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Research Article

Redundant Bone Cement Retention in Minimal Invasive Total Knee Arthroplasty

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Abstract

Bone cement fixation had been used for Total Knee Arthroplasty (TKA) since late 1960s and is currently the gold standard. The cemented fixation demonstrates efficient longevity during the long-term follow-up. However, the negative effect of the Redundant Bone Cement Retention (RBCR) after TKA was never discussed. We therefore determined the cause and effect of RBCR in this study. A single surgeon retrospectively reviewed 236 TKAs between March 2004 and February 2005. The data of RBCR, including size, location, and migration, were described by three experienced physicians. Furthermore, osteolysis occurrence was evaluated. The patient and surgery-related factors were analyzed and compared between the groups with and without RBCR. The mean follow-up period was 80.7 (range: 16-148) months. Postoperative plain film revealed RBCR in 39 of the 236 patients (16.5%). The average cement length was 92 (5.2-25.1) mm. In 66.7% of the patients, retention cement was located at zone 1, and the retention cement migrated in 15.4% of them. RBCR occurrence has no correlation with patient factors, such as body mass index, preoperative range of motion, and systolic blood pressure. Furthermore, no relationship was observed with surgical factors, such as bone-cutting and tourniquet time. No statistical difference was observed in osteolysis occurrence between RBCR and non-RBCR groups (5.2% versus 5.1%, P = 0.981). Moreover, no correlation was observed with osteolysis occurrence and the location, migration, and size diminished of the redundant cement. RBCR in TKA has no effect on osteolysis or other complication in mid-term follow-up. However, we recommend to remove the redundant cement cautiously without destroying cement structural strength.

Introduction

Total Knee Arthroplasty (TKA) is an effective and safe procedure for patients with end-stage knee osteoarthritis caused by trauma, infection, degeneration, or inflammatory disease, and TKA could restore life activity and diminish pain to improve patients' quality of life. After the advancement in TKA procedures in the past decades, bone cement fixation is currently the gold standard, and the longevity of the cemented fixation was efficient in the long-term follow-up [1]. The minimal invasive TKA has been developed to reduce soft-tissue injury and facilitate postoperative recovery

[2,3]. However, the surgical wound and soft-tissue exposure of minimal invasive TKA are smaller than those of traditional TKA, and completely removing excessive cement after cemented fixation is difficult. Lyndsey et al. reported that cement could result in linear wearing and debris formation. The macrophage responds to Polymethylmethacrylate (PMMA) particle phagocytosis and leads to osteolysis, potentially loosening the implant [4]. The negative effect of the Redundant Bone Cement Retention (RBCR) after TKA was never discussed. We hypothesized that the RBCR affects the implant survival rate and results in some complications, and we identified the associated factors.

Materials and Methods

Patients

This retrospective study included 236 patients who underwent MIS-TKA for advanced knee osteoarthritis from March 2004 to February 2005, and the MIS-TKA procedure was started in our hospital from March 2004 (Figure 1).
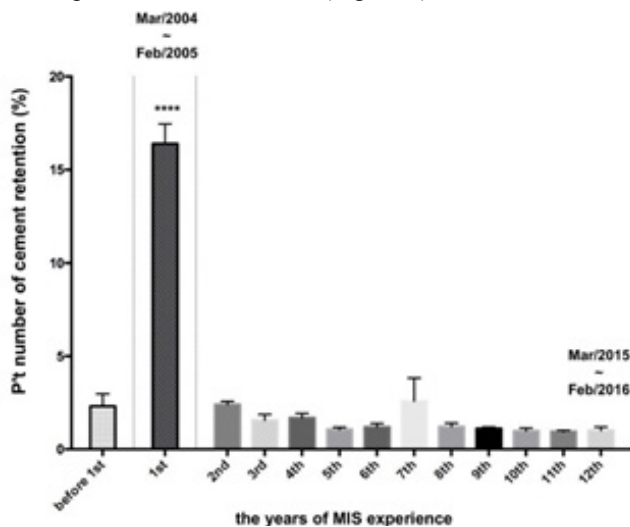

Figure 1: From March 2004 to February 2005, it was 1st year to do MIS-TKA in our hospital. The rates of cement retention were 2.17% before 1st year, 16.5% in 1ST year, and 0.82 ~ 2.3% after 1st year.

Inclusion and Exclusion Criteria

The inclusion criteria were patient more than 60 years and a diagnosis of advanced knee osteoarthritis. The exclusion criteria were having a knee surgery previously, undergoing a revision TKA, and follow-up period less than 1 year.

Patient Demographic Data

Patient demographic data were age, weight, height, and Body Mass Index (BMI); clinical characteristics were Systolic Blood Pressure (SBP) before skin incision and preoperative Range of Motion (ROM) of knee; and surgical factors were tourniquet time and bone-cutting thickness.

Surgical Procedures

All surgical procedures were performed by a single experienced joint surgeon. All patients were administered spinal anesthesia during the surgery. The systolic pressure was recorded and the tourniquet was inflated before the skin incision. A medial-curved skin incision of 5 - 6 cm was made through a mid-vastus approach, and the prosthesis used was a cement-fixed Nexgen posterior-stabilized knee system (Zimmer Biomet). We removed the excessive cement that was visible during the procedure. Wound closure was performed after surgical drain insertion and sterile dressing.

Outcomes

The clinical outcomes included size, location, and migration of RBCR and osteolysis occurrence in follow-up radiographs. All the radiographs were interpreted by two experienced orthopedic doctors and one experienced radiologist. The residual cement recognized by more than two doctors was identified as RBCR, and RBCR was evaluated at nine locations (Figure 2). Osteolysis was defined as any nonlinear region of periprosthetic cancellous bone loss with delineable margins in the radiograph during follow-up and absence of nonlinear regions in postoperative radiographs. We recorded the month in which osteolysis was noted and analyzed using the Kaplan-Meir method.
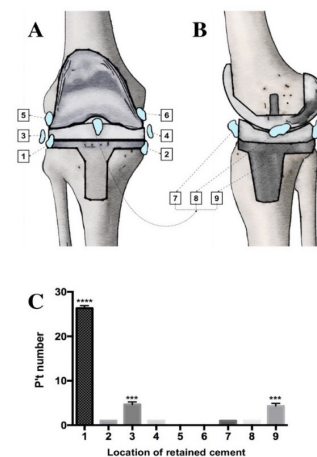

Figure 2: A: Post-operative X ray (antero-posterior view): Location 1: lateral aspect of tibia, Location 2: medial aspect of tibia, Location 3: lateral aspect of knee joint, Location 4: medial aspect of knee joint, Location 5: lateral aspect of femur, Location 6: medial aspect of femur. **B.** Post-operative X ray (lateral view): Location 7: anterior aspect of knee joint, Location 8: between knee joint, Location 9: knee medial aspect of knee joint. **C.** Location 1 was the most common position with cement retention (66.7%, 26/39) than other locations. The Location 3 was 2nd position (12.8%, 5/39), and the Location 9 was 3rd position (10.3%, 4/39).

Statistical Analysis

All analyses were performed using SPSS (version 22.0; IBM, Armonk, NY, USA). One-way analysis of variance was used to analyze demographic data, clinical characteristics, and surgical factors. $P < 0.05$ was considered statistically significant.

Results

Rate and length of cement retention

March 2004 to February 2005 was the first year in which MIS-TKA was performed in our hospital. The cement retention rate was up to 16.5% (39/236 patients) and significantly higher in the first year of MIS-TKA compared with that in the period of traditional TKA procedure or more experienced MIS-TKA (Figure 1). In total, 39 patients had cement retention. The cement length was 5.2-25.1 mm, and the average length was 92.7mm.

Location of cement retention

We classified cement retention according to location in Figure 2. Location 1 (tibia lateral side) was the most common

position with cement retention (66.7%, 26/39), followed by Location 3 (knee joint lateral side), which was 12.8% (5/39), and Location 9 (knee joint posterior side), which was 10.3% (4/39). The rate was 2.6% in Locations 2, 4, 7, and 8, and residual cement was not found in Locations 5 and 6.

Patient's demographic date, surgical factors, and functional results

The demographic data and surgical factors are presented in Table 1. The follow-up period was 81.0 ± 36.0 months in patients with no cement retention and 79.8 ± 39.4 months in patients with cement retention, and no statistical difference was observed (P = 0.861). In patient factors, no difference was observed between the two groups in terms of age, BMI, SBP, and preoperative knee ROM. In surgical factors, the tourniquet time and bone-cutting thickness were not different between RBCR and non-RBCR groups. The cement retention did not affect the postoperative KSS knee score or KSS function score (P = 0.282 and 0.181 for KSS knee and function scores, respectively; Table 2).

	cement retention (No)	cement retention (Yes)	p value
Patient number	197 (83.5%)	39 (16.5%)	
Patient follow-up (months)	81.0 ± 36.0	79.8 ± 39.4	0.861
Patient-factors			
Age (y/o)	68.1	70.4	0.198
Weight (Kg)	65.4	64.2	0.591
Height (cm)	153.2	152.3	0.644
BMI	27.8	27.5	0.436
SBP (mmHg)	143.4	139.1	0.857
Knee extension angle (pre-op)	6.3	7.0	0.485
Knee flexion angle (pre-op)	126.7	123.0	0.297
Surgical-factors			
Tourniquet time (min)	68.5	68.7	0.932
Bone cutting (mm)			
femur, distal_medial	7.9	7.6	0.433

femur, distal_lateral	7.6	7.4	0.675
femur, posterior_medial	12.5	12.2	0.749
femur, posterior_lateral	9.9	10.3	0.437
tibia, medial	3.1	3.1	0.903
tibia, lateral	8.4	8.9	0.214

Table 1: Factors and cement retention.

	cement retention (No)	cement retention (Yes)	p value
KSS Knee Score	87.5 ± 4.3	88.2 ± 4.0	0.282
KSS Function Score	92.5 ± 3.5	93.3 ± 3.0	0.181

Table 2: Functional results and cement retention.

Osteolysis

According to the Kaplan-Meier method, the bone cement retention did not increase osteolysis rate, and no significant difference was observed in RBCR and non-RBCR groups (P = 0.443; Figure 3). The patient was a 79-year-old woman who received right TKA for treating advanced osteoarthritis (Figure 4A and B). The radiograph showed retained cement in the lateral aspect of tibia (Location 1) postoperative 6 weeks (Figure 4C and D). Then the radiograph showed retained cement in the same position, but no osteolysis sign was found postoperative 6 years (Figure 4E and F).
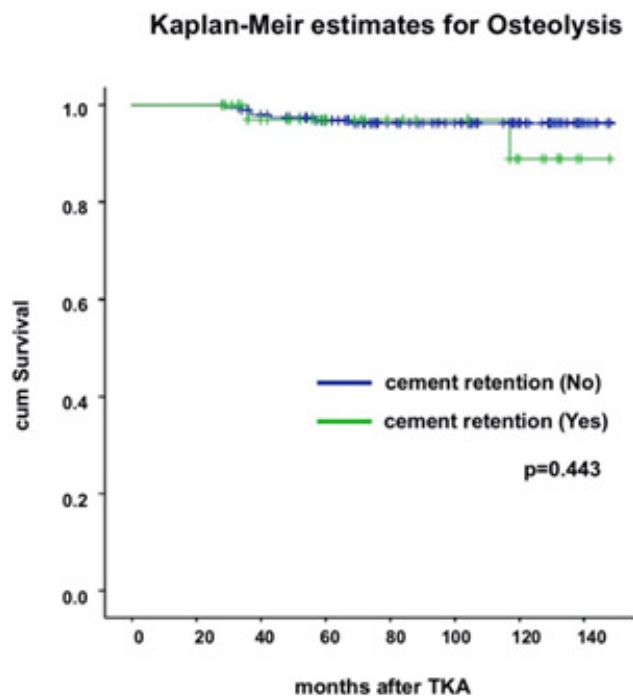

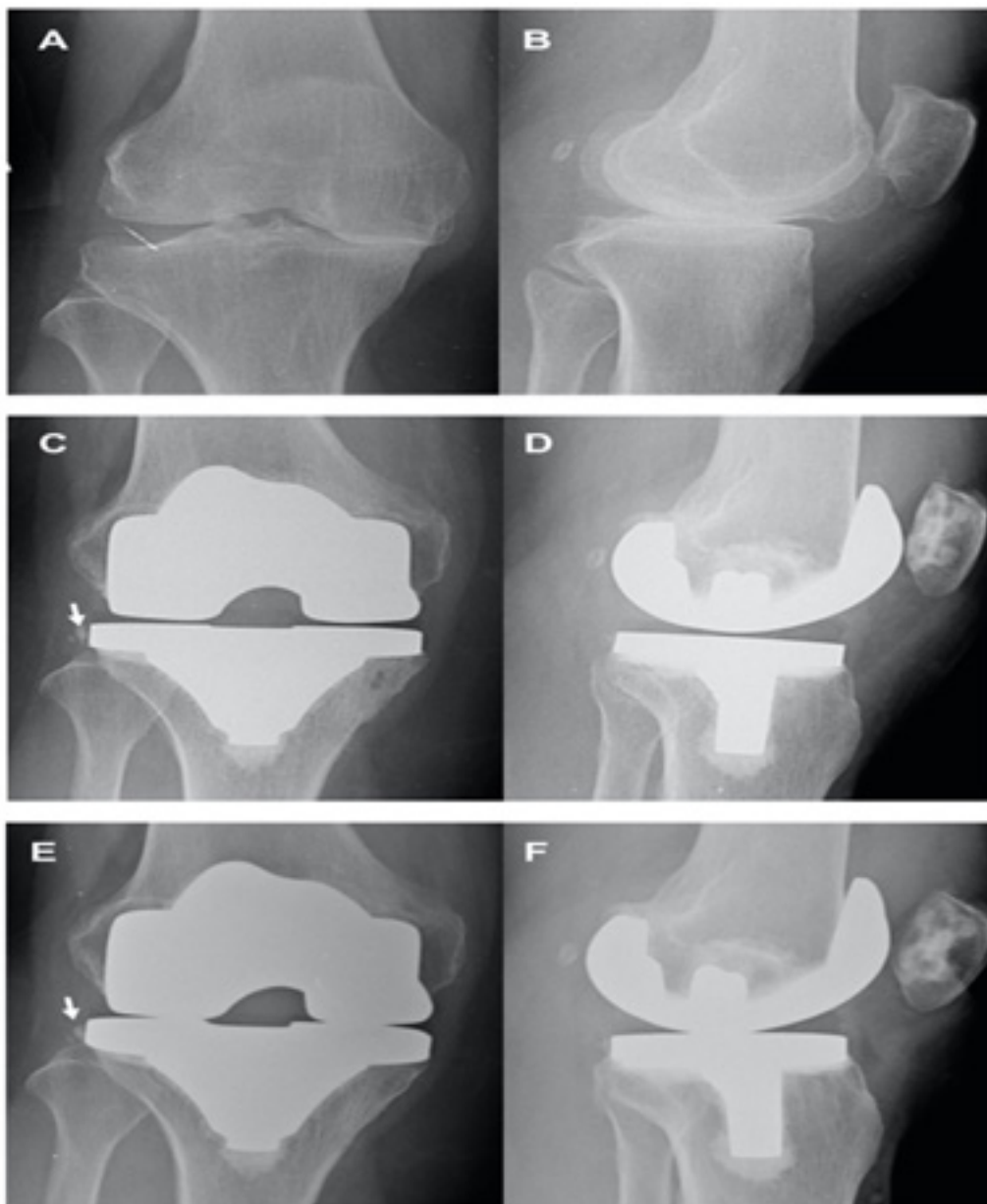**Figure 3:** The rate of osteolysis was not significant difference in cement retention or not (P = 0.443).

Figure 4: A and B: 79 year-old female painter suffered right advanced knee osteoarthritis. **C and D:** Cement retention was noted in lateral aspect of tibia (Location 1) at post-operative 6 weeks. **E and F:** persisted retained cement was in same position, and no osteolysis sign was found at post-operative 6 years. **G and H:** 76 year-old female painter suffered left advanced knee osteoarthritis. **C and D:** Cement retention was noted in posterior aspect of knee joint (Location 1) at post-operative 6 weeks. **E and F:** persisted retained cement was in same position, and no osteolysis sign was found at post-operative 7 years.

Discussion

Compared with traditional TKA, minimal invasive TKA involved less soft-tissue damage, leading to better patient outcomes and early activity after operation [5-8]. However, less visibility in the lateral aspect of the knee in minimal invasive TKA was noted, and this could lead to some complications, such as component malalignment, nerve injury, and patella tendon rupture [5,9,10]. The problems of cement retention were never studied before. In our study, up to 16.5 % (39/236) of the patients showed cement retention after minimal

invasive TKA during the first year but only 2.17% patients showed cement retention after the traditional TKA procedure (Figure 1). In the minimal invasive TKA procedure, the small wound incision and mid-vastus approach were used in our hospital, and the visibility of the lateral aspect of the knee was occluded by quadriceps muscle and knee joint capsule. Thus, the cement over the lateral aspect of knee was not clearly visible. Therefore, most residual cement was located at the lateral aspect of the knee (Location 1: 66.7% and Location 3: 12.8%) in our study (Figure 2). According to our experience in the first year, we changed the time of applying the cement on the bone and prosthesis and found a new technique called Scoop-out technique to remove residual cement over the lateral side of the knee (Figure 5). Ranjan et al. [11] suggested that the cement be applied on the bone and prosthesis during the waiting phase and prosthesis inserted during the working phase. The cement hardened during the setting phase, and it was difficult to remove the hardened cement. Some studies have found that injuring the cement mantles during the setting phase led to cement micro-fracture and caused cement-implant interface fixation failure and implant early failure [12-16]. Therefore, the knee was kept in full-extension position after prosthesis insertion during the working phase, and we used the dissector to scrape excessive cement, particularly at the lateral aspect of the knee. After that, the rate of cement retention significantly decreased to 0.82%-2.3% from the second year (Figure 1).
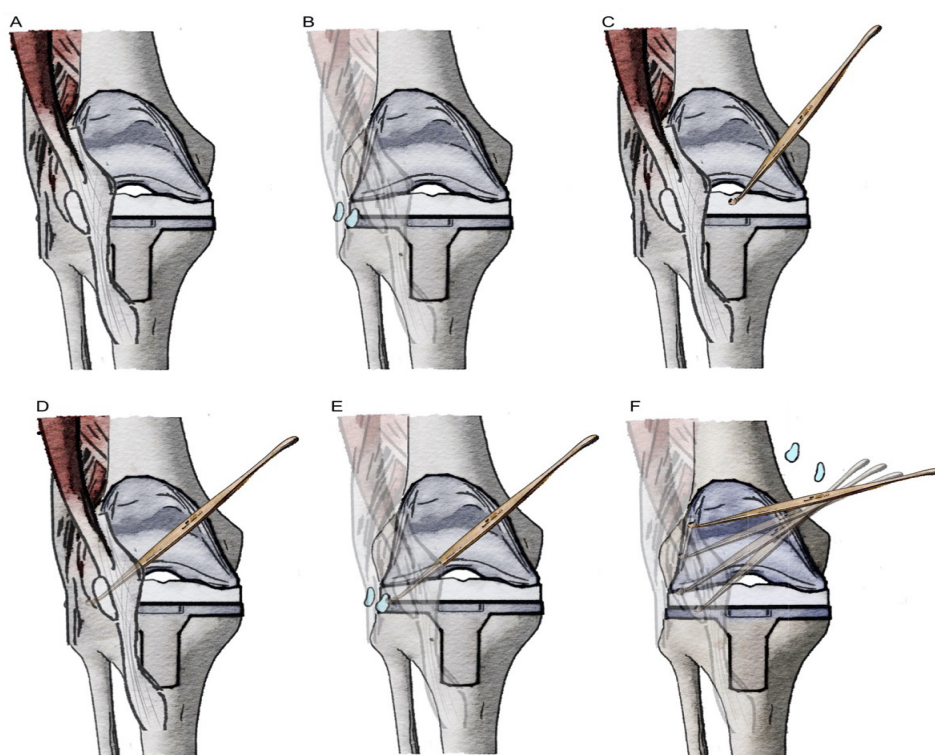

Figure 5: Using Scoop-out technique by dissector to remove the residual cement beside the component and one, especially at lateral aspect of knee.

Theoretically, patient factors such as high BMI, high tourniquet pressure, and joint ROM before surgery influenced the visibility during the operation [17]. Tubby patients had more soft tissue to occlude surgical visibility, and therefore, the rate of residual cement retention was higher in them than in thin patients. However, the height, weight, and BMI were nonsignificant in cement retention (Table 1). A higher SBP was recorded before skin incision, and a higher tourniquet pressure was inflated. It increased the soft-tissue tightness leading to decreased visibility during surgery; thus, the cement retention rate increased. However, the SBP did not influence the rate of residual cement in our study (Table 1). Greater joint stiffness wound increased the difficulty in removing cement during surgery, even after we appropriately released the soft tissue. In our study, it did not influence the cement retention rate (Table 1). The bone-cutting thickness led joint laxity or tightness to influence component alignment and surgical vision. If it was too tight, removing excessive cement from the lateral aspect of the joint became difficult. Bone cutting was not significantly different between RBCR and non-RBCR patients in our study. Therefore, the unskilled minimal invasive TKA technique and negligent retained cement were major

factors influencing cement retention (Figure 1), and the patient and surgical factors were not (Table 1).

Some studies have shown that cement wear debris cause some complications, such as periprosthetic osteolysis and formation of extraosseous cement granuloma [4,18-20]. Lyndsey Burton, et al. [4] showed that macrophage responds to PMMA particle phagocytosis and leads to osteolysis, potentially loosening the implant. Christoph Schulze et al. [18] showed that wear particles from interfaces between bone, cement, and prosthesis inhibited the osteoblast function, leading to osteolysis and prosthesis loosening. Babiak, et al. [20] showed that the wear of cement caused extraosseous cement granuloma or false aneurysm of popliteal artery. However, we did not find this phenomenon in our study, and the cement retention did not cause osteolysis or granuloma in mid-term follow-up (Figures 1 and 4).

The RBCR may cause patient knee discomfort during daily activities, but the postoperative KSS knee score and KSS function score were non-significantly different in patients with and without cement retention (Table 2). This study has some limitations. First, we did not arrange computed tomography (CT) to evaluate the cement retention. Hennie Verburg et al. [21] showed that CT imaging was an efficient tool to differentiate cement and bone. Cement and bone densities could not be easily distinguished on radiographs. Therefore, two experienced orthopedic doctors and one experienced radiologic doctor interpreted all the radiographs, and if residual cement was recognized by more than two doctors, it was identified as cement retention. Second, mid-term follow-up was conducted in our study, and longer follow-up time is required to confirm whether cement retention caused osteolysis and prosthesis wearing.

Conclusion

RBCR occasionally occurred after MIS-TKA, and the cement retention rate increased for less experienced surgeons. Cautiously removing the redundant cement is recommended to prevent potential liner wear. We need a larger sample size and longer follow-up time to validate whether cement retention causes osteolysis or complications.

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