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Effectiveness and safety of a cement-on-cement removal system for hip and knee arthroplasty revision surgery

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Cement removal during hip or knee arthroplasty revision is challenging and not exempt of complications. Cement-on-cement procedure is among techniques developed to safe removal of cement from bone, and it could be a realistic solution. This cement-on-cement devices can provide advantages in removing bone cement during hip and knee arthroplasty septic and non-septic revision surgeries, and can be regarded as an effective and safe alternative. We present our experience using the cement-on-cement technique in 34 cases between 2010 and 2021, including revision surgeries for 20 knee and 14 hip arthroplasties. In 3 out of 34 cases the technique failed, with a success of 91%. Mean surgical time was 2.77 (SD 0.93) hours and blood transfusion was required in 23 cases. Success was achieved in every aseptic case. Of all patients, 60% were septic cases. Infection was considered to be eradicated in 70% (14/20) of patients with a septic revision.
Cement-on-cement is a safe and effective alternative for cement removal during hip and knee arthroplasty revision.

Keywords: Surgical revision, bone cement, prosthesis related infections, cement removal, arthroplasty revision, cement-on-cement.
Level of evidence: III, retrospective case series.

INTRODUCTION

The use of prosthetic joint implants is a common procedure in orthopedic surgery. According to some reports, there is a projected increase of the number of joint replacements, so it is expected that prosthetic joint revisions will grow as well, with a potential huge economic impact in health systems[1,2].

One of the most challenging steps of revision surgery is cement removal, and several complications may happen. There is no gold standard procedure described for this purpose[3]. As a result of these undesired events, cement-in-cement techniques were developed with excellent results in aseptic revisions[4], but with unpredictable results in septic ones[5,6]. As an alternative, Ekelund et al[7] proposed a unique device for removing the old and new segments of cement together. The aforementioned technique was reinforced by Cordonnier et al[8] in small sample series of hip arthroplasty revisions, both with promising results.

The aim of this study was to seek an answer to the following questions: 1) Is cement-on-cement a safe technique to remove cement in total hip revisions (THR) and total knee revisions (TKR)? 2) Is it an effective technique in septic and non-septic revision? We hypothesized that a cement-on-cement device can provide advantages in removing bone cement during hip and knee arthroplasty septic and non-septic revision surgeries and can be regarded as an effective and safe alternative.

MATERIALS AND METHODS

After approval of the local ethics committee, a retrospective analysis of cases of orthopedic device related infections in our institution, a 700-bed tertiary hospital, during a twelve-year period (2010-2021) was performed. Inclusion criteria were patients who required knee or hip cemented stem arthroplasty for one- or two-stage revision surgery from 2010 to 2021 using the Metal Cemover® system for bone cement removal[9] (Fig. 1). Exclusion criteria were revision surgeries in which the device was not used, and patients without a minimum 12-month postoperative follow-up. Data were collected anonymously from our hospital database. We analyzed the following variables: age, gender, body mass index (BMI), comorbidities, American Society of Anesthesiologists (ASA) physical status classification[10], date of surgery and time elapsed from primary or previous surgery, reason for revision,

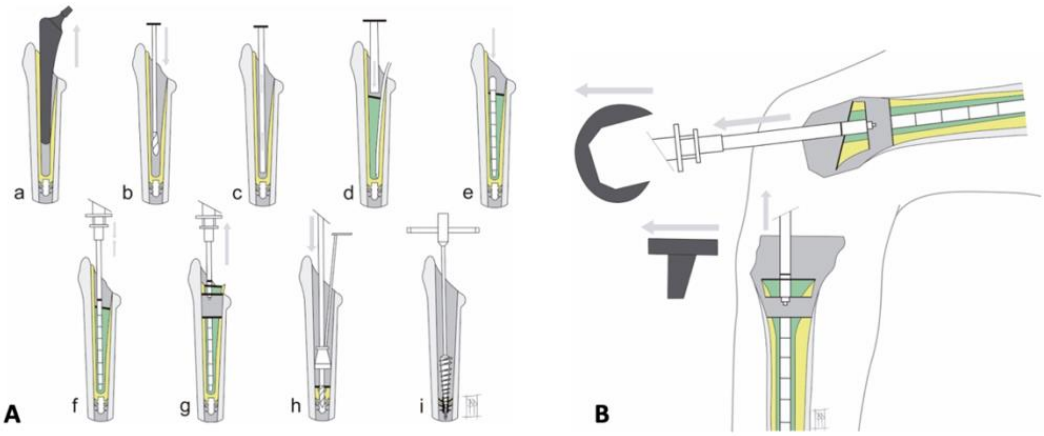

Figure 1. — Hip and knee new surgical technique. A) Hip surgical technique. (a) Stem removal. (b) Old cement roughened. (c) Extraction of debris. (d) New ultra-low cement introduction. (e) Metamers assembled introduction. (f) Extractor plugged. (g) Extraction of every single metamer with new and old cement linked. (h) Distal plug drilling. (i) Distal plug extraction with special threaded device[9]. Knee surgical technique. B).

presence of radiographic loosening, type of stem removed, revision surgery duration, use of tourniquet and spacer, postoperative transfusion requirement, microbiological diagnosis following culture, and antibiotic treatment. Primary implants were considered to be loosened if radiolucent lines measuring over 2 mm or progressive radiolucent lines were observed on postoperative radiological follow-up. Prosthetic joint infection was defined according to 2018 Musculoskeletal Infection Society (MSIS) criteria[11].

All interventions were performed by two senior orthopedic surgeons (DSM, FLOM) with extensive experience in complex hip and knee revision surgery, who stablished their own indication for using the device in all prosthetic's revisions surgeries with cemented stems and preserved bone cortex.

Cement removal using the device was considered effective if complete extraction was achieved without any additional surgical steps and, early patient weight bearing could be authorized without major complications in the first postoperative days in most of the patients. Incomplete cement removal was considered a failure of the procedure.

In revisions due to prosthetic joint infection (PJI), revision surgery was considered successful if the infection healed in a minimum of 6 months after completing antibiotic treatment. A PJI was considered to have been cured if the patient was pain-free, showed a normal skin appearance, developed no fistulae, and lab tests revealed no evidence of infection. Values from a complete blood count, erythrocyte sedimentation rate, and C-reactive protein levels were used as a common laboratory workup to monitor PJI.

The safety of the procedure was defined as the absence of major complications in the majority of the patients. Intraoperative fracture or cortical perforation during the operation as well as major neurologic or vascular injury were considered major complications. Differences in effectiveness and safety between THR and TKR were also analyzed.

RESULTS

In the period studied, 1,862 hip and knee revisions were carried out in our institution. In 1,819 patients, the cement-extraction device was not deemed necessary, in which case the procedure was not included in the analysis. Nine patients were excluded due to insufficient follow-up. Thirty-four patients (22 females and 12 males) were finally included in the study. The mean age at the time of revision was 70 years old (41-89). Average BMI was 30.2 kg/m^2 (Standard Deviation (SD) 4.5). The most common risk factors for infection were diabetes (4 patients), chronic steroid treatment (2 patients), biologic rheumatoid arthritis treatment (1 patient), and hematologic dyscrasia (1 patient). Only 2 patients were active smokers at the time of surgery. Almost half of our patients were ASA risk classification type II (41%), and the remaining 59% were classified as ASA III. Other past medical history data were unremarkable.

Detailed data on patient characteristics and the index revision procedure are provided in Table I. The final series comprised 20 cases of TKR and 14 cases of THR. While the majority of THR were primary revisions, most cases of TKR were second revisions. Osteoarthritis was the most frequent indication for

Table I. — Demographic characteristics of the patients and surgery details.

	THR[#]	TKR[f]	Overall
Number of patients	14	20	34
Gender (Female/Male)	9/5	13/7	22/12
Age*	75 (10.6)	72 (11.5)	70 (9.6)
BMI (kg/m^2)*	28.8 (4)	30 (5)	30.2 (4.5)
Mean time from primary surgery to revision (mos)*	88 (123)	55 (73.5)	68 (97)
First time revision surgery	12	5	17
Second time revision surgery	2	15	17
Reason for revision			
Prosthetic joint infection	11	9	20
Aseptic loosening	1	6	7
Instability	2	5	7
Surgical procedure			
One-stage revision	5	8	13
Two-stage revision	3	9	12
Total prosthetic reimplantation	8	17	25
Resection arthroplasty	6	0	6
Arthrodesis	0	3	3
Mean surgical time (min)*	136.4 (42)	186.8 (56)	2.8
Blood loss (mL)*	1277 (501)	985 (543)	1109 (538)
Mean inpatient (days)*	6.2 (1.35)	7.29 (2.3)	8.13 (2.43)

[#]Total hip revision; [f] Total knee revision; [*] Data are given as mean and standard deviation.

primary total hip arthroplasty (THA) or total knee arthroplasty (TKA) (82%). PJI was the major cause for revision in 20 patients from both groups. Radiologic loosening was found in 21 of the 34 patients. The mean time from prior or primary arthroplasty surgery to revision was 68 months (SD 97). Concerning the index revision procedure performed, 13 patients underwent one-stage, and 12, two-stage revisions.

In THR cases, three patients underwent a cemented hip hemiarthroplasty and in one patient a primary cemented THA was performed for hip fracture. Rest of them were primary elective THA with cemented stems. This finally resulted in 11 total hip and 3 partial hip arthroplasties included. One patient underwent primary THA and TKA due to femoral's head and medial condyle bone necrosis, respectively in different surgeries and, who required both revisions due to septic loosening. Most of final hip implants were regular monobloc, cemented, shortest stem as possible, and 6 out of 14 were cemented revision long-stem implants. Only one final revision prothesis was an uncemented long-stem diaphyseal anchorage implant with good femoral press-fit. Twelve patients received intravenous tranexamic acid preoperatively. We calculated blood loss during surgery according to the formula of Gross et al.[12], finding and average of 1277mL (SD 501) of blood lost per patient and 16 patients required intra- or postoperative blood transfusions.

In the TKR cases, 17 were rotating hinge arthroplasties, 2 constrained condylar implants, and 1 tumoral implant, all with cemented stems. All TKR implants after the cement removal, were rotating hinge arthroplasties due to severe soft tissue imbalance or bone loss. A tourniquet was used in 95% of TKR. All of them received intravenous tranexamic acid preoperatively. We found an average of 985 mL of blood lost per patient (SD 543), and 7 patients required blood transfusions.

The Metal Cemover® technique was successful in removing all bone cement in 31 patients (91%). Success was achieved in every aseptic case. The procedure was considered unsuccessful due to incomplete cement removal in 3 THR that required an extended trochanteric osteotomy. Early weight bearing was allowed and successfully resumed in all patients except in those 3 patients. One major intraoperative complication occurred in one patient during a rotating hinge arthroplasty revision; damage sustained by the popliteal artery was resolved intraoperatively by vascular surgeons without further consequences.

Regarding to infection control, PJIs were considered successfully solved in 14 out of 20 patients (70%) at a

Table II. — Results of microbiology in cultures of unsolved infections.

(1) *SAMR*	(4) *E cloacae MR*
(2) *R picketti, S mitis*	(5) *SAMS, E cloacae MR*
(3) *S epidermidis, E cloacae XMR*	(6) *E coli BLEE*

mean follow up of 28 months (6 months-6.25 years). Multidrug-resistant bacteria were responsible for 6 unresolved patient infections, which were finally managed successfully with antibiotic suppression (Table II).

Considering revision implant survival, no additional surgeries were required in any patient with the exception of 1 THR with uncontrolled instability due to acetabular malposition.

DISCUSSION

Hip and knee revision surgery remains a challenge for surgeons, due to potential complications which can occur. Furthermore, there is not defined gold standard for some procedures, like bone cement removal. The most relevant finding of this investigation is that cement-on-cement removal using Metal Cemover® facilitates the revision of both hip and knee arthroplasties with cemented stems, preserving bone stock in a safe and reproducible way with a 91% success rate and a complication rate of under 10%, in our series.

This technique also avoids other procedures such as extended osteotomies, with subsequent unable weight bearing until bone healing[13]. The use of a cement-on-cement system allows early weight bearing, which helps with sooner patient's recovery, and resulted in an average of 8 days of hospitalization (SD 2.43). Miner et al. came up with a 24% complication rate but stated that not all complications were explicable due to the osteotomy[14]. Flexible endoscopes and ultrasonic devices can also be an effective less invasive assisting option in cement removal because of reducing the risk of complications (e.g. cortical perforations) and eliminating the need for osteotomy but with a reported rate of complications in THR between 4% and 20%[15,16]. In contrast, we report only one major complication, namely damage to a popliteal artery in an 82-year-old male with a calcified popliteal artery, thus showing a much lower rate of complications than with others techniques. We cannot confirm the etiology of the arterial damage, but it did not appear to be related with the technique used for cement removal.

Blood loss is another matter of concern in hip and knee arthroplasty revisions, and bony procedures to remove cement may play a key role in this complication. The volume of intraoperative blood loss in our series of THR is similar to those reported in series of one- and two-stage revisions[17]. However, it is remarkable that Massin et al.[18] reported an average of 2000 mL (1500-3000) of blood loss in TKR, substantially greater than the 985mL (SD 543) lost in our series of TKR patients.

Our results are consistent with other studies which used devices similar to the one we described. Ekelund communicated a complete extraction in 16 of 20 THR cases in an average time of 35 minutes[7]. Cordonnier reported a 100% of effectiveness for cement removing without major complications[8], as well as Schurman reached complete cement removal in 12 of 15 (80%) cemented hip stem revisions without complications[19]. Laing succeeded in an 88% of femoral revisions using a similar segmental extraction procedure[20].

To the best of our knowledge, this study describes results obtained from the largest series of patients in which a cement-on-cement extraction technique was used. Gianotti et al. recently revealed satisfactory results of a similar technique, reporting complete cement removal in a small series of shoulder arthroplasty revision surgeries[21]. We show the effectiveness of this method in TKR with cemented stems, which are growing in popularity. We achieved 100% (20/20) success when removing cement in TKR. A favorable force's vector applied when extracting the metamers in knee could have influenced these results, and a biomechanical study would be required to demonstrate this.

Concerning final implant in the revision surgery, the bone stock saved with cement-on-cement technique, only in 6 THR a revision implant was used, with subsequent decreased in costs.

With regard to the effectiveness of cement removal in revision of PJI, we consider the infectious cause of the revision to have been eradicated in 70% of patients, percentage according to the success rates of one stage and two stage hip and knee arthroplasty revision surgeries for periprosthetic infection. Well-known success rates of 87% to 100% in one-stage knee arthroplasty revision surgeries and between 73% and 93% in two-stage knee arthroplasty revision surgeries have been published[22,23]. For infected hip arthroplasty revision surgery, success rates of 70% to 90% for one-stage and 80% to 90% for two-stage revisions are

achieved[24]. In our 6 cases in which the infection did not resolve, the culprit pathogens were multi-resistant microorganisms.

The study by Levine evaluates the effectiveness of extended trochanteric osteotomy in treating hip prosthetic infection. In 87% of the cases studied, the infection was cured and only 1 osteotomy did not consolidate[17]. Lim performed a retrospective review, finding that the infection was eradicated in 22 patients, though 4 patients (17%) developed a complication[25].

This study has several limitations. First, it reports retrospectively collected data from a cohort of THR and TKR. However, the characteristics of both groups were homogeneous in terms of the rate of infection and radiographic loosening. Second, no control group was used due to the fact that THR and TKR of cemented stems is an uncommon procedure, thus complicating efforts to design a similar study with a control group. For this reason, we established values of safety and efficiency based on data published in the literature using other systems of cement removal.

CONCLUSION

Cement-on-cement removal using the Metal Cemover® system is a valid alternative to traditional procedures for complete and accurate bone-cement removal in hip and knee revision arthroplasty surgeries.

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