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Minimally Invasive Unicondylar Versus Total Condylar Knee Arthroplasty – Early Results of a Matched-Pair Comparison

K Y Yang, M C Wang, S J Yeo, N N Lo

ABSTRACT

Fifty consecutive patients with isolated medial compartmental osteoarthritis of the knee were treated with minimally invasive unicompartmental knee arthroplasty (UKA). An equal number of patients with total knee arthroplasty (TKA) performed in the same period were selected and matched with respect to age, pre-operative range of motion and radiological grade of knee arthrosis. Both groups of patients were prospectively followed up. Comparison of the two groups at six months show that patients with minimally invasive UKA have less blood loss, quicker rehabilitation, earlier ambulation, shorter hospitalisation stay and better post-operative range-of-motion with reduced hospitalisation cost. Reflecting on a six-month follow-up and immediate post-operative events, we conclude that minimally invasive UKA is a relatively more cost effective procedure than TKA for these patients.

Keywords: unicompartmental knee arthroplasty minimally invasive

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INTRODUCTION

Total knee arthroplasty (TKA) is a proven procedure for the treatment of advanced knee arthrosis. However, as much as 20% of these patients have isolated unicompartmental osteoarthritis amenable for a unicompartmental replacement[1]. Unicompartmental knee arthroplasty (UKA) has been performed since the 1970s for these patients with an aim of replacing only the diseased compartment of the knee joint and preserving the bone stock. The initial results of UKA were very encouraging but later proved disappointing and many surgeons abandoned the procedure. The causes of the early failures are multi-factorial and include poor patient selection and surgical technique[2], inadequate implant design[3], polyethylene wear[4], inaccurate instrumentation[5], poor understanding of the knee kinematics etc. Improvement in all the above factors contributed to a resurgence of the interest in UKA in the 1990s with several proven implant designs. Latest published data showed that the survivorship of an UKA approached that of a total knee arthroplasty[6,7] with more than 95% at 10 years. Encouraged by the results, orthopaedic surgeons enhanced the procedure with the development of minimally invasive techniques. This reduces the incision size from 20 cm to about 8 cm and does not cut the quadriceps muscle or tendon, hence no longer disrupts the extensor mechanism. The theoretical advantages include smaller incision, reduced muscular dissection leading to lesser post-operative pain, quicker rehabilitation, reduced blood loss, lower infection rate[8], preservation of range-of-motion and lower cost. Retention of both cruciate ligaments may also provide better knee kinematics as compared to TKA. We performed a matched-pair comparison between the minimally invasive UKA and traditional TKA for patients with isolated medial compartmental osteoarthritis of the knee to confirm its early advantages.

MATERIALS AND METHODS

Fifty consecutive patients (50 knees) with isolated medial compartmental osteoarthritis of the knee comprised the study population and prospectively studied. All had minimally invasive UKA performed by two senior surgeons in our institution (N.N.L. and S.J.Y.). All the patients satisfy the inclusion criteria of (1) above the age of 50; (2) active community ambulator; (3) radiological evidence of medial compartmental osteoarthritis only; (4) absence of patello-femoral symptoms; (5) competence of both cruciate ligaments; (6) less than 15 degrees varus; and (7) absence of fixed flexion deformity.

Patients with inflammatory arthritis or incompetent cruciates are considered unsuitable for UKA[7]. Age and body habitus do not affect patient selection. The implants used were Miller-Galante Unicompartmental (Zimmer, Warsaw, IN) and P.F.C. Unicompartmental (Depuy, Leeds, UK) knee systems. Both systems are equipped with special instrumentations for minimally invasive surgery.

Department of Orthopaedic Surgery
Singapore General Hospital
Outram Road
Singapore 169608

K Y Yang, FRCS (Glas)
Associate Consultant

M C Wang, MD
Clinical Fellow

S J Yeo, FRCS (Edin)
Senior Consultant

N N Lo, FRCS (Edin)
Senior Consultant

Correspondence to:
Yang Kuang Ying
Tel: (65) 6321 4047
Fax: (65) 6224 8100
Email: kyyang@orthopods.net

During the same period, 50 patients (50 knees) with similar medial compartmental arthrosis but offered TKA were matched to the study population. They were operated by two other experienced surgeons who routinely performed TKA for unicompartmental arthrosis for the past 10 years. All these patients had cruciate retaining implants from NexGen (Zimmer, Warsaw, IN) and P.F.C. Sigma (Depuy, Leeds, UK) systems. The patients in both groups were matched with respect to age, pre-operative range of motion and radiological severity of arthritis and deformity. All patients were followed up prospectively once enrolled into the study. Only patients with Ahlback's grade II or III arthrosis were selected for both the control and study groups[9].

Both groups of patients follow the standard post-operative rehabilitation protocol designed for TKA in our institution. They are evaluated for the following parameters: operating time, amount of post-operative blood loss, lowest post-operative haemoglobin level recorded, transfusion requirements and duration of hospitalisation. The fall in the haemoglobin level was calculated accordingly. The progress of rehabilitation was monitored by the average time taken by the patient to achieve 90 degrees of flexion as well as to ambulate independently without assistance from the therapist. The patients were required to walk a distance of 25 m with or without walking aids. They also had to climb up and down a flight of six steps before discharge from the hospital. The patients were further evaluated at six months post-operatively to compare the range of motion achieved. Post-operative complications were also documented in detail. All parameters are then compared using the t-test.

RESULTS

The mean age of patients at the time of operation for the study (UKA) and control (TKA) group was 65.1 (range 54-80) and 65.5 (range 55-80) respectively. The UKA group had eight males and 42 females while the TKA group had 6 males and 44 females. The ratio of left to right knee was 21:29 in the UKA group and 24:26 in the TKA group. The two groups were very similar in characteristics as shown in Table I.

The mean operating times for both groups were also similar, with 90 (range 50 to 135, SD 24) minutes for UKA and 87 (range 60 to 160, SD 22) minutes for TKA. The total post-operative drainage was significantly lesser with UKA at 203 (range 100 to 380, SD 131) ml versus a mean of 333 (range 60 to 910, SD 229) ml for TKA ($p<0.01$). The drain can usually be removed by the first post-operative day after a UKA while it has to be kept for two days after a TKA. The reduced drainage also reflected a corresponding reduction in blood loss after a UKA. While the mean pre-operative haemoglobin for UKA and TKA was similar at 13.3 (range 10.0-16.0) g/dl and 13.1 (range 10.3 - 15.5) g/dl respectively, those with UKA had a higher post-operative haemoglobin of 11.5 (range 9.5-15.2) g/dl as compared to 10.5 (range 8.2 - 12.7) g/dl after a TKA ($p<0.01$). The fall in haemoglobin level after an UKA averaged 1.8 (range 0.5-3.2, SD 0.8) g/dl and was significantly lesser than the fall of 2.6 (range 0.8-5.9, SD 1.4) g/dl after a TKA ($p<0.01$). Of the entire cohort, three patients with TKA require blood transfusion but not in any patients with UKA.

As the pre-operative range of motion significantly influences the post-operative range of motion[10], the pre-operative range of motion of UKA and TKA groups was matched which averaged 124º and 121º respectively. Patients with UKA enjoyed a quicker rehabilitation and ambulate independently earlier at an average of 2.1 (range 1 to 5, SD 0.8) days after the operation as compared to 5.4 (range 4 to 9, SD 2.2) days with TKA ($p<0.01$). They achieved a flexion of 90º after 3.6 (range 2 to 7, SD 1.1) days in contrast to 6.9 (range 3 to 18, SD2.5) days required by those with TKA ($p<0.01$). They also had a shorter hospitalisation of 5.9 (range 3 to 11, SD 1.5) days than the control group of 9.4 (range 6 to19, SD 3.0) days ($p<0.01$). At six months, patients with UKA had a greater range of motion of 122º (range 107-148, SD 14) as compared to TKA group of 108º (range 92-139, SD 17) ($p<0.01$). None of the patients in both groups required manipulation to enhance the range of motion.

There were no early complications in patients with UKA. In contrast, one patient in the control group had to be treated for deep vein thrombosis confirmed on duplex ultrasonography. Another patient had an extended hospitalisation stay after she developed post-operative pneumonia. Both patients were well at the six months follow up.

Unicompartmental knee arthroplasty is also more affordable than a TKA. The cost reduction comes from both lower implant cost as well as a shorter hospitalisation stay. The unicompartmental prosthesis, at approximately S$1,000, is less than half the price of the total condylar design. The average total hospitalisation bill for a patient with UKA is S$8,700 as compared to that of S$12,000 with TKA.

The results are summarised in Table I with their statistical evaluation.

DISCUSSION

Proximal tibial osteotomy had been the time-tested treatment for patients with isolated medial compartmental osteoarthritis. However, various factors like inconsistent pain relief especially for patients above the age of 60,

Table I. Comparison of results between the UKA and TKA groups.

	UKA (range)	TKA (range)	p-value
No. of patients (knees)	50	50	
Male : Female	8:42	6:44	
Mean age	65.1 (54-80)	65.5 (55-80)	p=0.11
Mean operating time (minutes)	90 (50-135, SD 24)	87 (60-160, SD 22)	p=0.40
Days required for independent ambulation	2.1 (1-5, SD 0.8)	5.4 (4-9, SD 2.2)	p<0.01
Time to achieve 90° flexion (days)	3.6 (2-7, SD 1.1)	6.9 (3-18, SD 2.5)	p<0.01
Hospital stay (days)	5.9 (3-11, SD 1.5)	9.4 (6-19, SD 3.0)	p<0.01
Total post-operative drainage (ml)	203 (100-380, SD 131)	333 (60-910, SD 229)	p<0.01
Fall in post-operative haemoglobin (g/dl)	1.8 (0.5-3.2, SD 0.8)	2.6 (0.8-5.9, SD 1.4)	p<0.01
Mean pre-operative range-of-motion	124° (98-152, SD 13)	121° (96-148, SD 15)	p=0.25
Mean flexion achieved at 6 months	122° (107-148, SD14)	108° (92-139 SD 17)	p<0.01
Average hospitalisation bill	$8,700	$12,000	p<0.01

cosmetic deformity and poor survivorship at 10 years[11] encouraged orthopaedic surgeons to search for alternative solutions. Both total and unicompartmental knee replacement had been advocated since the 1970s for such patients. Unicompartmental knee arthroplasty had been plagued with problems initially. It is not until the 1990s that the UKA proved itself and regained its popularity. In a well-selected patient, the outcome and survivorship of the unicompartmental knee replacement approach that of TKA[12,13]. Unicompartmental knee arthroplasty, which was previously performed via a formal arthrotomy, has the advantage of preservation of bone stock and both cruciate ligaments. These patients have superior range of motion[14], better stair climbing ability and more normal knee kinematics[15]. Randomised control trial of patients with bilateral simultaneous knee arthroplasty, but with a unicondylar and a total condylar knee prosthesis each in the same patient, shows more patients prefer the unicompartmental replacement[16,17]. Revision arthroplasty, if necessary in future, is also easier with UKA than TKA largely due to preservation of bone stock and knee ligaments[18].

While the performance of UKA has been proven, new minimally invasive technique can improve the outcome even further. Open unicompartmental knee arthroplasty involves the similar wide exposure as that of a TKA. Lesser muscular dissection without violation of extensor mechanism reduces the post-operative pain and minimises disruption in quadriceps function. This may translate into decreased blood loss, lower infection rate[8], quicker rehabilitation and possibly shorter hospitalisation stay. Together with lower implant cost, the cost-benefit ratio for minimally invasive UKA can be much better than a traditional TKA for patients with isolated medial compartmental osteoarthritis. Our study confirms these potential early advantages of the minimally invasive UKA.

Minimally invasive UKA can be more technically demanding than the TKA. The mean operative time is slightly longer but none of the cases extend beyond 135 minutes. Careful selection criteria ensure that none of the patients intended for UKA requires a conversion to a TKA intra-operatively. The average incision length of 8 cm is adequate for all bony resection and soft tissue releases.

Comparing the two groups, the blood loss in the UKA group is significantly less. This is reflected by both the reduced post-operative drainage as well as the drop in the haemoglobin level. Though the mean difference in the drop in post-operative haemoglobin is only 0.8g/dl (1.8 g/dl for UKA for 2.6 g/dl for TKA), three patients in the TKA group require homologous blood transfusion. This represents a significant saving on the transfusion requirements in patients undergoing arthroplasty.

We also assessed the patients' post-operative recovery by the time taken to achieve a flexion of 90º as well as to ambulate independently. In these respects, patients with UKA significantly outperformed those who underwent TKA. Early post-operative complications, which only occurred in the TKA group, also hampered the rehabilitation. One patient with post-operative pneumonia walked only after nine days and required 18 days to flex to 90º. The other patient with deep vein thrombosis had severe lower limb pain and swelling that similarly delayed the therapy. At six months, the range of motion in the UKA group is clearly superior to those in TKA group. Activities that require deep flexion e.g. getting in and out of a car or squatting are significantly enhanced by increased range of motion.

With rising cost of healthcare, the cost effectiveness of any treatment procedure is under close scrutiny. Hence, we also studied the cost-benefit ratio of the UKA versus TKA for patient with unicompartmental arthrosis. The overall cost of treatment with UKA is lesser than that of TKA, stemming from both reduced hospitalisation stay as well as lower implant cost. Even factoring in the possibility higher failure rate for UKA, and the adding in the cost of subsequent revisions, the overall cost is still less than a TKA for indicated patients[19].

Early mobilisation and shorter hospitalisation stay may also reduce the morbidities like thromboembolism and nosocomial infection. Although the group with TKA had a patient each of pneumonia and deep vein thrombosis, this is not statistically significant for analysis.

CONCLUSION

Long-term survivorship of unicompartmental knee arthroplasty has been established for selected patients with isolated medial compartmental knee arthrosis. Although this study only reflects on the early results at six months, many of the potential benefits are realised during this period. In these patients, minimally invasive UKA is an attractive and more cost effective alternative to total knee arthroplasty.

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