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Outcomes of Primary Cementless Total Hip Arthroplasty for Rapidly Destructive Coxarthrosis from Osteonecrosis of the Femoral Head: A Matched Cohort Study

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Purpose: Total hip arthroplasty (THA) is the only definitive treatment for rapidly destructive coxarthrosis (RDC). THA for RDC has significantly higher perioperative blood loss with a greater requirement for transfusion than non-RDC primary THAs. Given the rarity of the disease, this study aimed to investigate perioperative and long-term outcomes of cementless THA for RDC that developed from osteonecrosis of the femoral head (ONFH).

Materials and Methods: Each of 26 RDC patients was matched to a patient with typical advanced-stage ONFH for comparison, according to age, sex, American Society of Anesthesiologists classification, and the type of implant used. As a primary outcome, perioperative blood loss was calculated as the sum of compensated and uncompensated blood loss.

Results: The RDC group had a significantly larger amount of total perioperative blood loss in comparison to the group with typical ONFH (791.5 mL vs. 511.2 mL, *P*=0.034), which was primarily attributable to compensated blood loss (496.1 mL vs. 141.5 mL, *P*=0.024), as uncompensated blood loss was not significantly different (*P*=0.152). Intraoperative transfusion volume was significantly higher in the RDC group (234.6 mL vs. 46.2 mL, *P*=0.007), while the difference in postoperative transfusion was marginally significant (*P*=0.092).

Conclusion: THA for RDC was accompanied by a higher perioperative blood loss, attributable mainly to a significant difference in the amount of intraoperative transfusion, in a matched comparison with patients with typical advanced-stage ONFH. However, extended operation time and prolonged hospitalization along with a large volume of transfusion did not translate into inferior long-term outcomes.

Keywords: Rapidly destructive coxarthrosis, Osteonecrosis, Surgical blood loss, Drainage, Total hip arthroplasty

INTRODUCTION

Since its first description in 1970 by Postel and Kerboull[1], rapidly destructive coxarthrosis (RDC) has been the subject of considerable investigation, yet its precise etiology remains uncertain owing to its relatively infrequent occurrence. Osteoarthritis, osteonecrosis of the femoral head (ONFH), or subchondral insufficiency fracture[2] have been proposed as possible mechanisms of RDC development, but RDC has not been described as a single disease entity and is rather considered as a single intricate phenomenon with multifactorial pre-

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disposition.

Initial radiologic assessments upon presentation with hip joint pain typically reveal either normal findings or mild pathologic changes within the hip joint. However, the subsequent rapid progression of arthritic changes or femoral head collapse, which is evident in follow-up radiographs taken during conservative care, presents a surprising challenge for clinicians. During RDC development, conspicuous radiographic manifestations include chondrolysis, joint space narrowing, subchondral cyst formation, and sclerotic changes, consistent with the diagnostic criteria of RDC[1,3-5]. This progression ultimately culminates in joint incongruency and subluxation within only a few months[6,7].

Osteoclastogenesis has been established as a contributing factor to the progression of RDC, as histologically evidenced by the identification of mature activated osteoclasts within the synovial membrane through staining for accumulated tartrate-resistant acid phosphatase[8]. The assessment of RDC disease activity involves the detection of type I collagen degradation, as indicated by serum cross-linking C-terminal telopeptide, along with certain serum bone turnover markers[9,10]. Increased inflammation in the hip joint is further implied by the detection of cytokines[11,12] and matrix metalloproteinases[13,14].

Cementless total hip arthroplasty (THA), which is the only available treatment modality for RDC, is associated with significantly higher blood loss and a greater requirement for transfusion in comparison to THAs administered to non-RDC patients[15,16]. Despite these issues, a limited body of literature has reported successful outcomes following THA for RDC in a small patient cohort[17-19]. Due to the limited research on this rare condition, no studies that specifically addressed ONFH-related RDC or used matched cohort analyses have been reported to the best of our knowledge. This study aims to investigate both perioperative and long-term outcomes associated with cementless THA performed for RDC with underlying ONFH, against a matched cohort with typical-advanced stage (association research circulation osseous [ARCO] stage IV) ONFH.

MATERIALS AND METHODS

The retrospective analysis was based on the medical records and imaging studies of 26 hips from 23 patients diagnosed with RDC and subjected to cementless THA at The Catholic University of Korea, Bucheon St. Mary's Hospital between January 2005 and December 2020. The diagnostic criteria for RDC, as per the definition posited by Lequesne[3,4], included a symptom duration of less than 12 months and radiographically confirmed hip joint space narrowing exceeding 2 mm or 50% within 6-12 months. For the advanced ONFH cohort, according to the revised staging system, ARCO stage IV ONFH is defined as osteoarthritis with accompanying joint space narrowing, acetabular changes, and/or joint destruction on plain radiograph[20] (Fig. 1). The study exclusively included patients with biopsy-confirmed ONFH pathology, thereby facilitating a comparative analysis with typical non-traumatic ONFH patients, while excluding those with suspected RDC progression attributable to osteoarthritis or subchondral insufficiency fracture. Individuals with abnormal coagulation profiles stemming from preoperative anticoagulation or antiplatelet agents, or attributed to underlying hematologic disorders or malignancies, were excluded from the study. The study protocol was reviewed and approved by the Institutional Review Board (IRB) of The Catholic University of Korea, Bucheon St. Mary's Hospital (December 12, 2023, No. HC23RISI0109). The written informed consent was waived by the IRB.

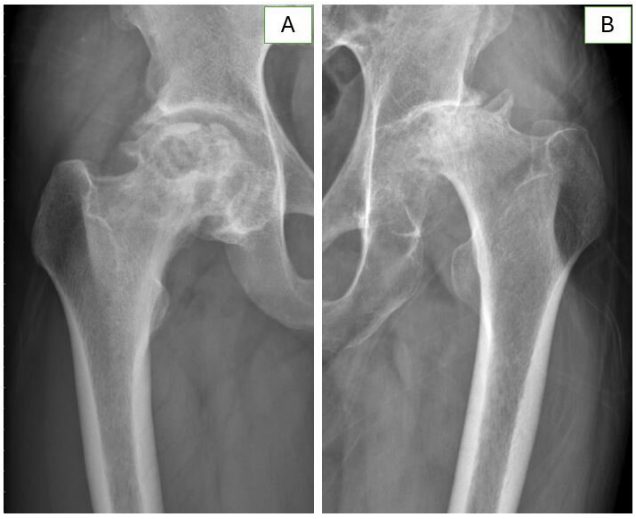

Fig. 1. A typical radiograph of RDC progression from ONFH. (A) A radiograph of a typical hip joint with ONFH of ARCO stage IV presenting arthritic changes accompanied by joint space narrowing. (B) A radiograph of a hip joint with rapidly destructive coxarthrosis joint exhibiting severe collapse 6 months after symptom manifestation. A biopsy taken intraoperatively confirmed osteonecrosis. RDC: rapidly destructive coxarthrosis, ONFH: osteonecrosis of the femoral head, ARCO: association research circulation osseous.

1. Control Group Selection: Matching

The RDC patients were subjected to a 1:1 matching process with ARCO stage IV ONFH (non-RDC) patients based on age, sex, American Society of Anesthesiologists (ASA) score, and the specific type of implant used. In all cases, Pinnacle® Porocoat shells were used as the acetabular components, while the femoral components were either type 1 (flat wedge–tapered) mid-short stems (Tri-lock®) or type 2 (dual wedge–tapered) standard-length stems (Summit®) produced by the same manufacturer (DePuy Orthopaedics Inc.), both with ceramic-on-ceramic articulation. With the exception of age, for which a matching tolerance for discrepancies of ±1 year were permitted (P=0.977), all other variables, namely sex, femoral component, and ASA classification, were matched exactly within each pair of patients from the two groups used for comparison (P>0.999). A total of 26 hips were meticulously selected for each group, resulting in an eligible cohort for subsequent analysis (n=52).

2. Surgical Procedure and Postoperative Care

All THAs were conducted under general endotracheal anesthesia, used a posterolateral approach, and were performed by a single surgeon. Preoperative assessments including hematocrit levels were routinely conducted on the day preceding surgery at admission, with subsequent evaluations on the fifth postoperative day. From the second day after surgery, patients were systematically directed to the rehabilitation center in this institute for structured rehabilitation activities including quadratus strengthening exercises, tilting table exercises, and parallel bar ambulation training.

3. Primary Outcome: Quantification of Blood Loss

The primary outcome was perioperative blood loss (mL), comprising both uncompensated and compensated components[15,21]. Uncompensated blood loss was estimated using the formula proposed by Mercuriali and Inghilleri[22], which is based on the multiplication of the estimated blood volume by the hematocrit change from the day before surgery to 5 days after the operation. The estimation of total blood volume was based on the method proposed by Nadler et al.[23], which uses the lean body mass determined from the patient's height and weight, with different constants for women and men. Compensated blood loss was quantified as the actual volume of transfused packed red blood cells (pRBC), with separate assessments for intraoperative and postoperative transfusions. Only transfusions conducted before the fifth postoperative day were included in the calculation of compensated blood loss.

4. Secondary Outcomes

Additional outcome parameters included postoperative total drainage volume (mL), duration of surgical procedure (minutes), length of hospitalization (days), Harris hip score at the most recent follow-up visit, and rates of complications, all designated as dependent variables. Complications encompassed instances of squeaking, anterior thigh pain, infection, aseptic loosening, hematoma formation, deep vein thrombosis, pulmonary thromboembolism, dislocation, and periprosthetic fractures.

Calculation of the Harris hip score was based on printed questionnaires, supplemented by physical examinations to assess the range of motion, conducted by a qualified physician. Follow-up hip radiographs were routinely obtained at scheduled intervals of 6 months for patients with follow-up periods exceeding one-year post-surgery. During each follow-up examination, the patients were asked about the presence of anterior thigh pain or audible squeaks, and the answers were documented.

5. Statistical Analyses

Tests of normality, followed by paired t-tests, were used for intergroup comparisons, with P-values below 0.05 deemed statistically significant. All statistical analyses were executed in IBM SPSS Statistics software (ver. 24.0; IBM Corp.).

RESULTS

The demographic characteristics of each cohort are detailed in Table 1. The mean age was 56.81±15.26 years for the RDC group and 56.85±15.38 years for the non-RDC group, with a mean ASA score of 1.96±0.45 for both groups. As the femoral component, Summit® was used in 10 cases (38.5%) and Tri-lock® was used in 16 cases (61.5%) in each group. Follow-up duration was shorter in the RDC group than in the non-RDC group (32.9 months vs. 54.0 months, P=0.063), although the difference did not attain statistical significance. All cases within the RDC group had pathologies indicative

Table 1. Demographics of the Matched Groups of RDC and Non-RDC ONFH

	RDC	Typical ONFH	*P*-value
No. of hips	26	26	>0.999
Sex			>0.999
Male	15 (57.7)	15 (57.7)	
Female	11 (42.3)	11 (42.3)	
Mean age (yr)	56.81±15.26 (28-78)	56.85±15.38 (28-79)	0.977
Femoral component			>0.999
Summit®	16 (61.5)	16 (61.5)	
Tri-lock®	10 (38.5)	10 (38.5)	
ASA classification			>0.999
I	3 (11.5)	3 (11.5)	
II	21 (80.8)	21 (80.8)	
III	2 (7.7)	2 (7.7)	
Follow-up period (mo)	32.9±32.1	54.0±40.6	0.063

Values are presented as number only, number (%), mean±standard deviation (range), or mean±standard deviation only.
RDC: rapidly destructive coxarthrosis, ONFH: osteonecrosis of the femoral head, ASA: American Society of Anesthesiologists.

Table 2. The Intergroup Comparison of the Results by Paired *t*-test between Matched RDC and Typical ONFH Samples

	RDC	Typical ONFH	*P*-value
Primary outcome			
Estimated blood volume (mL)	4,100.9±642.1	4,078.1±716.6	0.683
Estimated total perioperative blood loss (mL)	791.5±518.5	511.2±262.1	0.034*
Uncompensated blood loss (mL)	295.4±227.7	369.7±164.0	0.152
Compensated blood loss (mL)	496.1±635.8	141.5±279.6	0.024*
Intraoperative pRBC transfused volume (mL)	234.6±289.4	46.2±116.5	0.007*
Postoperative pRBC transfused volume (mL)	261.5±419.0	95.4±213.2	0.092
Perioperative hematocrit change (%)	7.1±5.5	9.0±3.2	0.142
Secondary outcome			
Postoperative total drainage volume (mL)	490.1±305.0	455.4±366.3	0.710
Operative time (min)	130.8±28.1	108.0±31.0	0.019*
Length of hospitalization (day)	17.2±4.5	13.2±3.5	0.002*
Harris hip score: preoperative	42.4±15.1	52.7±13.7	0.024*
Harris hip score: recent follow-up	88.9±7.4	90.8±10.2	0.783

Values are presented as mean±standard deviation.
RDC: rapidly destructive coxarthrosis, ONFH: osteonecrosis of the femoral head, pRBC: packed red blood cell.
*$P<0.05$.

of ONFH.

1. Primary Outcome

The evaluation of the estimated blood volume revealed no statistically significant difference between the two groups (P=0.683), which forms the basis for the calculation of the total perioperative blood loss. The RDC group had a significantly larger total perioperative blood loss than the typical ONFH group (791.5 mL vs. 511.2 mL, P=0.034). This difference was attributable primarily to a notable difference in compensated blood loss (496.1 mL vs. 141.5 mL, P=0.024), as the uncompensated blood loss did not differ significantly between the groups (P=0.152). The intraoperative transfusion volume was markedly higher in the RDC group (234.6 mL vs. 46.2 mL, P=0.007), while postoperative transfusion did not differ significantly (261.5 mL vs. 95.4 mL, P=0.092). Hematocrit change, which is directly related to uncompensated blood loss, also showed no significant difference (Table 2).

2. Secondary Outcomes

The postoperative drainage volume did not differ significantly between the two groups (P=0.710). The RDC

Table 3. The Comparison of Complications between THA for RDC and Typical ONFH

Complication	RDC (n=26)	Typical ONFH (n=26)
Squeak	0 (0)	1 (3.8)
Anterior thigh pain	1 (3.8)	1 (3.8)
Infection	0 (0)	0 (0)
Hematoma	0 (0)	0 (0)
Deep vein thrombosis	0 (0)	0 (0)
Pulmonary thromboembolism	0 (0)	0 (0)
Dislocation	1 (3.8)	0 (0)
Aseptic loosening	0 (0)	0 (0)
Periprosthetic fracture	1 (3.8)	0 (0)

Values are presented as number (%).
THA: total hip arthroplasty, RDC: rapidly destructive coxarthrosis, ONFH: osteonecrosis of the femoral head.

group had an extended length of hospitalization (17.2 days vs. 13.2 days, P=0.002) and longer operative time (130.8 minutes vs. 108.0 minutes, P=0.019). Preoperative Harris hip score was lower in the RDC group (42.4 vs. 52.7, P=0.024), but the recent Harris hip score did not differ significantly between the two groups (P=0.783), as shown in Table 2.

3. Complications

Among postoperative complications, audible squeaking was reported in a case with typical ONFH and was not observed in the RDC group, while anterior thigh pain was present in one patient from each group. A patient with RDC experienced dislocation but was treated successfully with conservative care using an abduction brace after closed reduction. Another patient presented with a periprosthetic fracture within 1 month after primary THA, which was surgically treated with fixation using multifilament cables. No other complications, including infection, hematoma, deep vein thrombosis, pulmonary thromboembolism, or aseptic loosening, were observed on follow-up (Table 3).

DISCUSSION

The destructive features characteristic of RDC mimic inflammation caused by infection, prompting doubts among surgeons about the satisfactory outcomes of THA. Anticipation of increased perioperative blood loss and concerns regarding the potential for implant-related infections hinder confident decision-making, despite studies reporting favorable outcomes with both cemented and cementless THA[17-19]. This study aimed to investigate the components of perioperative blood loss, to ascertain specific aspects necessitating such caution.

The literature about this condition frequently uses the term "rapidly destructive coxarthrosis (RDC)", but "rapidly destructive osteoarthritis (RDO)", "rapidly destructive arthrosis (RDA)", or "rapidly destructive arthropathy (RDA)" are also often used. The ambiguity of the pathological entity is reflected in a more inclusive term, "rapidly destructive hip disease (RDHD)", which also has been used historically. Given the notably high prevalence of ONFH, which accounts for approximately 50% of patients undergoing THA in East Asia[24,25], the instances of RDC that developed from ONFH are more prevalent than those of RDC originating from osteoarthritis or subchondral fractures in this population. Whereas elderly women are particularly at risk[26,27], the mean age within our RDC cohort was around 58 years, with a higher proportion of men. This observation implies demographic distinctions between individuals with RDC associated with ONFH and those with osteoarthritis.

The decision-making process underlying pRBC transfusions remains ambiguous in each case whether initiated at the operator's discretion upon intraoperative identification of relatively excessive bleeding or through the anesthesiologist's experiential judgment. However, the difference in the amount of compensated blood loss, particularly intraoperative pRBC transfusions, mainly contributed to the observed difference in total perioperative blood loss. Additionally, although not attaining statistical significance (P=0.092), a discernable difference of 166 mL in postoperative transfusions was noted between the two groups.

Some studies have suggested that postoperative blood loss through the drain tube may result in an increased requirement for pRBC transfusions, or vice versa[28-30]. Nevertheless, the findings of this study reveal no significant difference between groups in the amount of postoperative drainage volume (P=0.710), while the difference in the quantity of transfusions was evident. A high degree of inflammation severity, including extensive synovitis and bone marrow edema, might lead to an increased bleeding tendency[15]. Therefore, in THA for RDC, much effort is placed on meticulous synovectomy and bleeding control, which may have contributed to significantly longer operation times. Furthermore, implant fixation, sealing most of the acetabular

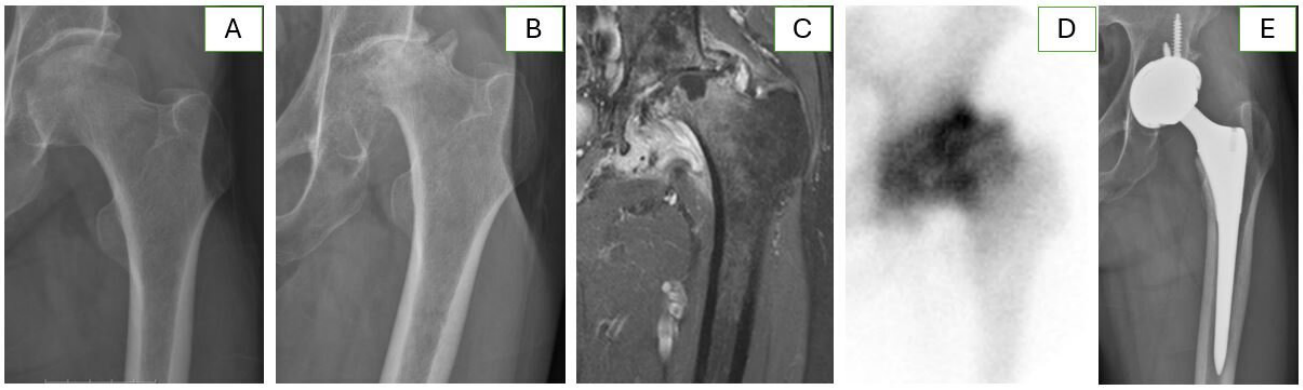

Fig. 2. A series of images from a case of patient with rapidly destructive coxarthrosis (RDC) treated with total hip arthroplasty. (A) A radiograph of a normal hip joint with pain at the time of presentation. (B-D) Rapid destruction of a femoral head at 6-month follow-up. Magnetic resonance images and bone scan images show features of RDC. (E) A radiograph taken 1 year after total hip arthroplasty.

surface and proximal femur likely resulted in a similar amount of postoperative drainage volume in both groups. Thus, the causal relationship between blood loss and transfusion may not be totally clear. Several hypotheses have been proposed to explain increased blood loss in RDC. First, extensive bone marrow edema extending over the peritrochanteric area[31] characterized by increased levels of cytokines[11,12] and matrix metalloproteinases[13,14] and by local inflammation contributes to increased marrow pressure[32] and augmented blood flow at the level of femoral neck cutting and femoral component implantation. In contrast, in typical advanced-stage ONFH, bone marrow edema is likely to improve, and its range contracts back to the necrotic border, which might had extended to the peritrochanteric area in the preceding early stages[31]. Consequently, THAs in such cases would not breach the edematous cancellous component during the femoral neck cut, potentially resulting in a less inflammatory environment. Second, synovitis within the hip joint at the time of THA is posited to be more severe in RDC than in typical advanced-stage ONFH, which was substantiated by magnetic resonance imaging as well as operative findings[15]. The hypervascularity of granulation tissue may contribute to these observations. Third, the significantly prolonged operation time may also contribute, in part due to additional procedures required for the clearance and cleansing of the joint space laden with liquefied bone debris, while hemorrhagic events persist.

A 59-year-old male visited our clinic with left hip pain that had lasted for a few weeks, during which a hip joint radiograph showed normal findings (Fig. 2A). After 6 months of conservative care, a follow-up radiograph revealed severe joint destruction with collapse of the femoral head (Fig. 2B). Magnetic resonance imaging at that time additionally showed acetabular changes with severe synovitis (Fig. 2C), and intense uptake of Technetium-99m was observed on bone scan images in the corresponding lesion (Fig. 2D). The patient was treated with THA and was pain-free with a satisfactory result (Harris hip score of 96) 1 year after surgery (Fig. 2E).

There are several limitations to this study. First, its retrospective study design with a relatively small sample size was necessitated due to the rarity of the disease. Thus, to mitigate selection bias, a matched cohort analysis was used. Yet, logistical constraints, particularly in femoral component matching due to recent diversification in implant selection at the institute, precluded larger-scale matching. Second, transfusions other than pRBC, such as platelet concentrates, single-donor platelets, or fresh frozen plasma, were not factored into the analysis and may potentially alter the coagulation status of patients. The infused volume of such agents along with hemodilution caused by perioperative hydration might also have affected hematocrit changes. Third, comorbidities such as diabetes mellitus, chronic kidney disease, or hypertensive conditions, were not meticulously detailed; instead, the ASA scores, reflective of the overall general condition of patients, were matched for comparison. Lastly, a disparity in the follow-up period (32.9 months vs. 54.0 months, P=0.063) may have interrupted equal comparisons in the assessment of the Harris hip score and the incidence of long-term complications. Future investigations should strive for larger sample sizes to enhance statistical power

through the integration of multicenter data.

CONCLUSION

THA for patients with RDC demonstrated increased perioperative blood loss, which was attributable mainly to a significant difference in the amount of intraoperative pRBC transfusion, in a matched comparison with patients with typical advanced-stage ONFH. However, extended operation time and prolonged hospitalization along with an increased amount of transfusion did not translate into an inferiority in the long-term functional and radiological outcomes of THA performed for RDC patients. Therefore, careful perioperative patient blood management is essential to achieve successful THA.

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Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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