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ORIGINAL ARTICLE

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Clinical outcomes in the revision of unicondylar arthoplasties to bicondylar arthroplasties. A matched-pair study

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Abstract *Introduction* The aim of the following study was to find out how much a previously implanted unicondylar prosthesis affects the clinical and functional outcome of a total knee arthroplasty in case of revision surgery. *Materials and methods* A matched-pair comparative analysis was performed on 28 patients (group A) who required bicondylar knee arthroplasty following failed unicondylar arthroplasty and 28 patients (group B) with primary bicondylar knee arthroplasty. Both groups were matched according to age, sex, weight, height, type of prosthesis, and follow-up time after bicondylar arthroplasty. The patients' evaluation was based on the Knee Society Score and the WOMAC Score. Radiographs (AP weight-bearing and lateral) were taken of the knee. The average follow-up time after bicondylar arthroplasty was 55 ± 15 months in group A and 56 ± 13 months in group B. *Results* The knee score was 71.8 ± 18 and 80.4 ± 10 points ($p = 0.01$) and the function score 56.1 ± 15 and 64.1 ± 19 points ($p = 0.1$) for group A and group B, respectively. The subjective assessment according to the WOMAC Score was statistically significant in terms of the functional outcome. Increased postoperative range of motion of $109° \pm 11°$ was noticed for group B in comparison with group A ($101° \pm 8°$; $p = 0.004$). Patients revised from an unicondylar arthroplasty required a significantly thicker polyethylene inlay (12.9 ± 3 mm) compared with the primarily implanted group (10.3 ± 3 mm; $p = 0.004$). *Conclusion* Revision of an unicondylar to a bicondylar knee replacement showed inferior functional results in comparison to primary bicondylar knee arthroplasty. Patients are satisfied after conversion of an unicondylar to bicondylar prosthesis, but not quite as much as patients who received a primary bicondylar arthroplasty. However, in the small number of patients where revision surgery after failed unicondylar prosthesis is required, the patient had already been successfully treated for many years.

Keywords Revision unicondylar prosthesis · Matched-pair study

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Introduction

The treatment of unicompartmental osteoarthritis with an unicondylar or bicondylar knee arthroplasty remains controversial [28, 32]. Unicondylar arthroplasty offers the advantage of retaining the knee joint biomechanics because of retention of the cruciate ligaments and the preservation of the uninvolved femoral-tibial and patellofemoral compartment [4]. Only minimal bone resection is required on the femoral and tibial sides for implantation of unicondylar prostheses, leaving sufficient bone stock should revision surgery be necessary [18, 26].

Less satisfying results with unicondylar arthroplasty due to higher revision rates were reported by Marmor [33] and Scott et al. [47] in the 1980s and early 1990s and were mainly due to improper patient selection. Furthermore, these authors felt that tibial polyethylene components of less than 8 mm are more likely to fail. Van Loon et al. [52] also noticed higher failure rates in bicondylar arthroplasty when 6 mm polyethylene components were used.

Recent studies have shown similar functional and clinical results after unicondylar and bicondylar arthroplasty [43]. Laurencin et al. [30] found that patients who received an unicondylar arthroplasty in one knee and a bicondylar arthroplasty on the other side felt that the unicondylar prosthesis was better with regard to function. Rougraff et al. [46] reported on patients with isolated osteoarthritis who were treated with either an unicondylar or tricompartmental arthroplasty. After an average of 78 months' follow-up, he noted a signifi-

cantly better range of motion (113° vs 93°) and better results on the Knee Society Score (90 vs 85 points) after unicondylar vs tricompartmental arthroplasty. The unicondylar patients required less revision surgery (4%) in comparison with patients who had received a total knee arthroplasty (11%).

There are conflicting reports with respect to failed unicondylar arthroplasty. Some authors claim that it is much easier to revise an unicondylar prosthesis than a bicondylar prosthesis [7, 51], whereas others have stated that there is no difference [38]. Other studies have shown similar [43] or even slightly higher [2] revision rates in unicondylar prostheses. In a 20-year follow-up study of 14,772 patients who had received an unicondylar arthroplasty, 1135 patients (7.7%) required a revision operation [32].

A limited number of studies are available focusing on the clinical results of patients who required a revision operation after failed unicondylar arthroplasty, but none of them have compared the results to a primary bicondylar arthroplasty [8, 11, 14, 16, 23, 27, 32, 38].

The purpose of our matched-pair study was to compare patients who received a total knee arthroplasty after failed unicondylar arthroplasty with a cohort of patients who underwent bicondylar knee arthroplasty as their primary treatment in order to find out how much a previously implanted unicondylar prosthesis affects the clinical and functional outcome of a total knee arthroplasty. These clinical aspects might be of interest to younger patients who may require joint replacement for unicompartmental osteoarthritis [20].

Patients and methods

Twenty-eight patients (group A) underwent a revision operation after a failed unicondylar prosthesis. The primary indication for unicondylar arthroplasty was osteoarthritis confined to the medial compartment. The patients' age averaged 60 ± 7.5 years at the initial operation. In 16 cases the St. Georg prosthesis (Waldemar Link, Hamburg, Germany) and in 12 cases the Wessinghage prosthesis (Sulzer Orthopaedics, Baar, Switzerland) was utilized. The tibial portions of both types of prosthesis are made of non-metal-backed polyethylene and had an average thickness of 8.5 ± 1.7 mm, range 6–11 mm. In all cases failure of the unicondylar prosthesis was due to aseptic loosening, either at the femoral or tibial site. Revision surgery was required after an average of 66.8 ± 34.6 months, and in all cases conversion to an unconstrained bicondylar prosthesis (Natural Knee, Sulzer Orthopaedics, Baar, Switzerland) was performed. Sixteen total knee replacements were uncemented, 7 cemented, and in 5 patients a hybrid implantation was performed using a cemented femoral and uncemented tibial component. Patella resurfacing was carried out during revision surgery in 5 patients. The patients were followed up on average 55 ± 14.7 months after the revision operation of an unicondylar to a bicondylar or total knee prosthesis. The mean age of the 6 male and 23 female patients was 71.5 ± 6.8 years, mean height 1.64 ± 0.1 m, mean body weight 84.2 ± 12 kg and mean body mass index 31.2 ± 3.2 kg/m^2.

Each patient of group A was matched with a patient in group B who had received a bicondylar or total knee prosthesis (Natural Knee), primarily according to age, sex, weight, height, body mass index and follow-up time. These patients comprised group B. A deviation of ± 5 kg/m^2 in the body mass index was accepted. The mean age of the 6 male and 23 females in group B was 71.5 ± 6.6 years, mean height 1.64 ± 0.09 m, mean body weight 83.8 kg $\pm$ 15 kg and the mean body mass index 31.1 ± 4.4 kg/m^2. Twenty-five patients received an uncemented prosthesis and 3 patients, a cemented prosthesis. The average follow-up time was 56 ± 13 months.

The operation was performed using a tourniquet for haemostasis in all cases. A medial parapatellar approach was used, and the bicondylar prosthesis was implanted in accordance with the recommended technique by the manufacturer, commencing with the femoral component. After the preparation of the bone had been completed, the tibial component was implanted, followed by insertion of the polyethylene inlay and fixation of the femoral component. Finally, the pneumatic tourniquet was released, and two drains were placed inside the joint before the wound was closed in layers.

For revision operation cases, the unicondylar prosthesis and the cement were removed first (Figs. 1 and 2). The subsequent steps of implantation of the total knee arthroplasty were carried out in an identical manner to the primary implantation. Bone defects at the femoral or tibial site were filled with bone chips harvested during the preparation of the lateral femoral condyle and the tibial plateau. No allograft was required.

For both groups the postoperative management was identical. Continued passive motion for 45 min twice a day was performed starting on the 1st postoperative day

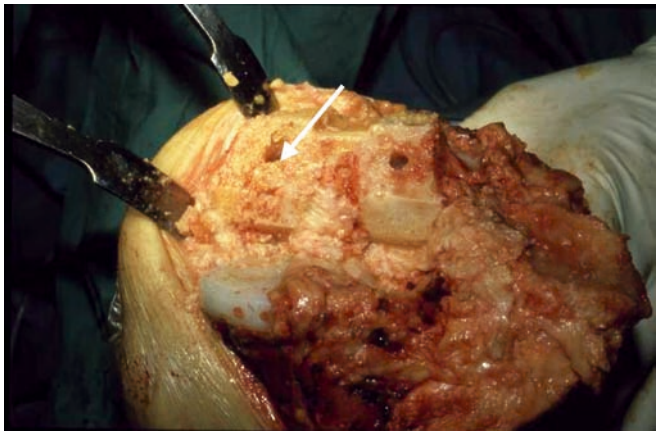

Fig. 1 Intraoperative view of the prepared femur for bicondylar arthroplasty in a patient who required conversion of an unicondylar to a bicondylar prosthesis. Bone defects at the medial femoral condyle are filled with bone chips (*arrow*) harvested from the lateral femoral condyle

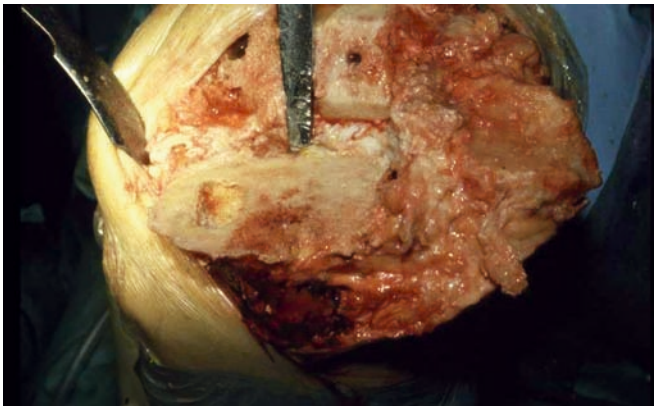

Fig. 2 Intraoperative view after femoral and tibial preparation was finished of the same patient as in Fig. 1. After removal of the peg of the tibial unicompartmental component, a bone defect remained at the central site of the medial tibial plateau

until the patient was discharged from the hospital. Drains were removed on the 3rd postoperative day, and the patients progressed to full weight-bearing with crutches. The patients were discharged from hospital after 10 days, as long as 90° of active knee flexion was achieved.

Clinical and radiological evaluation

The clinical evaluation performed at follow-up was based on the Knee Society Score [21] and the WOMAC Score [10].

The Knee Society Score consists of a knee score and a knee function score. The knee score evaluates the knee joint itself for knee pain, range of motion, anteroposterior and medial-lateral stability. The knee function score rates the patient's ability to walk and to climb stairs. Each score allows for a maximum rating of 100 points.

The WOMAC score gives a subjective evaluation of the knee and evaluates the symptoms and functional disability of patients by using a version of the score translated into German [50]. The score has three main categories: 'pain', 'stiffness' and 'function'. The pain category includes 5 questions, the stiffness category 2 questions and the function category 17 questions. Patients answered each question using a scale from 0–10, indicating 0 as the best and 10 as the worst situation.

Additionally, clinical charts were reviewed, and AP weight-bearing and lateral radiographs were obtained at follow-up. The tibiofemoral alignment was measured using the AP weight-bearing view.

Each patient was questioned and then examined by a colleague (M.J.) of the department who had not treated or seen the patient before.

Statistical analysis

The data are presented as mean and standard deviation of the mean. The *t*-test (Welch) for independent samples was used for statistical analysis. The level of statistical significance was set to an alpha-level of $p < 0.05$. All data were analysed with the SPSS statistical package release 10.0 (SPSS, Chicago, IL).

Results

Group A patients were evaluated an average of 55 ± 15 months after surgery, and group B patients an average of 56 ± 13 months after surgery. Regarding evaluation using the Knee Society Score, no significant difference was found between the groups in the function score (Table 1). The knee score was significantly lower in group A in comparison with group B ($p = 0.001$). The category 'pain' yielded a mean score of 36 ± 4 points for group A and 43 ± 04 points for group B ($p = 0.001$). The anteroposterior stability score was 8.7 ± 2.2 points for group A and 9.11 ± 1.9 points for group B ($p = 0.2$), and the medial-lateral stability score was 12.5 ± 2.5 points for group A and 13.5 ± 2.3 points for group B. Patients of group A had an average range of motion of $101° \pm 8°$ and group B patients, $109° \pm 11°$ ($p = 0.01$). An extension lag of 5° was noticed in 4 patients from group A and in 2 patients from group B. One patient in each group showed an extension lag of 10°. The participants scored their walking distance in group A at 23.6 ± 8.7 points, whereas in group B patients averaged a score of 28.2 ± 9.4 points ($p = 0.06$).

The assessments based on the WOMAC Score (Table 2) yielded no statistical difference in the pain ($p = 0.7$) and stiffness ($p = 0.2$) categories. Patients from group B had a higher average function score compared with patients from group A ($p = 0.04$). Five patients from group A rated their knees with a pain score greater than 5, and three of them ranked their knee function score also as greater than 5. These five patients of group A had an average knee score of 50.6 ± 20.8 points and an average function score of 42 ± 5.1 points in accordance with the Knee Society Score. Three of these 5 patients underwent a subsequent revision operation, due to unaddressed patellofemoral osteoarthritis or loosening of the uncemented tibial plateau. The revision operations were performed after an average interval of 18 ± 6 months. Manipulation under anaesthesia was required in 2 patients 9 days and 5 months postoperatively. At follow-up the range of motion of these two

Table 1 Clinical results based on the Knee Society Score for the patients who had received a total knee arthroplasty after failed unicondylar arthroplasty (group A) and the patients with primary total knee arthroplasty (group B)

INSALL Score	Group A	Group B
Knee score	71.1 ± 18*	80.4 ± 10
Function score	56.1 ± 15**	64.1 ± 19

*$p = 0.001$
**$p = 0.1$

Table 2 Clinical results based on the WOMAC Score for the patients who had received a total knee arthroplasty after failed unicondylar arthroplasty (group A) and the patients with primary total knee arthroplasty (group B)

WOMAC Score	Group A	Group B
Category A (pain)	2.3 ± 2.6*	2 ± 1.7
Category B (stiffness)	2.6 ± 2.6**	1.8 ± 2.3
Category C (function)	2.9 ± 2.3***	1.7 ± 2

*$p = 0.7$
**$p = 0.2$
***$p = 0.04$

patients was from full extension to 110° of flexion. Two patients did not demonstrate any obvious reasons for their limited functional outcome.

Four revision operations were required in total in group A. As already mentioned in 1 patient, their uncemented tibia plateau was revised to a cemented one with additional patella resurfacing 39 months postoperatively. Patella resurfacing was performed in all other cases with one additional substitution of the polyethylene inlay from 11 mm to 13 mm.

Radiographs of both groups did not show any signs of radiolucency on the AP and lateral views. The anatomical axis, measured on the AP view, was 5 ± 3° of valgus for both group A and group B. Group A patients who were revised after unicondylar arthroplasty required a significantly thicker polyethylene inlay of 12.4 ± 3 mm in comparison with group B patients after primary bicondylar knee arthroplasty of 10.3 ± 3 mm ($p = 0.009$).

Discussion

The purpose of the current study was to investigate the impact of an unicondylar arthroplasty on the clinical and functional outcome when revised to a bicondylar arthroplasty or total knee arthroplasty. Patients who had undergone revision of an unicondylar to bicondylar arthroplasty were matched with a group of patients after primary bicondylar arthroplasty. The Knee Society Score and the WOMAC self-questionnaire were utilized to evaluate each patient. Several factors such as patient age, gender [15, 40], body mass index [17], surgical approach [5], tourniquet [34] and prosthetic design [22, 48] may influence the patient outcome significantly and were considered in the patient selection for each group.

Patients who were converted from an unicondylar to a bicondylar arthroplasty scored on average 71.1 points on the knee score and 56.1 points on the function score. Gill et al. [16] and McAuley et al. [35] also re-examined patients after revision of an unicondylar to a bicondylar prosthesis and reported scores of 78.3 and 89 points on the knee score and 67.7 and 81 points on the function score, respectively. Our current results were slightly inferior in comparison with these previous studies. The average body mass index of our obese patients was 31 kg/m^2 (normal body mass index 18.5–25 kg/m^2) and may have been higher than for patients in other studies. Lower Knee Society function scores have been reported in obese patients [17, 49]. These patients have more difficulty climbing stairs and walking longer distances.

Patients in the primary arthroplasty group had knee scores of 80.4 points and function scores of 64.1 points. Decreased range of motion and inferior knee score results were observed in the revision group in comparison with the primary arthroplasty group. Scarring or thickening of the joint capsule is more likely after revision surgery and may be partially responsible for the decreased knee flexion. However, knee flexion beyond 90° was achieved in both the primary and revision groups. Ninety degrees of knee flexion is considered to be the minimum range of motion required in order for patients to perform activities of daily living (for instance, to get on public transportation or to sit down in a chair) [29]. Despite the differences in the total range of motion, similar values were scored with respect to walking distance and stair climbing for both groups.

Bullens et al. [13] reported a poor correlation between objective and subjective outcome systems. The WOMAC self-questionnaire has a very high capacity to discriminate between satisfied, neutral and dissatisfied patients but only partially correlates with the results of the Knee Society Score in the current study [19]. With regard to knee function, inferior results were noticed after revision surgery based on the WOMAC self-questionnaire, while no difference was found in the Knee Society Score (Tables 1 and 2). According to the Knee Society Score, the assessment of the patient's function includes walking and stair-climbing activity, whereas the WOMAC self-questionnaire assesses the ability of the patient to perform activities of daily living in more detail. The predominant limitations in our revision group were stair climbing, getting into and out of a car, and getting into or out of a bath tub. Decreased range of motion seems to have an important impact on patient outcome.

None of the revised patients in the current study required an allograft in order to fill bone defects. Similar findings have been reported by Levine et al. [31] and McAuley et al. [35]. The lateral condyle of the femur provides autogenous bone which can be used to fill defects in the medial compartment. Figure 1 shows the femoral condyles after the femoral bone cuts were carried out in a patient who required conversion of an unicondylar to a bicondylar arthroplasty. Bone defects on the femoral side are, in general, minimal. On the tibial side, cuts are frequently made lower in revision surgery in order to address bone defects of the medial tibia plateau. The first cut should be performed just underneath the tibial component (Fig. 2). This will cut through the peg of the tibial component, but the peg can be removed with a small chisel afterwards. Defects caused by the peg of the tibial component of the unicompartmental prosthesis can be filled with bone chips or cement (Fig. 2). Chakrabarty et al. [14] experienced more difficulties with the removal of metal-backed tibial

components than polyethylene components in their paper on revision of unicondylar arthroplasty.

Patients from group A required significantly thicker polyethylene inlays in comparison with group B. However, bone defects on the tibial side seem to be more problematic in revision surgery than defects on the femoral side [23]. In contrast, Padgett et al. [38] stated that 75% of their revised cases had severe bone loss. In cases of severe bone loss, tibial components with medial wedges or stemmed tibial components may be required [35]. Other authors claim that bone defects are not as problematic. Chakrabarty et al. [14] found no bone defects in 42% of patients and only minor defects in 36% when revising unicondylar arthroplasties. Correct leg alignment is sometimes difficult to achieve during revision surgery due to bone defects on the femoral or tibial side. To prevent incorrect alignment, the femoral component should remain in place until the first cuts have been prepared. This will enable the surgeon to achieve correct cuts, especially on the femoral side, in order to maintain appropriate flexion and extension gaps. The tibiofemoral alignment in our study was 5° of valgus in both groups. Other studies have shown that malalignment increases the risk for aseptic loosening in knee arthroplasty [24, 41].

No revision surgery was necessary in the primary arthroplasty group at follow-up. Four patients in the revision group required additional revision surgery. All of the revised patients complained of patellofemoral pain, and the patella was resurfaced. However, these patients complained of more pain and less function in comparison with other patients of group A even after the second revision surgery. Previous studies have shown that there is no difference in clinical outcome after primary bicondylar arthroplasty with or without patella resurfacing [1, 3, 6, 12, 53]. Ogon et al. [37] also did not find any advantage of patella resurfacing over patella retention in the long-term follow-up of primary bicondylar arthroplasty. Due to the limited number of patients in our study, no conclusion can be drawn regarding the necessity of patella resurfacing in revision surgery. In an additional patient a loose cementless tibia component was converted to a cemented component. The majority of patients in both groups received uncemented components, but in 12 patients of group A and in 3 patients of group B, either one or both components were cemented. Clinical studies have shown that the fixation method of the implants in primary arthroplasty seems to have no impact on patient outcome [9, 25, 36, 39, 44, 45]. However, it remains questionable whether cemented components should be used routinely in revision arthroplasty. One may hypothesize that cemented arthroplasty may provide a better primary stability and might more easily address minor bone defects.

Robertsson [42] utilized the Swedish Arthroplasty Registry to detect a cumulative failure rate of 6% after conversion of an unicondylar to a bicondylar prosthesis. In contrast, 14% of patients who underwent revision of a total knee arthroplasty to a new knee arthroplasty required yet another revision. Furthermore, he found that patients revised after a medial unicompartmental arthroplasty were more satisfied than patients after revision of their primary knee arthroplasty [43]. The outcome after revision of an unicondylar prosthesis seems to be better than after revision of a bicondylar prosthesis. Based on these findings, we designed the current study in order to focus on the impact on the clinical and functional outcome of an unicondylar prosthesis prior to the implantation of a bicondylar prosthesis. In case of minor clinical and functional differences between the converted and primary bicondylar arthroplasty patient, one may hypothesise that unicondylar arthroplasty can be seen as a therapeutic option before bicondylar arthroplasty is required.

The patients in our study were on average 60 years old when the initial unicondylar arthroplasty was performed. For the very small percentage of patients in whom revision surgery is necessary, total knee arthroplasty could be delayed for 6 years, and patients are satisfied after conversion of an unicondylar to a bicondylar prosthesis, but not quite as much as patients who obtained a primary total arthroplasty. However, even if revision is required, the patient has already been successfully treated with an unicondylar prosthesis for many years.

In conclusion, it may be worthwhile doing an unicondylar knee arthroplasty if only the medial compartment is relevantly diseased, because a revision with a bicondylar prosthesis later on does not yield fundamentally worse results than with a primary bicondylar prosthesis. The unicondylar prosthesis, however, is a small intervention for younger patients, the rehabilitation is faster, and the primary outcome is usually better than after primary bicondylar arthroplasty.

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