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Cemented Versus Uncemented Reverse Shoulder Arthroplasty Treatment of Proximal Humerus Fractures: National Shoulder Arthroplasty Data from Türkiye

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Background: This study evaluated national trends in cemented and uncemented reverse shoulder arthroplasty (RSA) for proximal humerus fractures using a comprehensive national surgical database. This study aimed to compare RSA used in the treatment of proximal humerus fractures with the literature and to determine the country's trend.

Methods: A cross-sectional study was conducted using the health records of individuals aged ≥ 18 years who underwent RSA for proximal humerus fractures between 2016 and 2022. Patients were divided into cemented and uncemented groups, and demographic data (age, sex), duration of hospital stay, transfusions, revisions, mortality, and Charlson Comorbidity Index (CCI) scores were analyzed.

Results: A total of 618 cemented RSA and 1,364 uncemented RSA procedures were reviewed. Patients who underwent cemented RSA were significantly older than those who had uncemented RSA ($p = 0.002$). Transfusion rates were higher in the cemented RSA group ($p = 0.006$). The frequency of revision surgery was 6.1%. Younger age and male sex were associated with revision ($p < 0.001$). CCI scores were higher among transfused patients than non-transfused patients ($p < 0.001$). The incidence of cemented RSA was 11.7% and 49% in 2016 and 2022, respectively. Differences were found among hospital types and geographical regions.

Conclusions: While cemented RSA has been gaining attention and increased application in recent years for proximal humerus fractures, uncemented RSA still predominates. The choice between these 2 methods is largely influenced by regional and hospital-level factors. The type of RSA and high CCI scores were found to have no significant impact on the risk of surgical revision.

Keywords: *Proximal humerus fracture, Reverse shoulder arthroplasty, Cement, Charlson Comorbidity Index, National trends*

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Complex proximal humerus fractures and fracture-dislocations are serious injuries that limit independence and affect the quality of life of the patients. By 2030, an increase of 32% is expected in these fractures.[1] In the treatment of these fractures, especially in the elderly, reverse shoulder arthroplasty (RSA) has been applied at increasing rates in recent years.[2] However, despite the increasing utilization of RSA, the decision to use cemented or uncemented fixation for the humeral stem remains controversial.[3]

Although uncemented humeral stems are mainly used for indications other than proximal humerus fractures in RSA, both cemented and uncemented RSAs have been considered valid options in the treatment of proximal humerus fractures in recent years.[4,5] In the fixation of the humeral stem, polymethyl methacrylate is used in the cemented technique and press-fit fixation (porous-coated or grit-blasted surface) is used in the uncemented technique.[6] It has been suggested that fixation with cement is stronger than fixation without cement in the first 2 years.[6] However, concerns for bone loss, shorter operative times, fewer complication rates (including infection, neurological injury, and thromboembolism), and efforts to reduce surgical costs have recently made uncemented humeral fixation more popular.[6-9]

The present research was undertaken with the aim of describing the evolving national trends in the use of cemented and uncemented RSA procedures in the management of proximal humerus fractures. The secondary aim was to examine Charlson scores, transfusion rates, and geographical distribution. This study utilized a robust platform, namely the Turkish Ministry of Health's extensive national electronic shoulder arthroplasty database, to examine this issue in depth. In doing so, we hoped to shed light on current practices in treating proximal humerus fractures with cemented and cementless arthroplasties and ultimately guide future decisions for the optimization of patient care and outcomes.

METHODS

This study was conducted according to the Declaration of Helsinki and received approval from the Turkish Ministry of Health with a waiver for informed consent for retrospective data analysis and the health information privacy law (No. 95741342-020/27112019).

Health records of individuals who underwent RSA due to proximal humerus fractures in public, private, and university health institutions were collected via the e-health database of the Ministry of Health of the Republic of Türkiye.[10]

We performed a computerized medical record search to identify all patients who underwent RSA for proximal humerus fractures in Türkiye. The database was searched using the International Classification of Diseases (ICD) codes in line with the World Health Organization's 10th revision of the International Statistical Classification of Diseases and Related Health Problems (ICD-10). ICD code S42.2 (code for closed proximal humerus fractures) was used to detect patients older than 18 years of age who sustained proximal humerus fractures between January 2016 and December 2022. The review of the database was performed in April 2023. The records of patients who underwent cemented or uncemented RSA were extracted, allocated, and pooled using operation-specific procedure codes, implant-specific codes from invoices, and treatment-specific codes (https://skrs.saglik.gov.tr/).

After the proximal humerus fracture cases were extracted, the patients who underwent RSA (612551, P612551) were separated according to procedure codes and grouped into cemented and uncemented subsets according to the codes specific to the implants that were used. Patients' demographic data (age and sex), duration of hospital stay (days), transfusion status, revision surgery, time between primary and revision surgery (months), mortality rate during hospitalization, and Charlson Comorbidity Index (CCI) scores were evaluated from the records. The 10-year survival rate of the patients was calculated according to the CCI. A total of 19 parameters are evaluated in the CCI and each comorbidity is scored from 1 to 6. The highest age-adjusted CCI score is 37 points.[11] Patients who received different treatment options in the Ministry of Health's national shoulder arthroplasty electronic database were excluded from the study. A total of 1,982 patients who underwent RSA due to proximal humerus fractures were included in the study.

Statistics

IBM SPSS Statistics version 25 (IBM Corp.) was used in this study. Mean, standard deviation, minimum, maximum, frequency, and percentage statistics were used for descriptive variables. Chi-square tests (Pearson and likelihood ratio) were used for categorical variables. Student *t*-tests and Mann-Whitney *U*-tests were used to compare continuous variables between groups. The significance level for all tests was determined as 0.05.

RESULTS

Between 2016 and 2022, a total of 169,614 patients with proximal humerus fractures were identified according to

their ICD-10 codes. A total of 1,982 RSA cases were included in this study (Fig. 1). The demographic data of the patients (age and sex), duration of hospital stay, number of patients who underwent transfusion, frequency of revision surgery, time to revision surgery, and mortality are given in Table 1. There was no statistical difference in sex, duration of hospital stay, or frequency of revision among patients who underwent cemented and uncemented RSA ($p > 0.05$). While the mean age of the patients who underwent cemented RSA was 71.1 ± 9.7 years, the mean age of the uncemented RSA group was 69.6 ± 10 years ($p = 0.002$) (Table 1). The mean follow-up period of the patients was 32.6 ± 21.0 months (range, 4–88 months). The frequency of transfusion was higher in the cemented RSA group (37.2%) than in the uncemented RSA group (31%) ($p = 0.006$) (Table 1).

The mortality rate of the patients during hospitalization was 0.3%. Mortality was observed in 1 patient with

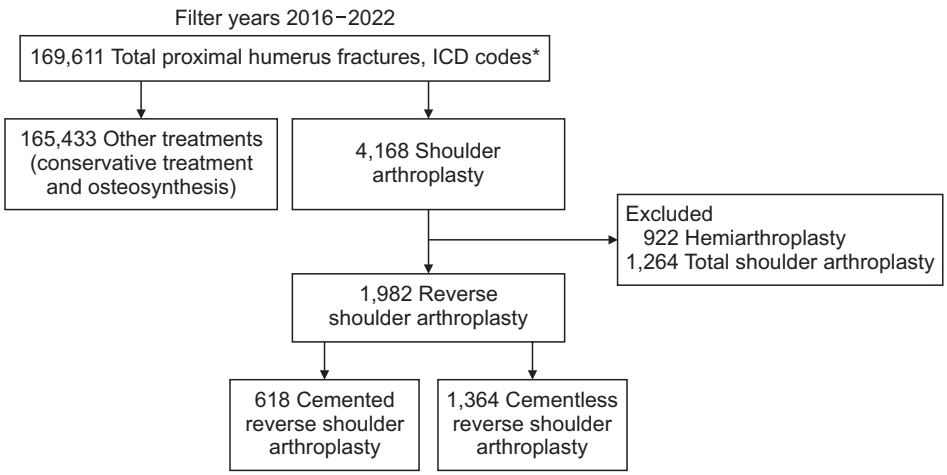

Fig. 1. Flow diagram of patients with proximal humerus fractures treated with reverse shoulder arthroplasty between 2016 and 2022. ICD: International Classification of Diseases. *ICD code S42.2 for closed proximal humerus fractures.

Table 1. Demographic Data

Variable	All patients	Cemented RSA	Cementless RSA	*p*-value
Number	1,982	618 (31.2)	1,364 (68.8)	
Age (yr)	70.1 ± 9.9 (19–97)	71.1 ± 9.7 (19–95)	69.6 ± 10.0 (20–97)	0.002*
Sex				0.107
Male	442 (22.3)	124 (28.1)	318 (71.9)	
Female	1,540 (77.7)	494 (32.1)	1,046 (67.9)	
Duration of hospital stay (day)	4.75 ± 3.35 (1–17)	4.79 ± 3.29 (1–17)	4.74 ± 3.39 (1–17)	0.408
Transfusion				0.006*
Yes	653 (32.9)	230 (37.2)	423 (31.0)	
No	1,329 (67.1)	388 (62.8)	941 (69.0)	
Revision surgery				0.087
Yes	120 (6.1)	29 (4.7)	91 (6.7)	
No	1,862 (93.9)	589 (95.3)	1,273 (93.3)	
Time to revision surgery (mo)	10.2 ± 13.3 (0.5–66.7)	8.04 ± 11.8 (0.5–54.2)	10.9 ± 13.8 (0.5–66.7)	0.213
Mortality	6 (0.3)	1 (0.05)	5 (0.25)	

Values are presented as number (%) or mean ± standard deviation (range).
RSA: reverse shoulder arthroplasty.
*$p < 0.05$.

cemented RSA and 5 with uncemented RSA. The frequency of revision surgery for any reason was 6.1%. There was no statistically significant difference between the 2 groups regarding revision surgery ($p = 0.087$) (Table 1). Both age and male sex were associated with revision surgery ($p < 0.001$) (Table 2). While the revision rate was 6.7% among patients who underwent uncemented RSA, it was 4.7% in the cemented RSA group. Patients undergoing revision surgery had an average of 10.2 ± 13.3 months (median, 4.6 months; range, 0.5–66.7 months) between the initial surgery and the revision. There was no statistically significant difference in this regard between the cemented and uncemented RSA groups ($p = 0.213$) (Table 1).

The mean CCI score of the patients who underwent revision surgery was 4.1 ± 3.2 (median, 3; range, 0–14). The mean CCI score was 4.2 ± 3.0 (median, 4; range, 0–15) for patients who did not undergo revision surgery. There was no statistically significant difference in this regard ($p = 0.571$). While the mean CCI score was 4.6 ± 3.2 (median, 4; range, 0–15) for transfused patients, it was 3.9 ± 2.9 (median, 4; range, 0–14) for non-transfused patients. There was a statistically significant difference between the 2 groups regarding CCI scores, which were higher among transfused patients ($p < 0.001$).

Table 2. Relationships between Revision and Age and Sex

Variable	Revision	No revision	*p*-value
Age (yr)	65 ± 11 (20–86)	70 ± 10 (19–97)	< 0.001
Sex			< 0.001
Male	56 (12.7)	386 (87.3)	
Female	120 (4.2)	1476 (95.8)	

Values are presented as mean ± standard deviation (range) or number (%).

Table 3. Relationships between Treatment Modality and Hospital Level

Variable	Cemented RSA	Cementless RSA	*p*-value
University hospital	103 (26.3)	289 (73.7)	0.013
Secondary or tertiary state hospital	310 (34.2)	597 (65.8)	
Private hospital	205 (30.0)	478 (70.0)	
Total	618 (31.2)	1,364 (68.8)	

Values are presented as number (%).
RSA: reverse shoulder arthroplasty.

The incidence of cemented RSA was non-significantly higher in secondary and tertiary care hospitals (34.2%) ($p = 0.075$). The incidence of uncemented RSA was significantly higher in university hospitals (73.7%) ($p = 0.013$) (Table 3). Uncemented RSA was utilized for 68.8% of all patients who underwent RSA for proximal humerus fractures between 2016 and 2022 (Table 4). Considering the distribution of geographical regions, cemented RSA was utilized most commonly in the Black Sea region of Türkiye with a frequency of 43.2%. Uncemented RSA was most frequently utilized in the Marmara region ($p < 0.001$) (Table 4).

According to Turkish national shoulder arthroplasty

Table 4. Relationship between Treatment Modality and Region Distribution

Variable	Cemented RSA	Cementless RSA	*p*-value
Marmara region	191 (26.9)	520 (73.1)	< 0.001
Aegean region	165 (36.8)	283 (63.2)	
Mediterranean region	67 (35.8)	120 (64.2)	
Central Anatolian region	127 (27.0)	343 (73.0)	
Black Sea region	60 (43.2)	79 (56.8)	
Eastern Anatolian region	2 (28.6)	5 (71.4)	
South-eastern Anatolian region	6 (30.0)	14 (70.0)	
Total	618 (31.2)	1,364 (68.8)	

Values are presented as number (%).
RSA: reverse shoulder arthroplasty.

Table 5. Distribution of RSA between 2016 and 2022

Year	Cementless RSA	Cemented RSA	*p*-value
2016	53 (88.3)	7 (11.7)	< 0.001
2017	109 (93.2)	8 (6.8)	
2018	200 (87.7)	28 (12.3)	
2019	199 (70.6)	83 (29.4)	
2020	236 (76.4)	73 (23.6)	
2021	276 (66.5)	139 (33.5)	
2022	291 (51.0)	280 (49.0)	
Total (n = 1,982)	1,364 (68.8)	618 (31.2)	

Values are presented as number (%).
RSA: reverse shoulder arthroplasty.

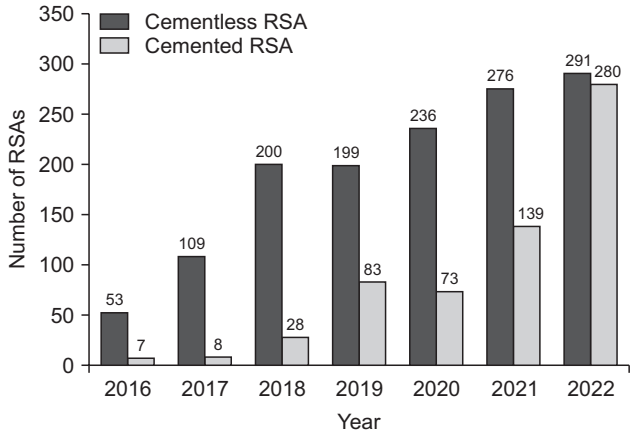

Fig. 2. Number of cemented and uncemented reverse shoulder arthroplasties (RSAs) for proximal humerus fractures on the country level during the study period.

data, cemented RSA for proximal humerus fractures was applied at a rate of 18% between 2016 and 2019, while it increased to 38% between 2020 and 2022. Uncemented RSA was the most preferred RSA application every year. While the preference for cemented RSA was 11.7% in 2016, this rate increased to 49% in 2022 (Table 5, Fig. 2).

DISCUSSION

We report the first study comparing cemented and uncemented RSA for proximal humerus fractures using the national electronic database of the Turkish Ministry of Health. The most important finding of our study is the increasing use of RSA, especially cemented RSA, for these fractures in Türkiye. The use of cemented or uncemented RSA for proximal humerus fractures was found to differ by region, and male sex and younger age increased the revision rates.

Boileau et al.[12] reported a 7.8% revision rate in the course of a 12-year follow-up period in patients who underwent primary RSA for different reasons. Our study had a mean follow-up period of 32.6 months; the revision rate was 6.1%. It was previously reported that there was no difference in terms of revision surgery in patients who underwent cemented and uncemented RSA (1.6% vs. 1.9%, respectively; $p > 0.05$).[3] In patients who underwent RSA for any reason, the revision frequency in cases of cemented RSA was reported to be higher than that for uncemented RSA (4% vs. 1.5%, respectively; $p = 0.028$).[13] In our study, although the revision rates were higher than those previously reported in the literature, there was no significant difference in revision surgery rates between patients who underwent cemented and uncemented RSA (6.7% vs. 4.7%, respectively; $p = 0.087$). Gorman et al.[13] reported that the time to revision was significantly longer in the cemented RSA group than in the uncemented group. Consistent with findings in other studies, there was no significant difference between the 2 groups regarding the rate of revision surgery and time to revision.[11,14] However, revision rates in cemented RSA may vary due to the follow-up period and the total number administered being relatively less than uncemented RSA. Lopiz et al.[15] reported that the mean time to revision for patients who underwent RSA for proximal humerus fracture with subsequent revision surgery was 36.8 months. Our study found that revision surgery was performed in an average of 10.2 months. This period was relatively short compared to the literature. We cannot comment on the reasons for this with the available data, but further studies on the reasons for this finding are planned.

In the literature, the specific indications for primary RSA and the frequency of complications are frequently listed among the reasons for revision.[13,16,17] However, we found limited studies examining the patient-related factors that may lead to revision.[16,18] According to a report of the Australian National Arthroplasty Society, the cumulative rate of revision was higher in male patients than female patients among those who underwent RSA for osteoarthritis or rotator cuff arthropathy ($p < 0.05$).[18] The same report emphasized that age was not a risk factor among patients who underwent RSA for osteoarthritis.[18] On the other hand, Chelli et al.[16] reported that the 10-year survival rate after RSA among patients younger than 60 years was 75%, while the 10-year survival rate among patients aged 60–69, 70–79, and ≥ 80 years was 88.8%, 91.3%, and 94.3%, respectively ($p < 0.001$). In the same study, the revision rate was higher for male patients than female patients (10.4% vs. 5.6%, respectively; $p < 0.001$). Our study found that revision surgery was more common in male sex and younger ages. This may be due to the fact that the male patients and younger patients had higher activity levels compared to female patients and older patients.

In the present study, uncemented RSA was applied at a rate of 68.8%. In the literature, advantages of uncemented RSA including shorter surgical time, ease of revision, long-term biological fixation, and no cost of additional equipment required for cement have been reported.[19] The more frequent preference for uncemented RSA is due to these advantages. On the other hand, Phadnis et al.[8] reported that cemented RSA was preferred more often in cases of fractures and posttraumatic indications. According to the National Arthroplasty Association of Australia, uncemented RSA with a frequency of approxi-

mately 73% was preferred between 2008 and 2013.[18] In the present study, uncemented RSA was most often preferred in university hospitals, at a rate of 73.7%, while the application of cemented RSA was more common in secondary and tertiary hospitals, at a rate of 34.2%. In addition, while the rate of cemented RSA applications was 11.7% in 2016, it increased to 49% in 2022.

Voskuijl et al.[20] reported that each unit increase in CCI scores increases the risk of hospital readmission and the risk of transfusion in patients who have undergone orthopedic arthroplasty surgery. In addition, Kim et al.[21] showed that the CCI is a good predictor of postoperative complications, length of hospital stay, non-routine discharge, and mortality following shoulder arthroplasty. We found that patients with higher CCI scores had a significantly higher transfusion rate, similar to the literature. However, similar to Lopiz et al.,[15] we did not find a relationship between CCI scores and revision rates.

Salesky et al.[14] reported that patients who underwent cemented RSA were older than patients who underwent uncemented RSA (66.6 vs. 61.4 years, respectively; $p = 0.03$). On the other hand, in a study published recently, it was reported that there was no difference between the groups in terms of age ($p = 0.903$).[17] Lopiz et al.[15] found that patients who underwent uncemented RSA were older than those who underwent cemented RSA (80 vs. 78 years, respectively; $p = 0.09$). In our study, however, the patients of the cemented RSA group were older on average than those of the uncemented RSA group (71.1 vs. 69.9 years, respectively; $p < 0.002$). There is no consensus in the literature regarding the relationship between age and cement use. It may be due to different reasons, such as different types of fractures, the experience of the surgeon, and general health insurance.

In the literature, the transfusion rate in cases of shoulder arthroplasty varies between 8.1% and 43%.[22] In our study, the transfusion rate was 32.9%. We attribute the wide range of transfusion rate values to the fact that different clinics have different application procedures. Malcherczyk et al.[23] reported that arthroplasty application alone does not increase the rate of indications for transfusion. However, the need for transfusion was increased among patients with coronary artery disease, renal dysfunction, and ASA classification scores of 3–4.[23] We found that the need for transfusion was increased among patients with higher CCI scores. In addition, the transfusion rate in cases of cemented RSA was higher than that for uncemented RSA (37.2% vs. 31%, respectively; $p < 0.006$). In a recently published study, the use of cement during shoulder arthroplasty did not change the rate of total blood loss ($p = 0.141$); however, it was emphasized that the use of cement significantly increased the need for transfusions ($p = 0.000$).[24] Hardy et al.[22] also showed that the utilization of cemented humeral stems significantly increased the need for transfusions ($p < 0.05$).

Sabesan et al.[25] reported that the mortality rate ranged from 0.6% to 0.2% among patients treated with RSA for any reason. Lehtimaki et al.[26] reported that the mortality rate was 4.3% within the first year for patients who underwent RSA surgery for acute proximal humerus fractures. In addition, in contrast to our findings, some previous studies reported that using cemented stems increases the overall mortality rate.[8,27] We attribute these differences to the evaluation of early mortality rates only during hospitalization in our study.

In a previous study, the average duration of hospitalization among patients who underwent RSA was reported to be 2.6 days.[28] In our study, the average hospital stay was 4.7 days. There was no difference in terms of duration of hospital stay between the cemented and uncemented RSA groups ($p > 0.05$). The longer hospital stays observed in our study may be due to differences in the time taken to stabilize comorbid diseases and the general health insurance policies of the patients hospitalized after fractures.

The numbers of RSA applications in the Eastern and South-eastern Anatolian regions of Türkiye were lower than those of other regions. This may be because these regions have fewer hospitals and doctors. According to data from 2020, the region with the lowest number of hospitals and hospital beds in Türkiye is the Eastern Anatolian region. In the same study, the region with the lowest number of physicians was reported as the South-eastern Anatolian region.[29] In addition, geographical, cultural, and sociodemographic differences may play roles in healthcare effectiveness.[30] While the region where cemented RSA was most preferred was the Black Sea region, with a rate of 43.2%, uncemented RSA was most frequently preferred in the Marmara and Central Anatolian regions at 73.1% and 73%, respectively.

This study was a multicentre study with potential differences in surgical techniques and surgeons' decisions to apply cement during RSA procedures were based on personal preference. The bias that might arise in multicentre studies was limited by having an independent observer analyze the data. Second, in this retrospective study, the minimum follow-up period was short. Another limitation was that the patients' clinical and radiological results were not evaluated. Analysis according to proximal humerus fracture classification was similarly not performed. Finally, complications and long-term outcomes were not evalu-

ated for this patient group. Future multicentre prospective studies will help determine the relationship between using cemented or uncemented stems and the risk of complications. The strongest aspect of our study is that, as far as we know, it is the first to compare cemented and uncemented RSA applications using national arthroplasty data from the Turkish Ministry of Health.

This study has revealed an intriguing trend: while cemented RSA has been progressively attracting interest as a treatment for proximal humerus fractures, its uncemented counterpart remains the more prevalent practice. Significantly, we found that these RSA applications had low early mortality rates, underlining their efficacy and safety. Neither the usage of cement nor high CCI scores affected the risk of subsequent surgical revision, revealing a degree of resilience in treatment outcomes irrespective of these factors. The choice between cemented and uncemented RSA seems to be influenced by the level of the hospital and regional variations, suggesting the interplay of institutional preferences and expertise in treatment decisions. This study provides crucial insight into the diverse landscape of RSA treatments across Türkiye.

CONFLICT OF INTEREST

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

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