orthopaedic Department, ASST Gaetano Pini-CTO, via Bignami 1, 20126 Milano.*
[2]*Orthopaedic Department, Ospedale Luigi Sacco, Via Giovanni Battista Grassi, 74, 20157 Milano.*
Correspondence : Alessio Biazzo, Orthopaedic Department, ASST Gaetano Pini-CTO, via Bignami 1, 20126 Milano.
E-mail : ale.biazzo@yahoo.it

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knee arthroplasty (BKA) and Bi-Uni have been proposed to bridge the gap between UKA and TKA *(17)*.

Several studies *(6,19-21)* have demonstrated good functional results of BKA in patients with medial tibio-femoral and patello-femoral arthritis. These studies have shown similar results in this patient group using either a BKA or a TKA technique. The authors noted BKA surgery resulted in less intra-operative blood loss and greater mean post-operative range of movement but longer mean operating time. The English literature reports only two matched paired studies comparing the early clinical results of Bi-Uni versus TKA *(6,8)*. A single retrospective study has been published by Parratte et al. *(17)* describing the long term results of Bi-Uni in patients with bicompartmental knee arthritis.

The hypothesis of the current study is that Bi-Uni can produce equivalent long term clinical scores and patient satisfaction but better function and faster recovery than TKA in patients with bicompartmental knee osteoarthritis involving both the medial and lateral tibio-femoral compartments.

MATERIALS AND METHODS

Between January 1999 and March 2005, 22 patients with bicompartmental tibio-femoral osteoarthritis were treated with simultaneous implantation of medial and lateral UKAs (Bi-Uni) (Group A). The patients in group A were matched with patients who had undergone a computer assisted TKA for bicompartmental tibio-femoral arthritis in the same period (Group B). Patients were matched in terms of pre-operative arthritis grade, age, gender and pre-operative range of motion. When matching patients a maximum difference with respect to age of 3 years and motion of 10o was accepted. All surgeries were performed by 2 of the authors (N.C. and A.M.). Eleven patients included in this study had been the subject of a previous publication detailing the early clinical results of Bi-Uni surgery.

The patients underwent pre-operative clinical and radiological evaluation using the Knee Society Score (KSS) *(14)* and Ahlback's classification of osteoarthritic change *(1)*. Osteoarthritic changes did not exceed grade IV in the medial or lateral compartment and grade II in the patello-femoral compartment. Inclusion criteria were an asymptomatic patello-femoral joint, a varus deformity less than 8o, body-mass index lower than 35, no clinical evidence of anterior cruciate ligament (ACL) laxity or flexion deformity and pre-operative range of motion of at least 110o.

All UKAs and TKAs components were cemented on the tibial and femoral side. The unicompartmental implant used in the majority of patients in the Bi-Uni group was the UC-Plus Solution (Smith and Nephew, Memphis, USA) with a fixed all poly tibial component (Figure 1). A GMK-Uni (Medacta, Castel San Pietro, Switzerland) with a fixed metal backed tibial component was used in the last 3 cases. In group B a posterior cruciate retaining mobile bearing TKA (Search, Aesculap, Tuttelingen, Germany) was used. A total computer-assisted CT-free alignment system (Orthopilot 3.0, Aesculap, Tuttelingen, Germany) was used for TKA implantation. The patella was not resurfaced in any patient. Full weight-bearing was allowed as soon as tolerated in all patients.

At the latest follow-up the clinical outcome was evaluated using the WOMAC Arthritis Index (4), the KSS and a dedicated UKA score developed by the Italian Orthopaedic UKA Users Group (GIUM) (9,15,16). One author (B.A.) not involved in the original surgery evaluated all patients at the last follow-up. The HKA angle was measured on long leg standing antero-posterior radiographs (Figure 1). Statistical analysis of the results was performed and because of an abnormal data distribution, a 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 $P < 0.05$. The duration of hospital stay was calculated for each group.

RESULTS

At latest follow-up (average 15 years), 13% of patients were lost to follow-up in group A (3 cases) and 18% in group B (4 cases). A total of 19 patients in group A and 18 patients in group B were available for clinical evaluation. There were no statistically significant differences in the surgical time between

Fig. 1. — Antero-posterior weight-bearing radiograph of bilateral Bi-Uni in active young-lady

the two groups. The duration of hospital stay was significantly shorter in the Bi-Uni group ($p<0.05$) with a mean of 6.31 days compared to a mean of 7.9 days in the TKA group. No statistically significant difference was seen in the length of follow-up between the 2 groups.

The mean pre-operative age was 59.7 years (range: 45-68) for the Bi-Uni group and 61.2 years (range: 48-70) for the TKA group. The mean pre-operative hip-knee-ankle angle (HKA) was 175o (range: 172-178o) and 176o (range: 172-180o) for the Bi-Uni group and TKA group, respectively. Pre-operatively, the mean KSS was 43.65 (range: 39-52) in Bi-Uni group and 42.7 (range: 36-51) in the TKA group. The pre-operative Functional score was 48.45 (range: 44-57) for group A and 47.65 (range: 45-51) for group B. There were no statistically significant differences in all the pre-operative data for the two groups.

The mean post-operative HKA angle was 176.8o in the Bi-Uni group and 179.4o in TKA group at last follow-up. This difference was statistically significant ($p<0.05$) and indicated a better HKA angle was achieved in the TKA group. All TKA implants were positioned within 4o of an ideal HKA angle of 180o. All the knees in the Bi-Uni group had a range of motion greater than 120o compared to only 13 knees in the TKA group (Table 1).

At latest follow-up no statistical significant differences were seen between the two groups in the KSS, GIUM score and Function score. The percentage of knees considered normal according to the GIUM score was similar in both groups. Using the WOMAC Arthritis Index, there was no statistically difference between the two groups for the Pain index. However, the patients undergoing Bi-Uni did showed a statistically significant superior outcome for function ($P < 0.05$) and stiffness ($P < 0.01$) WOMAC indexes compared with the TKA group (Table 1).

There were no statistically significant differences in the surgical time between the two groups. The duration of hospital stay was statistically shorter in the Bi-Uni group ($p<0.05$) with a mean of 6.31 days compared to a mean of 7.9 days in the TKA group. No statistically significant difference was seen in the length of follow-up between the 2 groups.

In the Bi-Uni group there were two intraoperative fractures of the anterior tibial spine (Fig. 2). This was thought to be an avulsion fracture due to excessive intra-operative traction on the ACL despite different slopes of the tibial insert. In both patients the fracture occurred during surgery and was addressed with internal fixation. No adverse effect on the final outcome was seen as a result of the intra-operative fracture.

Table I. — Post-operative results for the 2 groups

	Group A (Bi-Uni) 19 patients	Group B (TKA) 18 patients	P
Post-op HKA angle	176.8 (173-180)	179.4 (range 177-180)	0.00008
Post-op IKS score	78.3 (range 71-87)	75.1 (70-85)	0.18
Post-op Function score	80.5 (range 68-96)	75.5 (65-88)	0.07
Post-op GIUM score	77.4 (range 67-88)	74.8 (range 62-81)	0.10
WOMAC pain	4 (range 1-7)	4.22 (range 2-6)	0.68
WOMAC function	7.22 (range 4-11)	8.67 (range 6-12)	0.04
WOMAC stiffness	1.7 (range 0-4)	2.54 (range 1-4)	0.008

Fig. 2. — Anterior tibial spine avulsion in a 58-year old lady treated with screw osteosynthesis.

In the Bi-Uni group one case of resorption of anterior tibial spine was seen at 7 years after surgery. This was thought to be due to poor balancing of the knee and required conversion to a TKA (Figures 3-6). No complications were reported in the TKA group. No infections were seen.

DISCUSSION

Traditionally, medial and lateral tibio-femoral osteoarthritis with or without patello-femoral disease was seen as an ideal indication for TKA. TKA has been favored in this clinical setting despite evidence that Bi-Uni may better preserve knee biomechanics. As stated by Confalonieri and Manzotti "Few surgeons around the world have been using two UKAs to address the two tibio-femoral compartments simultaneously. The benefits of this approach when compared to TKA include greater tissue sparing, reduced surgical morbidity, and easier revision surgery. In addition, a recent study has demonstrated that Bi-Uni more closely resembles the biomechanics of an intact knee than does a TKA *(2,3,11)*. Fuchs et al. reported that implants preserving both cruciate ligaments can achieve functional results at least similar to TKA without any arthritis progression *(11)*. Current patient's expectations following knee replacement surgery include a knee that resembles normal and allows an unrestricted active life, and the superior biomechanical resemblance of the Bi-Uni to a normal knee might better match these expectations"*(10)*.

The potential advantages of Bi-Uni compared with TKA have resulted in a renewed interest in this type of combined compartmental implants *(17)*. One of the primary aims of Bi-Uni is to restore more normal knee kinematics and function by preserving the patient's bone stock and ligamentous structures. This bone and ligament-sparing technique can be considered minimally invasive surgery, not only

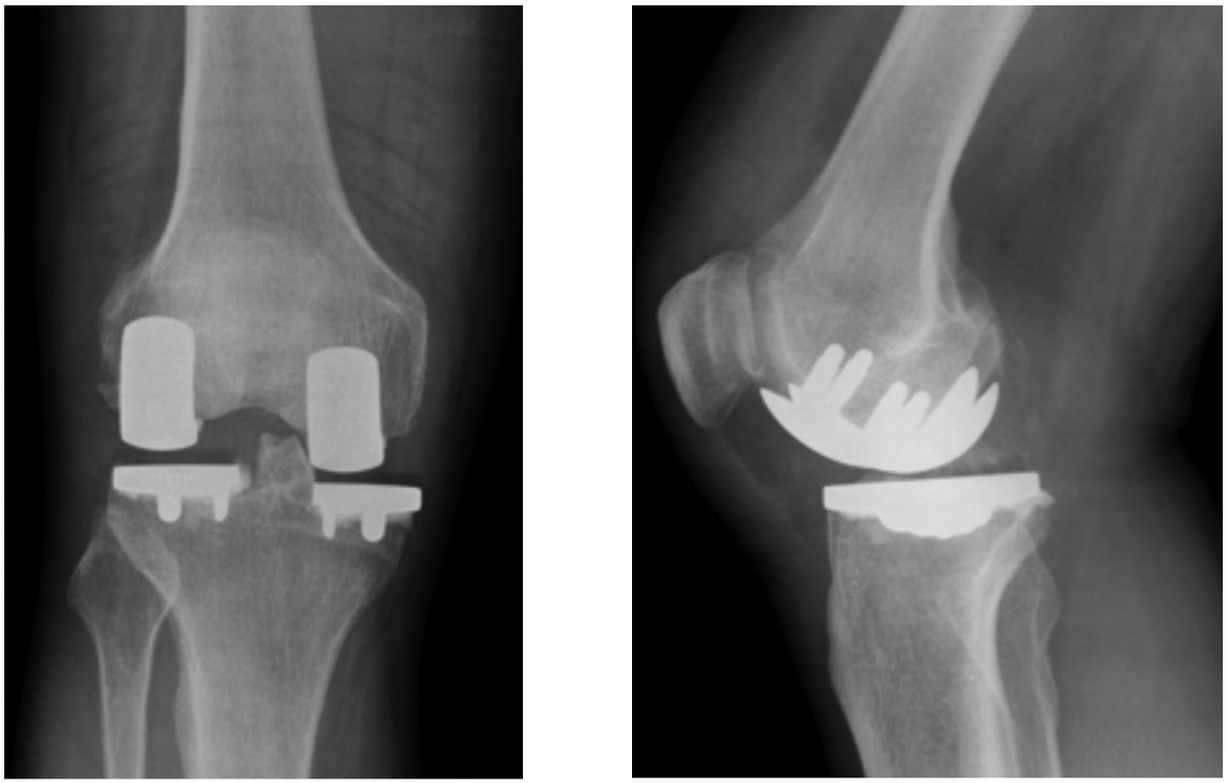

Fig. 3, 4. — Post-operative x-ray of Bi-Uni implantation in a 68-year old male.

for the intrinsic knee structures but also the skin and the muscular tissue *(3,7,8,11,13,18)*. According to kinematic and gait studies, appropriately selected patients who undergo bi-unicondylar knee arthroplasty can have excellent functional outcomes similar to those observed with UKA *(17)*.

Several authors *(6,19-21)* have reported the results of medial UKA plus PFA compared to TKA for the treatment of bicompartmental knee osteoarthritis. Tan et al. *(20)* performed a matched paired study comparing UKA plus PFA to TKA. These authors showed that compared with the TKA group patients undergoing a UKA plus PFA had longer operative time, less mean intraoperative blood loss and greater range of movement. Tamam et al. *(19)* evaluated the short term outcomes of patients undergoing BKA using a robotic-assisted system. They reported 24 out of 29 patients had good to excellent results and no major complications. No patients in their study required revision or conversion to a TKA. Chung et al. *(6)* compared isokinetic knee muscle strength and physical performance in patients who underwent either BKA for medial plus patello-femoral arthritis or TKA. This study showed that although theoretically plausible with use of bone blocks and cruciate ligament preservation, BKA was not superior in recovery of knee muscle strength at 1 year compared with TKA. Yeo et al. *(21)* demonstrated that the results of BKA are similar to those of TKA for medial and patello-femoral arthritis in the mid-term. The authors showed intraoperative blood loss was significantly lower in the BKA group compared with the TKA group.

Few authors have described the results of Bi-Uni for the management of medial and lateral tibio-femoral osteoarthritis. Parratte et al. *(17)* reported the long term results of Bi-Uni and medial UKA

Fig. 5, 6. — Resorption of the anterior tibial spines causing severe unbalancing after 7 years

plus PFA. They had a 17-year survival to revision of 78% for the Bi-Uni group and 54% for the UKA plus PFA group. They reported 4 cases of anterior tibial spine avulsion. In the Bi-Uni group 17% of patients underwent a revision for aseptic loosening of the tibial plateau. In the UKA plus PFA group, 36% of patients underwent revision, in the majority of cases as a result of aseptic loosening of the patello-femoral implant (most of them were uncemented implants performed before 1989). In 2009 we published the early clinical results of Bi-Uni versus TKA for the treatment of medial and lateral tibio-femoral osteoarthritis *(8)*. No statistical significant differences were seen in the KSS and GIUM score between the 2 groups. However, the patients undergoing Bi-Uni showed a statistically significant superior outcome for function and stiffness WOMAC indexes compared with the TKA group. Two patients in the Bi-Uni group sustained tibial spine avulsions but no patients required revision or conversion to a TKA.

In the current study we performed a matched paired comparison of 19 Bi-Uni and 18 traditional TKA implanted using a navigated technique. Patients were matched for age, arthritis grade, gender and pre-operative range of motion. The average follow-up period was 15 years. Comparison of the results showed a statistically significant superior outcome for function ($P < 0.05$) and stiffness ($P < 0.01$) WOMAC indexes for the Bi-Uni group compared with the TKA. No differences were seen between the two groups for the Pain index. In the Bi-Uni group all patients achieved a range of motion greater than 120° compared to only 13 knees in the TKA group. No statistical significant differences were seen between the two groups in the KSS, GIUM score and Function score. A significantly better mean post-operative HKA angle was achieved in the TKA group. This finding may be explained by the use of computer assisted alignment in these patients only.

This studies strengths include the long follow-up period, use of strict inclusion criteria, all participants were younger than 70 years and the majority of patients had post-traumatic osteoarthritis. The limitations of this study include the small number of patients involved and the lack of homogeneity

of the implants used in the Bi-Uni group. However, the Authors believe the results of this study suggest that Bi-Uni is a reliable technique for the treatment of bicompartmental tibio-femoral osteoarthritis of the knee resulting in better and faster recovery compared to TKA. Bi-Uni has the advantage of greater tissue and bone sparing compared to TKA and as a result may better preserve knee kinematic. However, this surgery should be performed in specialized centers by experienced surgeons until new technologies permit increased reproducibility of the technique.

CONCLUSION

The findings of this study suggest that Bi-Uni is a valid alternative to TKA in selected patients with bicompartmental knee osteoarthritis involving both the medial and lateral tibio-femoral compartments. Further matched paired studies are required to assess the long-term results of this technique.

The Authors believe that, despite standard TKA designs still representing the "gold standard" in bi-compartmental knee osteoarthritis, the compartmental approach to knee reconstructive surgery represents a new frontier. However, replacing only the damaged compartment and preserving the normal biomechanics will require not just strict inclusion criteria but also new technologies that allow the surgeon to make extremely precise adjustments to implant alignment by providing continuous feedback during surgery.

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