CLINICAL ARTICLE

Minimally Invasive Unicompartmental Knee Arthroplasty for Spontaneous Osteonecrosis of the Knee

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Objective: To explore the outcome and surgical technique of minimally invasive unicompartmental knee arthroplasty (UKA) for spontaneous osteonecrosis of the knee.

Methods: Twenty-seven patients with medial compartmental spontaneous osteonecrosis treated by minimally invasive Oxford phase 3 UKA from January 2009 to June 2013 were reviewed retrospectively. Twelve subjects were men and 15 women, with an average age of 64.6 ± 8.6 years (52–82 years). At the time of diagnosis, 11 patients had with grade III necrosis and 16 grade IV according to Mont's classification. Pain, range of motion (ROM) and Hospital for Special Surgery (HSS) knee scores were evaluated before and after UKA. Pre-and postoperative alignment of the lower limbs was measured and compared. Postoperative radiographic assessments were made according to the guidelines proposed by the Oxford group at the final follow-up.

Results: All patients were followed for a mean time of 27.8 ± 15.9 months (6–59 months). There were no serious adverse events, such as infection, bearing dislocation, aseptic loosening, pulmonary embolism, deep venous thrombosis, cardio-cerebral vascular incident or psychological problems. One revision was required for unrelated causes (fracture of tibia plateau) 3 years after arthroplasty. One femoral component was tilted with a postoperative radiographic angle $>10^\circ$. One radiolucent line was observed in a patient with spontaneous osteonecrosis of the knee. The two patients with implant failure had no symptoms at last follow-up. Visual analogue scale scores decreased from 6.9 ± 0.9 to 2.0 ± 1.1 ($t = 19.27$, $P = 0.00$). Pain was relieved in 96.3% of subjects (26/27). The mean post-operative ROM and femorotibial angle were $125.7^\circ \pm 9.6^\circ$ and $177.7^\circ \pm 3.1^\circ$, respectively. HSS scores increased from 61.3 ± 9.7 to 93.0 ± 4.8 ($t = 14.46$, $P = 0.00$). Of the 27 patients, 26 (96.3%) were satisfied with the outcome of this surgical procedure.

Conclusion: Minimally invasive UKA is an effective means of managing spontaneous osteonecrosis of the knee. The short-term outcome of UKA is encouraging.

Key words: Knee arthroplasty; Osteoarthritis; Minimally invasive; Spontaneous osteonecrosis of the knee

Introduction

After the hip, the knee is the second most common location for osteonecrosis and presents in two major forms: spontaneous and secondary osteonecrosis¹. Spontaneous osteonecrosis of the knee (SONK) of no identifiable cause was first

identified as a separate disease by Ahlbäck *et al.* in 1968². Secondary osteonecrosis is most commonly caused by steroids and alcohol.

Unicompartmental knee arthroplasty (UKA) is one of the treatment options for patients with arthrosis of the medial

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compartment of the knee. With improvement in surgical techniques and instruments, this procedure has shown many advantages over total knee arthroplasty (TKA) for treatment of anteromedial osteoarthritis (AMOA), including less soft tissue injury, smaller incision, minimal bone resection, preservation of normal knee kinematics, reduced hospital stay and more rapid recovery³⁻⁷. Moreover, it appears acceptable to replace only one (the affected) compartment. The mobile Oxford medial UKA (Oxford Unicompartmental Knee; Biomet, Bridgend, UK) has been widely and successfully used for more than three decades, since 1998, when the phase 3 implant was introduced. Many excellent long-term results have been reported for this procedure for AMOA⁸⁻¹⁰.

Spontaneous osteonecrosis of the knee is a type of bone necrosis that often leads to subchondral collapse and disabling arthritis¹¹. SONK, which usually affects the medial femoral condyle, is characterized by acute knee pain and tenderness of the medial knee compartment. Its anatomical features are similar to those of AMOA and include focal loss of bone and cartilage in the medial compartment with intact ligaments and lateral compartment, this constellation being an indication for UKA. Nevertheless, limited studies were published about UKA in SONK¹²⁻¹⁵. The role of UKA versus AMOA for SONK remains unclear, particularly regarding the technical aspects. This observational study was performed to investigate the outcome and surgical technique of minimally invasive UKA for SONK.

Materials and Methods

Twenty-seven patient with medial compartmental spontaneous osteonecrosis treated in our institution by minimally invasive Oxford phase 3 UKA from January 2009 to June 2013 were reviewed retrospectively. Twelve subjects were men and 15 women, with an average age of 64.6 ± 8.6 years (52–82 years). Informed consent to participate in the study was obtained from all patients, according to the rules of the local ethics committee. After a detailed medical history and physical examination, all patients were subjected to MRI and

X-ray. None of the study subjects had any history of osteonecrosis or of recent operations on the affected knee. All patients were diagnosed by MRI and X-ray. Radiographs can show SONK of the medial compartment of the knee at the late stage, which is characterized by collapse of the medial compartment². At the time of diagnosis, 11 patients had grade III necrosis, and 16 grade IV according to Mont's classification¹. The indications for UKA were severe medial knee pain and considerable difficulty in walking and performing daily activities with an intact lateral compartment, varus deformity $<15^\circ$, flexion contracture $<15^\circ$ and intact anterior cruciate ligament¹⁶.

All UKA procedures were performed by the senior author. A mobile Oxford medial UKA (Oxford Unicompartmental Knee; Biomet) was used in all patients (Fig. 1). All UKA procedures were performed with the same minimally invasive surgical technique and blood loss management. All patients were placed in a supine position on a standard operating table after spinal anesthesia had been induced. A tourniquet was applied to the proximal thigh on the operative side and inflated to 300 mm Hg. A medial parapatellar incision was made; the patella was not everted. Tibial resection was performed using an extramedullary tibial alignment guide. The femoral condyle was prepared using an intramedullary rod. The distal femoral condyle was milled for balance of the 90° and 20° flexion gaps, that is, the extension and flexion gaps. All osteonecrotic bone was completely removed with a curette. If the lesion was greater than 5 mm^2 , it was filled with autologous bone graft obtained from the bone removed during the procedure (Video S1).

For follow-up, the patients were both clinically and radiographically examined. The following clinical outcomes were evaluated: duration of surgery, blood loss, hospital stay, complications, range of motion (ROM) of the knee, visual analogue score (VAS) and Hospital for Special Surgery (HSS) knee score. Weight-bearing anteroposterior and lateral radiographs of the knee were obtained, as well as long hip-to-ankle films to assess the femorotibial angle and implant position. Pre- and post-operative alignment of the low limbs was measured and compared. Postoperative radiographic assessments were made at the final follow-up according to the guidelines proposed by the Oxford group¹⁷. Loosening of the components was identified by an $>2 \text{ mm}$ area of radiolucency around the components. Over-rotation of a component was diagnosed if the alignment angle exceeded 10° . Each evaluation was made twice by two independent observers. The endpoint was defined as revision for any reason. Patient-related information was collected using a standardized questionnaire administered before surgery and at follow-up.

All data were analyzed using SPSS version 17.0 (SPSS, Chicago, IL, USA). Data are reported as the mean and standard deviation. The χ^2 and Student's *t*-tests were used to determine whether there were statistically significant differences between the groups. A *P* value <0.05 was considered statistically significant¹⁸.

Fig. 1 The three components of the mobile Oxford medial unicompartmental knee arthroplasty (phase 3).

Fig. 2 A 65-year-old woman with SONK. (A) Anteroposterior standing radiograph of the knee prior to surgery. (B) T1 weighted image of the same knee showing focal lesion of the medial condyle. (C) T2 weighted coronal image of the same knee showing focal lesion of the medial condyle. (D) Anteroposterior view of (UKA) at 2-year follow-up.

Results

All patients were followed up for a mean of 27.8 ± 15.9 months (6–59 months). One UKA required revision to a TKA after 3 years for an unrelated reason; namely, as a result of the lateral tibial plateau and fibular head fracture sustained in major trauma. There had been no clinical symptoms of implant failure or radiographic signs of loosening before the accident. There were no serious adverse events, such as infection, bearing dislocation, aseptic loosening, pulmonary embolism, deep venous thrombosis, cardio-cerebral vascular incident or psychological problems.

The mean operation time was 77.8 ± 12.8 min (57–102 min), perioperative blood loss 106.1 ± 74.8 mL, volume of drainage 132.3 ± 35.0 mL and mean incision length $9.7 \pm$

1.3 cm. In all patients, passive full flexion of the knee and painless active full flexion were possible within 7 postoperative days and 3 postoperative months, respectively. The mean postoperative ROM was $125.7^\circ \pm 9.6^\circ$ at the final follow-up, which did not differ significantly from the preoperative ROM ($t = 0.86$, $P = 0.40$). The mean VAS score decreased from 6.9 ± 0.9 to 2.0 ± 1.1 ($t = 19.27$, $P = 0.00$). Pain was relieved in 96.3% (26/27) of subjects. The mean HSS score increased from 61.3 ± 9.7 to 93.0 ± 4.8 by the time of final follow-up ($t = 14.46$, $P = 0.00$). Twenty-six of the 27 patients (96.3%) were satisfied with the outcome of this surgical procedure (Table 1).

According to the guidelines proposed by the Oxford Group¹⁷, postoperative radiographic assessments showed that one component in one subject was not in an acceptable

TABLE 1 Unicompartmental knee arthroplasty outcomes (mean $\pm$ SD)

Index	Preoperation	Postoperation	t value	P value
HSS score	61.3 $\pm$ 9.7	93.0 $\pm$ 4.8	14.46	0.00
VAS score	6.9 $\pm$ 0.9	2.0 $\pm$ 1.1	19.27	0.00
ROM (°)	127.3 $\pm$ 7.0	125.7 $\pm$ 9.6	0.86	0.40

position, the femoral component being tilted with a postoperative radiographic angle $>10^\circ$. One radiolucent line was observed in this series. The two subjects with implant failure had no clinical symptoms at the final follow-up. The difference between mean preoperative and postoperative axial alignment was not significant. The mean post-operative femorotibial angle was $177.7^\circ \pm 3.1^\circ$ (Figs 2–4).

Discussion

The most important finding of this study was that the short-term outcome of UKA in patients with SONK is encouraging. Minimally invasive UKA is an effective means of managing SONK with less trauma and quicker recovery than other procedures. It relieves pain and improves HSS scores.

Unicompartmental arthroplasty is a well-recognized treatment option for unicompartmental osteoarthritis of the knee. The Oxford unicompartmental knee has a mobile bearing with full congruency, minimizing polyethylene wear. Svard and Price reported a 95% cumulative rate of survival of this prosthesis over 10 years⁶. Pandit *et al.* reported the outcomes of 1000 phase 3 Oxford medial UKAs using a minimally invasive surgical approach performed by two surgeons. With revision as the end point, the 10-year survival rate was 99.8%¹⁹. In 2011, Price reported the second decade data of the Oxford UKA, having previously reported longitudinal data from 1, 6 and 10 postoperative years^{20–22}. In the most recent study, postoperative function and HSS score were still significantly better than baseline values. These findings suggest that the Oxford UKA is a reliable treatment option for anteromedial osteoarthritis of the knee.

In 1968, Ahlback *et al.* described SONK as a typically unicompartmental disease². Subsequently, Mont and Hungerford modified the Ficat and Arlet staging of osteonecrosis of the hip to developed the following staging system for femoral condyle osteonecrosis: Stage I, MRI scan findings are positive, but plain radiographs reveal no changes; Stage II, radiographs reveal cystic and sclerotic changes in the distal femur and/or proximal tibia; Stage III, subchondral collapse is evidenced by the crescent sign; and Stage IV, evidence of degenerative changes is present on both sides of the joint (e.g., joint space narrowing, osteophytes). More recently, Mont *et al.* reported that there is limited involvement of the periarticular bone in this disease. SONK mainly affects the medial femoral condyle¹¹. Although SONK is poorly understood, its anatomical features are similar to those of AMOA (focal loss of bone

Fig. 3 A 82-year-old man with stage IV SONK treated by UKA with autologous bone graft. (A) Radiograph of the knee prior to surgery. (B) Long hip to ankle film for measuring the femorotibial angle. (C) Radiograph of the knee after UKA surgery. (d) UKA at 2.5 year follow-up on a long hip to ankle film.

and cartilage in the medial compartment with the ligament intact). Therefore, UKA seems to be an appropriate procedure, particularly for patients older than 60 years with unaffected lateral and patellofemoral compartments. Some

Fig. 4 A 60-year-old man with stage III SONK. Trauma-related lateral tibia plateau and fibular head fracture occurred 3 years after arthroplasty, which was revised with TKA. (A) Anteroposterior standing radiograph of the knee prior to surgery. (B) T1 weighted image of the same knee showing focal lesion of the medial condyle. (C) Radiograph of the knee after UKA surgery. (D) Lateral tibia plateau and fibular head fracture. (E) Revision with TKA.

surgeons believe joint arthroplasty is the only appropriate treatment for SONK with secondary articular collapse^{12,13,15}.

Recently, several studies have shown excellent functional outcome and survivorship of UKA after treating SONK. Bruni *et al.* reported 84 patients with late-stage SONK with a mean follow-up of 98 months. The overall prosthesis survival was 89%. Ten revisions were performed; the most common reasons for failure being subsidence or aseptic loosening of the tibial component. No patient underwent revision for progression of osteoarthritis in the lateral or patellofemoral compartments¹². Similarly, Langdown *et al.* assessed 29 knees (27 patients) with SONK and 5 years follow-up using the Oxford Knee criteria. They confirmed that the Oxford Medial UKA is reliable in the short to medium term for spontaneous focal osteonecrosis of the knee and achieves results similar to those for primary osteoarthritis¹⁴. Servien *et al.* reported a comparison study of 33 SONK

and 35 osteoarthritis cases. The mean follow-up was 5 years. The results were comparable in terms of pain, knee score and function. The prosthesis survival rate was 92.8% for the SONK group and 95.4% for osteoarthritis group. There was a higher rate of radiolucencies in the SONK group; however, they were asymptomatic¹⁵.

Minimally invasive UKA is an effective means of managing SONK with little traumas and quick recovery. The short-term outcome of UKA is encouraging. However, patient selection and surgical techniques are different for SONK than for osteoarthritis and UKA may be very challenging in subjects with SONK. When planning treatment of patients with SONK, the extent and stage of the lesion should be assessed. Stage I and II SONK can potentially be treated conservatively because these stages are potentially reversible. Treatment relies on protected weight-bearing with crutches, non-steroidal anti-inflammatory medications, analgesics, and physical therapy for

strengthening the quadriceps and hamstring muscles. When avascular necrosis is at an early stage, surgical intervention may cause more extensive loss of bone and TKA with complex augments may subsequently be required to repair for the resultant bone defect. UKA is much more appropriate when the avascular necrosis has matured and is at late stage, as evidenced by an obvious defect that is usually surrounded by sclerotic bone, especially in those older than 60 years of age. From a technical point of view, implantation of UKA in patients with SONK is a demanding procedure and the following considerations must be taken into account. Firstly, the bone collapse and defect of the medial femoral condyle are often located in the weight-bearing area in extension. Failure to identify the presence of bone defect may result in the surgeon recessing the spigot too deeply and thereby milling too much bone from the medial condyle. This may result in imbalance between the extension gap and flexion gap. Secondly, because the osteonecrotic bone lesion is surrounded by sclerotic bone, complete removal of the avascular necrosis may be difficult to achieve with the Oxford mill tool; therefore a scoop can be used to remove the osteonecrotic lesion using the sclerotic bone as a reference. Thirdly, optimal management of SONK depends directly on the size of the lesion. When the lesions are larger than 5 mm², it is necessary to fill large craters with autologous bone graft obtained from the bone removed at surgery; otherwise, the bone defect may cause instability of components.

This study has the following potential weaknesses. Firstly, we had no control group undergoing UKA for osteoarthritis of the knee. Secondly, the quality of a prospective study is poorer than that of a prospective randomized controlled trial. However, it is difficult to implement blinding and random comparison when studying surgical management of two conditions. Besides, among the 540 knee UKAs performed in our institution over 5 years, only 27 were performed for SONK. The smallness of our sample can be explained by the low incidence of the SONK in the general population. Finally, the follow-up time was relatively short. Some complications, such as loosening and revision, may occur at a later stage. Long-term study is still needed to clarify the outcomes.

The results of our study indicate that minimally invasive Oxford phase 3 UKA is a reliable procedure with excellent clinical and radiological results for medial unicompartmental late-stage SONK. The medium-term outcome of UKA is encouraging.

Supporting Information

Additional Supporting Information may be found in the online version of this article on the publisher's web-site:

Video S1 Minimally invasive unicompartmental knee arthroplasty.

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