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Medium-term clinical results of unicompartmental knee arthroplasty for the treatment for spontaneous osteonecrosis of the knee with four to 15 years of follow-up

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ABSTRACT

Background: Unicompartmental knee arthroplasty (UKA) is an option for the treatment of spontaneous osteonecrosis of the knee (SONK). However, there are limited studies focusing on this area. This study presents medium-term clinical outcome data of UKA for SONK.

Methods: We reviewed 50 SONK knees in 48 patients that were treated by UKA. The mean age, height, and body weight were 73 years, 153 cm, and 57 kg, respectively. The mean follow-up was 8.4 years (range, four to 15 years). Preoperatively, we measured the size and the volume (estimated by width × length × depth) of the necrotic bone mass on T1-weighted magnetic resonance imaging. The clinical results were evaluated serially at follow-up visits radiographically and with the Knee Society Scoring (KSS) and Oxford Knee Scoring (OKS) systems.

Results: There were no revisions, re-operations, or major complications. The mean sizes of the necrotic lesions were 17.2 mm (14.7–22.3 mm) in width, 28.2 mm (6.2–34.7 mm) in length, and 11.3 mm (3.2–14.5 mm) in depth. The mean volume was approximately 5.4 cm^3 (0.7–10.3 cm^3). The mean flexion of the knee, KSS Knee Score, Function Score, and OKS increased from a preoperative 128.7–137.5°, 52.3–91.3, 39.7–90.2, and 21.6–40.2, respectively, at the latest follow-up. At the last follow-up, all patients had good or excellent OKS.

Conclusions: This study demonstrates that UKA is a good option and is reliable for the treatment of SONK irrespective of necrotic bone mass size.

1. Introduction

Spontaneous osteonecrosis of the knee (SONK) was first reported with 40 cases by Ahlback et al. in 1968 [1]. SONK usually presents with severe knee pain of acute onset without a significant episode of trauma predominantly in females older than 55 years of age. Typical SONK lesion occurs in medial femoral condyle. On radiographs, SONK is initially recognised as a flattening of the medial femoral condylar joint surface and progresses to radiolucent osteochondral bone defect at the subchondral zone. On

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magnetic resonance imaging (MRI), a SONK lesion presents a fragmented subchondral bone mass circumscribed by a low-intensity layer on T1-weighted images [1–4]. To date, the exact aetiology of the SONK has not been defined.

For patients with more advanced symptomatic SONK, various joint-preserving surgeries have been considered. Recently, unicompartmental knee arthroplasty (UKA) has been accepted as a surgical option for SONK. The Oxford UKA was originally developed mainly for the treatment of anteromedial osteoarthritis (AMOA) of the knee with intact ligaments, and SONK was considered to be a rare but possible indication [5]. Increasing numbers of studies of this device have reported good long-term clinical outcomes with survival rates of 90.6% to 95.1% at 15 years [6–9] and 92% at 20 years [10]. However, as most of the reported cases were AMOA, the clinical results of the UKA for SONK was not analysed separately. As a result, the long results of UKA for SONK are not well defined.

The aim of this single-centre study was to determine the mid- to long-term clinical outcomes of a consecutive series of 50 UKA-treated SONK cases. In addition, the relationship between the size of bone defects created by removal of necrotic bone and implant survival was assessed.

2. Materials and methods

We reviewed 50 consecutive SONK knees in 48 patients who were treated with UKA between 2002 and 2014. All of the SONK lesions were located in the medial femoral condyles. All SONK patients who were candidates for joint-replacement surgery underwent UKA, and these patients constituted 25.6% (50/195) of all UKA cases performed at our institution during the study period.

The patients were 10 males and 38 females. The mean age at surgery was 73 years (57–83 years). The mean height and body weight were 153 cm (141–171 cm) and 57 kg (35–75 kg), respectively. All had undergone UKA with the Oxford mobile-bearing UKA Phase 3 (Zimmer-Biomet, Swindon, UK) with cement fixation. The surgical procedures were performed following standard minimally invasive surgery guidance [11]. Microplasty instrumentation technique was used from 2012 onwards [5]. Bone defects after curettage of dead bone mass, milling and drilling of the femoral condyle, were filled with cement during fixation the femoral component. All of the UKAs were performed by one of the authors (S.F.). Preoperative radiographic evaluation was made on antero-posterior and lateral standing views, Rosenberg A–P view. Valgus stressed A–P view at 20° knee flexion was used to demonstrate that the intra-articular varus deformity is correctable. The stage of SONK was evaluated according to Aglietti grading criteria [2] as follows: Stage I: normal on radiograms; stage II: slight flattening of the affected weight-bearing portion of the condyle on close scrutiny; stage III: radiolucent lesion adjacent to the joint surface, surrounded by sclerotic subchondral bone; stage IV: the collapsed radiolucent lesion surrounded by evident sclerosis; stage V: secondary degenerative osteoarthritic changes with osteophyte formation and subchondral sclerosis and erosion both on femur and tibia sides.

All patients underwent MRI using the 1.5-T ECHELON (Hitachi Ltd., Tokyo, Japan) to estimate necrotic bone mass and to ensure intact anterior and posterior cruciate ligaments. When the intact anterior cruciate ligament was not recognised, the case was excluded from this study. The maximal width, length and depth in millimetres among T1-weighted MRI slices were measured. As the presumptive volume of the necrotic bone, multiplied values, the width (mm) × length (mm) × depth (mm) were calculated (Figure 1).

Routine follow-up examinations were performed at one, two, three, and six months, and twice a year after UKA. The mean follow-up period was 8.4 years (four to 15 years). We measured weight-bearing alignment of the lower limb at the routine follow-up visits. Bony change at the cement–bone interface in femoral as well as tibial sides was carefully observed at each follow-up visit. The clinical knee functions of respective patients were serially evaluated with the Knee Society Scoring (KSS, giving both an objective and functional score) system [12] and the Oxford Knee Scoring (OKS) system [13]. The maximal flexion angle of the knee was measured at one-year intervals on lateral X-ray images of the knee in maximum flexion and the standing knee

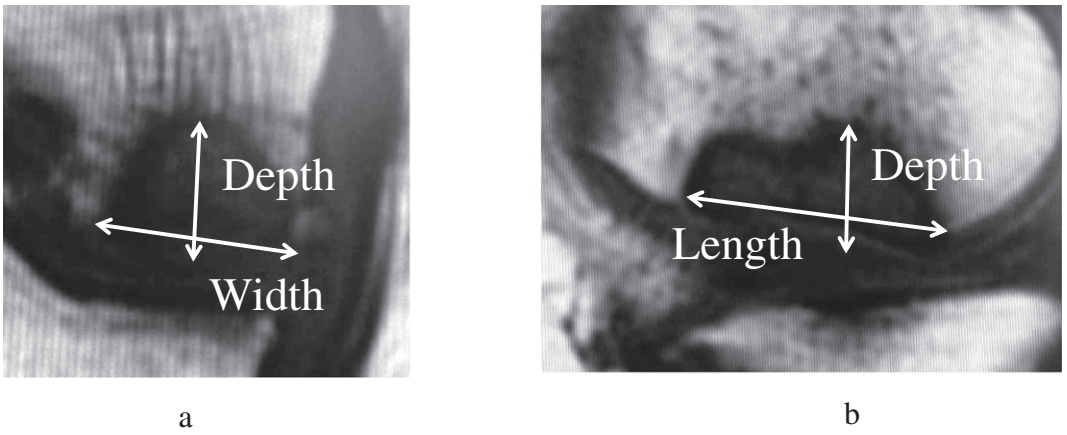

Figure 1. MRI T1 Weighted Image a) Coronal Plane, b) Sagittal Plane

Table 1
The size of the necrotic lesion.

	Width (a) (mm)	Length (b) (mm)	Depth (c) (mm)	Volume lesion a × b × c (cm^3)
Average	17.2 ± 4.1 (14.7–22.4)	28.2 ± 6.2 (6.2–34.7)	11.3 ± 2.9 (3.2–14.5)	5.4 ± 3.4 (0.7–10.3)

alignment of the lower limb over the follow-up periods. The maximal flexion angle of the knee was measured on radiograms as the angle between distal femoral axis and proximal tibial axis. The angle was measured by one of authors (S.F.).

2.1. Statistical analysis

A survival table was constructed and the cumulative rates were calculated using the Kaplan–Meier survival analysis with a 95% confidence interval (CI) [14]. All data are presented as means with ranges.

For comparisons of outcomes assessed at latest follow-up to that before surgery, a paired *t*-test was used with a level of significance at $P \ll 0.05$. All statistical analyses were performed with R (The R Foundation for Statistical Computing, Vienna, Austria).

3. Results

The 50 SONK lesions in 48 patients were categorised to stage III in nine cases, stage IV in 24 cases, and stage V in 17 cases, according to the Aglietti grading system. The standing knee alignment of the lower limb was 7.1° varus on average (ranging three to 12° varus) before surgery, and 2.2° varus (0 to five degrees varus) after surgery. No significant postoperative complications occurred in any of the patients.

The presumptive necrotic bone mass parameters of patients calculated on MRI images are shown in Table 1.

The mean flexion angle of the knee significantly ($P \ll 0.0001$) increased from a preoperative 128.7° (110–140°) to 137.5° (110–153°), and KSS Knee Score, Function Score, and OKS improved significantly ($P \ll 0.0001$) from 52.3 (30–64) to 91.3 (87–100), 39.7 (15–55) to 90.2 (65–100), and 21.6 (12–28) to 40.2 (34–48), respectively, at the latest follow-up (Table 2). All patients had a good (34–41) (22 cases) or excellent (≫41) (28 cases) OKS [15]. There were four deaths (from causes unrelated to UKA) in a mean 6.6 years after surgery (range, five to eight years); three cases were lost at mean 4.3 years (four to five years) after surgery. All of those seven cases were stable at their final follow-up. The clinical data of those seven cases at their final follow-up time were included. There were no revisions or re-operations during the follow-up periods, consequently, the Kaplan–Meier survival rate of the UKA was 100%. A representative knee with bone defect filled with cement is presented in Figures 2 and 3.

4. Discussion

Although the aetiology of SONK has not been elucidated yet, the ratio of SONK patients among those treated with UKA in Japan appears to be much higher than that in western countries (1.9–2.3%) [9,10]. Actually, the SONK patients treated with UKA constituted 25.6% (50/195) of all UKA cases in our institution during this study period. One possible reason for the high incidence of the SONK in the Japanese population might be due to the high incidence of varus knee alignment and resulting higher load on the medial compartment of the knee when compared with western people [16,17].

To date, several reports focusing on the clinical outcome of UKA for SONK have been published. UKA has been considered an appropriate treatment for SONK when the cruciate ligaments are intact and the lateral compartment is well preserved. Jauregui et al. [18] reported meta-analysis including seven studies with 276 knees that showed that UKA had good clinical outcomes both in the short and long term with an overall revision rate of 5.51%. In the study, estimated survival without revision was 76% at 10 years and, for patients with an indication of primary osteonecrosis, estimated survivorship free of any revision was 93% at 10 years after surgery. Langdown et al. [19] reported the results of 29 SONK patients treated by Oxford mobile-bearing UKA with a survival rate of 100% at 5.2 years; Servien et al. [20] reported the results of 33 SONK patients treated by UKA with a survival rate of 92.8% at five years; Bruni et al. [21] reported the results of 84 SONK patients treated by UKA with a survival rate of 89% at 10 years; Parratte et al. [22] retrospectively reviewed 31 knees with survivorship of 96.7% at 12 years; and

Table 2
Clinical results.

	Flexion of the knee (degrees)	Knee Score	Function Score	OKS
Preoperative average	128.7 ± 7.8 (108–140)	52.3 ± 4.7 (30–64)	39.7 ± 4.7 (15–55)	21.6 ± 3.4 (12–28)
Average at the latest follow-up	137.5 ± 8.4 (110–153)	91.3 ± 5.7 (87–100)	90.2 ± 13.3 65–100)	40.2 ± 4.4 (34–48)

OKS, Oxford Knee Society score.

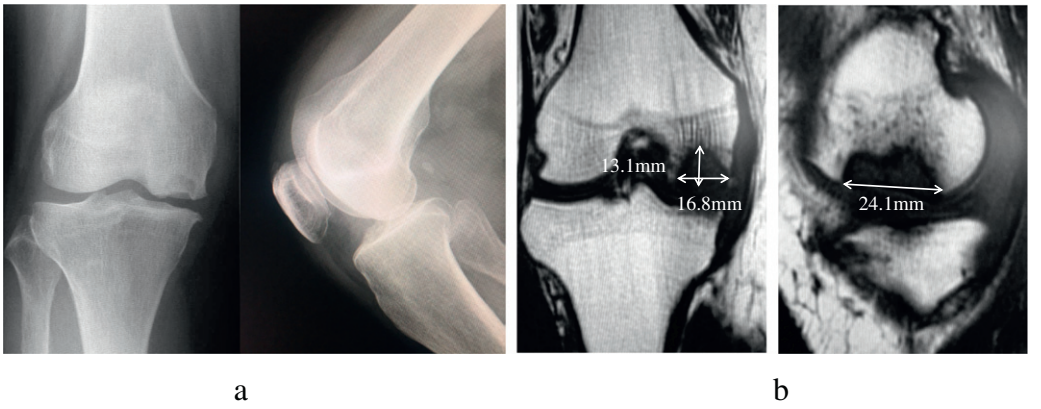

Figure 2. 67 year-old female patient a) radiographs. b) MRI with 5.3 cm^3 of necrotic tissue in juxta articular part of the right medial femoral condyle

Heyse et al. [23] reported 52 cases of UKA for SONK with survivorship of 90.6% in 15 years. Chalmers et al. [24] reported 47 knees of UKA for SONK including five knees of secondary osteonecrosis of the knee, and patients undergoing UKA for SONK without secondary osteonecrosis survivorship was 93% at 10 years. Thus, because of the limited number of SONK patients with UKA in those reports when compared with that of AMOA cases with UKA, long-term clinical outcome of the UKA-treated SONK cases has not been clarified yet.

One major concern for UKA for the treatment of SONK was that bone defect of significant size in medial femoral condyle is inevitably generated at surgery by removal of necrotic subchondral bone mass of various sizes, which might raise a potential risk for less stable support of the femoral prosthesis and adverse impact on long-term clinical outcome of the UKA. This study was designed to evaluate the potential risk by investigating 50 knees with medial SONK treated with mobile bearing UKA over a mean follow-up period of 8.4 years with maximum follow-up period of 15 years in association with necrotic bone mass; the results presented good or excellent outcome in all of the patients at final follow-up without revision surgery, or other significant complications regardless of the necrotic bone mass shown in the respective cases. Consequently, it was concluded that clinical outcome of UKA for SONK would be acceptable and equivalent to that for AMOA, though there still might remain concern for worse results in more prolonged follow-up periods. With respect to necrotic bone mass in SONK, Choy et al. [25] classified the volume as small (0–10 cm^3), medium (10–20 cm^3), and large (20–30 cm^3) to evaluate the clinical results. One case with 22.8 cm^3 of necrotic bone presented loosening of the femoral component. According to this classification, all of the 50 knees in 49 cases presented in this study were classified as small, and one case as medium. This result may indicate limited necrotic bone mass in SONK and little impact on the clinical outcome of the UKA.

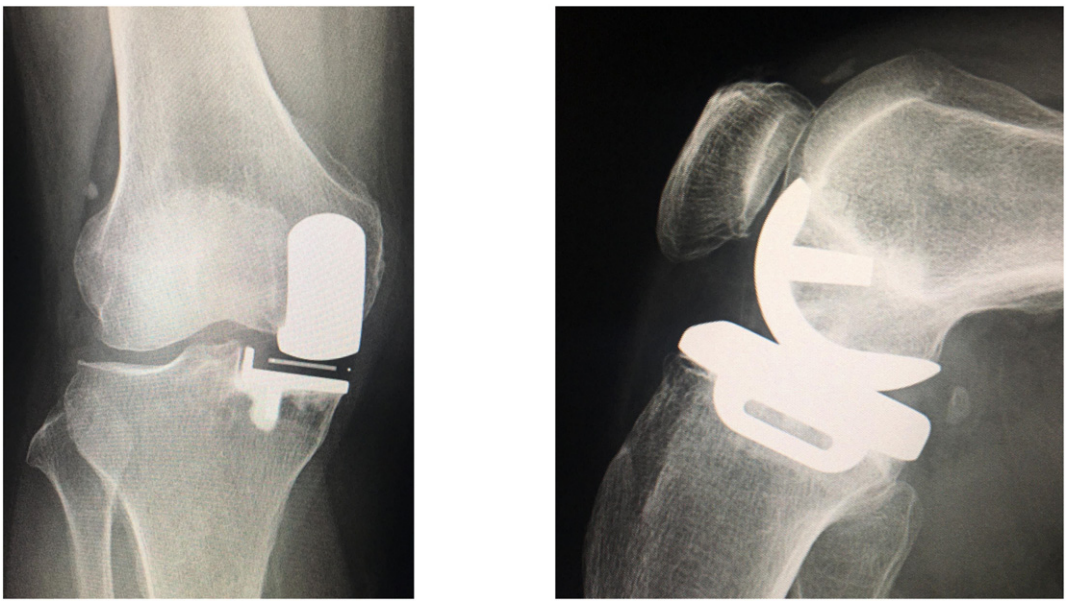

Figure 3. The components remain stable without radiolucency at 13.5-year follow-up. The flexion of the knee, KSS Knee Score, Function Score and OKS significantly increased from a preoperative 138 degrees to 143 degrees, 55 to 100, 50 to 90 and 28 to 45, respectively at the latest follow-up.

Many surgical options for SONK have been described, including conservative treatment [26–28] by non-weight bearing or bisphosphonate intake, core decompression [3], arthroscopic debridement [3], high tibial osteotomy (HTO) [29,30], osteochondral autografting [31], mosaic osteochondral autografting transplantation [32] with concomitant HTO autologous chondrocyte implantation [33] combined with HTO. There is limited data on the outcomes of those options. But Marti et al. [26] concluded that the natural history of SONK was not altered by HTO. Jureus et al. [27] reported that bisphosphonate delayed progression of SONK by suppression of remodelling of the necrotic bone, however, it is not known how long the treatment should be continued for with effectiveness. Good clinical results of HTO for SONK in the short and medium term were reported [29,30]. Osteochondral autografting [31,33] with HTO for younger patients was reported with good short-term clinical results, and recently, good short-term clinical results of mosaic osteochondral autograft transplantation with opening wedge HTO in small group patients were reported [32]. However, long-term results of those joint-preserving methods with or without HTO have been controversial with larger numbers of cases needed. Krych et al. [34] compared UKA with HTO and concluded that patients younger than 55 years treated with UKA restored high levels of activity early after surgery in mid-term follow-up with remaining concern for potential failure in the long term.

In comparison with Total knee arthroplasty (TKA) [4,35], UKA has some advantages, including low incidence of surgical complications, lower mortality [36,37], faster recovery [38] and better functional outcomes, and higher rate of return to original work and sport [39]. UKAs are also reported to be more cost-effective [40,41].

The study had several limitations. Firstly, the study design was a retrospective review. Secondly, there was no control group such as TKA, osteotomy or osteochondral graft groups from our institution to compare clinical outcomes. Thirdly, the number of cases and follow-up period were limited for a more detailed evaluation of the outcome of the UKA for SONK. Fourthly, our method of calculating the volume of the necrotic lesion tends to overestimate the size, however, this is the standard method of determining volume based on MRI data.

In conclusion, in this independent study, there was a 100% survival rate of the Oxford Phase 3 UKA for SONK in the middle to long term (up to 15 years after surgery). All patients had good/excellent results at last follow-up and there were no reoperations or complications. This suggests that the Oxford mobile-bearing UKA is a good and definitive treatment for medial femoral SONK.

Declaration of Competing Interest

The authors have no conflicts of interest to declare.

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