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Surgical Trends of Shoulder Arthroplasty: Nationwide Epidemiologic Study in South Korea

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Background: The aim of this study was to determine the nationwide shoulder arthroplasty trends in South Korea based on an analysis of nationwide data acquired from the Korean Health Insurance Review and Assessment Service (HIRA).

Methods: We analyzed a nationwide database acquired from the HIRA that covered 2008 to 2017. International Classification of Diseases, 10th Revision (ICD-10) codes and procedure codes were used to identify patients who underwent shoulder arthroplasty, including total shoulder arthroplasty (TSA), hemiarthroplasty (HA), and revision shoulder arthroplasty.

Results: From 2008 to 2017, a total of 19,831 shoulder arthroplasties were performed; there were 16,162 TSAs and 3,669 hemiarthroplasties. During the 10-year study period, there was an exponential increase in the incidence of TSA (from 513 cases in 2008 to 3,583 cases in 2017), while the number of hemiarthroplasties remained steady. The most common diagnoses for TSA were rotator cuff tears (6,304 cases, 39.0%) and osteoarthritis (6,589 cases, 40.8%) for all 9 years. Osteoarthritis was the most common reason for TSA during the first 3 years (2008–2010), but rotator cuff tears ultimately surpassed osteoarthritis during the last 3 years (2015–2017). HA was performed to treat proximal humerus fracture (1,770 cases, 48.2%) and osteoarthritis (774 cases, 21.1%). In terms of hospital types, the rate of TSA in hospitals with 30–100 inpatient beds increased from 21.83% to 46.27%, while the rates of the other types of surgery decreased. A total of 430 revision surgeries were performed during the study period, and infection (152 cases, 35.3%) was the most common reason for revision surgery.

Conclusions: Overall, the total count and incidence of TSA, unlike HA, increased rapidly between 2008 and 2017 in South Korea. Moreover, at the end of the study period, nearly half of the TSAs were performed in small hospitals (30 to 100 beds). Rotator cuff tears were the leading cause of TSA at the end of the study period. These findings revealed an explosive increase in reverse TSA surgery.

Keywords: *Shoulder replacements, Epidemiology, National health insurance, International Classification of Diseases, Korea*

Pain in the shoulder joint frequently occurs in the aged population and significantly affects the function of the arms and quality of life.[1] Implant arthroplasty is an advisable treatment method for severe arthritis in the shoulder joint when improvements in function and pain are not expected with conservative treatment. It is also used in humeral head fractures where an appropriate reduction procedure is challenging. There have been many advances in the shoulder implant designs since being introduced in 1893,[2] and further progress has been made in the last 20 years with the introduction of reverse total shoulder arthroplasty (TSA) designed by Paul Grammont.[3] Advances in the implant design and surgical method have expanded the indications of shoulder implant arthroplasty; this has been coupled with changes in demographic factors such as the increase in the ratio of the aged population. As a result,

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the incidence of arthroplasty is increasing globally.[3-5] Jo et al.[6] have confirmed the drastic increase in the incidence of reverse TSA in South Korea by analyzing the surgical trends of proximal humerus fractures in aged patients. There is, however, no comprehensive study on the surgical trends of shoulder arthroplasty in South Korea. Thus, the purpose of this study was to investigate the surgical trends, such as common causes and the incidence of shoulder arthroplasty (TSA and hemiarthroplasty [HA]) in South Korea in the past 10 years.

METHODS

Data Source

Since reverse total shoulder devices were introduced in South Korea in 2007, we analyzed the database acquired from the Health Insurance Review and Assessment Service (HIRA) from 2008 to 2017. In South Korea, health insur-

Table 1. ICD-10 Diagnosis Codes Used for Analysis of Primary Shoulder Arthroplasty

Disease category	ICD-10 code	Description
Fracture	S42.2	Fracture of upper end of humerus
	M80.92	Unspecified osteoporosis with pathological fracture, upper arm
	M84.41	Pathological fracture NEC, shoulder region
	M80.01	Postmenopausal osteoporosis with pathological fracture, shoulder region
	M80.42	Drug-induced osteoporosis with pathological fracture, upper arm
	M80.51	Idiopathic osteoporosis with pathological fracture, shoulder region
Osteoarthritis	M12	Other specific arthropathies
	M13	Other arthritis
	M19	Other arthrosis
Rheumatoid arthritis	M05	Seropositive rheumatoid arthritis
	M06	Other rheumatoid arthritis
Osteonecrosis	M87	Avascular necrosis of bone
	M90	Osteopathies in diseases classified elsewhere
Malunion	M84	Malunion of fracture
Tumor	C40	Malignant neoplasm of bone and articular cartilage of limbs
	D15	Benign neoplasm of other and unspecified intrathoracic organs
	D48	Neoplasm of uncertain or unknown behavior of other and unspecified sites
Infection	M86	Osteomyelitis
Rotator cuff tear	M75.1	Rotator cuff syndrome
	S434.02	Sprain and strain of rotator cuff capsule
	S4608	Injury of muscle(s) and tendon(s) of the rotator cuff of shoulder
Instability	M2531	Other instability of joint, shoulder region
	S4300	Anterior dislocation of humerus
	S434	Sprain and strain of shoulder joint
	M2441	Recurrent dislocation and subluxation of joint, shoulder region
	M2421	Disorder of ligament, shoulder region

ICD-10: International Classification of Diseases, 10th Revision, NEC: not elsewhere classified.

ance is mandatory for all citizens, of whom 3% are subject to Medicaid. All health care providers can claim benefits for relevant medical practices performed on inpatients or outpatients to National Health Insurance Service by submitting bills containing information, such as a prescription code, diagnosis code based on International Classification of Diseases, Ninth Revision (ICD-9), and demographic information such as sex and age, to HIRA. Therefore, diagnosis, treatment, demographic information of almost all medical practices performed at medical institutions are prospectively recorded in the database of HIRA. Approval of Institutional Review Board of Hanyan Univeristy Hosptial was acquried prior to the inception of this study (No. HYUH 2020-11-012).

Data Collection

We extracted demographic information of all patients who underwent shoulder arthroplasty during the observation period from 2008 to 2017 by using codes of TSA (N2071, N2076), shoulder HA (N2711, N2716), and revision shoulder arthroplasty (revision) (N3711, N3716, N3721, N3726, N4711, N4716, N4721, N4726).

We investigated information including the year in which the surgery was performed, age and sex of the patient, type of medical institution, main cause of the surgery, and comorbidity. In South Korea, medical institutions are classified into a clinic, hospital, general hospital, and tertiary hospital depending on the size of the institution. They are primarily classified by bed capacity: an institution with a number of beds below 30 is classified as a clinic, below 100 is a hospital, and above 100 is classified as a general hospital. General hospitals with more than 20 departments satisfying the specific requisition to professionally carry out a higher level of medical practice for treating severe diseases are designated as tertiary hospitals. We identified International Classification of Diseases, 10th Revision (ICD-10) codes entered as primary and secondary diagnosis names during the hospitalization period and investigated the reason for shoulder arthroplasty. The list of diagnosis codes is shown in Tables 1 and 2. If appropriate codes corresponding to the surgery were not available, we considered that the case had code entry errors and classified them into others.

Statistical Analysis

We used a descriptive statistic method to analyze the pa-

Table 2. ICD-10 Diagnosis Codes Used for Analysis of Revision

Disease category	ICD-10 code	Description
Fracture	S42.2	Fracture of upper end of humerus
	S42.3	Fracture of shaft of humerus, closed
Infection	M00	Pyogenic arthritis
	M01	Direct infections of joint in infectious and parasitic disease classified elsewhere
	M86	Osteomyelitis
	T81.4	Infection following a procedure, NEC
	T84.5	Infection and inflammatory reaction due to internal joint prosthesis
	T84.6	Infection and inflammatory reaction due to internal fixation device
	T84.7	Infection and inflammatory reaction due to other internal orthopedic prosthetic devices, implants, and grafts
	T85.7	Infection and inflammatory reaction due to other internal prosthetic devices, implants, and grafts
Instability	M2531	Other instability of joint, shoulder region
	S43.00	Anterior dislocation of humerus
	S43.09	Dislocation of shoulder, unspecified
	S43.4	Sprain and strain of shoulder joint
	M2441	Recurrent dislocation and subluxation of joint, shoulder region
	M2421	Disorder of ligament, shoulder region

ICD-10: International Classification of Diseases, 10th Revision, NEC: not elsewhere classified.

tient's demographic data. To identify and compare the number of surgeries performed per 100,000 population each year, we used data from the website of Korean Statistical Information Service (http://www.kosis.kr). We analyzed all the datasets using SAS statistical software ver. 9.13 (SAS Institute, Cary, NC, USA).

RESULTS

Table 3 presents demographic data for TSA and HA. From 2008 to 2017, a total of 19,831 patients received primary shoulder arthroplasty, involving 16,162 cases of TSA and 3,669 cases of HA. The average age of patients who underwent primary shoulder arthroplasty was 71.8 years, and 77.7% of them were women. In terms of medical institution types, hospitals mainly performed TSA, and general hospitals mostly performed HA. Osteoarthritis (40.8%) and rotator cuff disease (39.0%) accounted for the leading causes of TSA. HA was mostly performed due to fracture (48.2%) and osteoarthritis (21.1%).

Total count of TSA and HA between 2008 and 2017 is depicted in Tables 4 and 5 and Fig. 1. The number of

Table 3. General Characteristics and Diseases Leading to Shoulder Replacement

Characteristics	TSA	Hemiarthroplasty
Total	16,162	3,669
Age (yr)	72.3 ± 7.5	70.0 ± 11.9
< 65	1,951 (12.1)	942 (25.7)
65–74	7,664 (47.4)	1,235 (33.7)
> 74	6,547 (40.5)	1,492 (40.7)
Sex		
Male	3,574 (22.1)	857 (22.7)
Female	12,588 (77.9)	2,812 (74.6)
Healthcare institution type		
Tertiary hospital	3,816 (23.6)	796 (21.7)
General hospital	5,134 (31.8)	1,630 (44.4)
Hospital	6,765 (41.9)	1,177 (32.1)
Clinic	447 (2.8)	66 (1.8)
Primary indication		
	Osteoarthritis: 6,589 (40.8)	Fracture: 1,770 (48.2)
	Rotator cuff: 6,304 (39.0)	Osteoarthritis: 774 (21.1)
	Fracture: 638 (3.9)	Osteonecrosis: 468 (12.8)
	Osteonecrosis: 426 (2.6)	Rotator cuff: 171 (4.7)
	Rheumatoid arthritis: 215 (1.3)	Malunion/nonunion: 66 (1.8)
	Instability: 172 (1.1)	Rheumatoid arthritis: 46 (1.3)
	Malunion/nonunion: 63 (0.4)	Tumor: 19 (0.5)
	Tumor: 26 (0.2)	Instability: 17 (0.5)
	Osteomyelitis: 16 (0.1)	Osteomyelitis: 12 (0.3)
	Other: 1,713 (10.6)	Other: 326 (8.9)

Values are presented as mean ± standard deviation or number (%).
TSA: total shoulder arthroplasty.

Table 4. Total Shoulder Arthroplasty Trend by Healthcare Institution Type

Healthcare institution type	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Tertiary hospital	154	104	174	251	302	362	446	540	716	767
General hospital	199	158	243	315	380	457	573	744	986	1,079
Hospital	112	141	195	288	464	663	817	1,060	1,367	1,658
Clinic	48	78	33	20	25	18	43	51	52	79
Total	513	481	645	874	1,171	1,500	1,879	2,395	3,121	3,583

Table 5. Hemiarthroplasty Trend by Healthcare Institution Type

Healthcare institution type	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Tertiary hospital	85	99	95	90	98	84	57	76	57	55
General hospital	147	168	126	187	206	172	171	165	153	135
Hospital	75	83	125	116	129	146	141	135	138	89
Clinic	9	6	7	8	8	7	4	9	5	3
Total	316	356	353	401	441	409	373	385	353	282

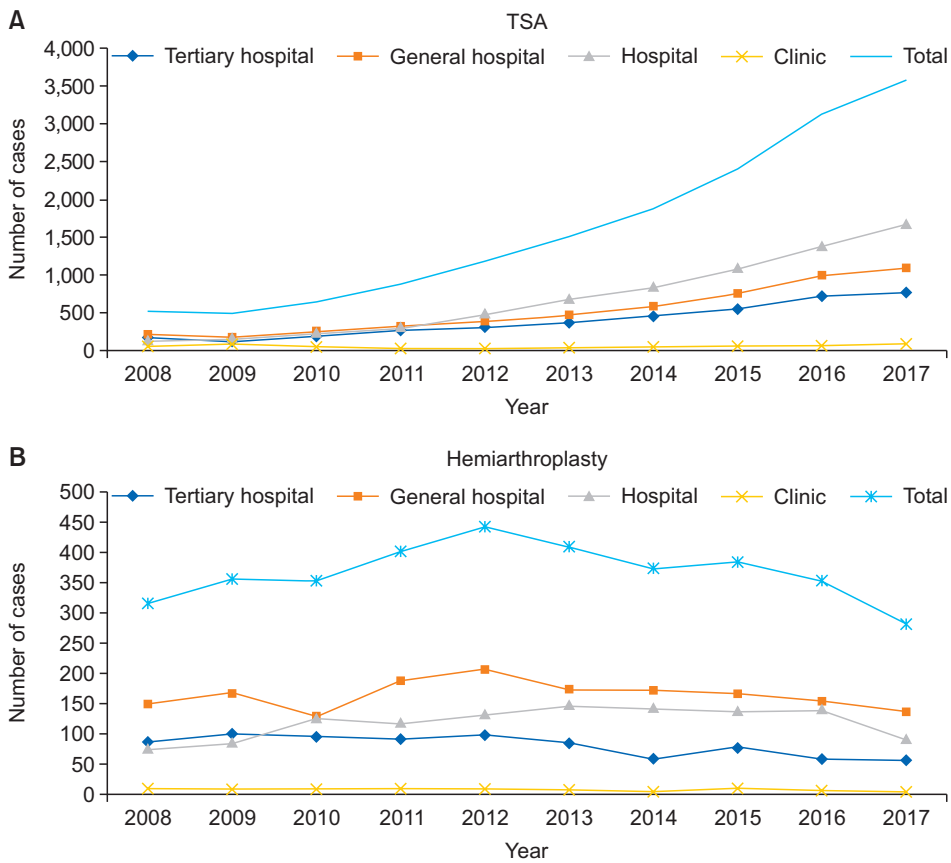

Fig. 1. Trend of total shoulder arthroplasty (TSA; A) and hemiarthroplasty (B).

TSA exponentially increased every year over the study period, and the average annual percentage change (AAPC) was 24.1%. On the contrary, HA did not show significant changes and remained steady (average, 367; standard deviation [SD], 46).

The incidence per 100,000 population was 1.08 cases in 2008 and 6.97 cases in 2017, showing an exponential increase (Fig. 2) with an AAPC of 23.0%. In the case of HA, the incidence was 0.66 cases in 2008, increased to 0.90 in 2012, and gradually declined to 0.55 in 2017. In terms of changes segmented by the types of medical institutions (Tables 6 and 7, Fig. 3), the increasing incidence of TSA remained the same in all of the tertiary hospitals, general hospitals, and hospitals. While TSA was most frequently performed in general hospitals until 2011, the largest number of TSA was performed in hospitals from 2012 onwards. With regard to changes occurring in the ratio in each type of medical institution, the ratio of TSA conducted in hospitals gradually increased, while the ratio of TSA conducted in general hospitals and tertiary hospitals decreased since 2011. On the other hand, HA was more frequently performed in general hospitals than in hospitals.

A total of 430 cases of revision shoulder arthroplasty were performed during this period. Revision burden,[4] calculated as the number of revision shoulder arthroplasty

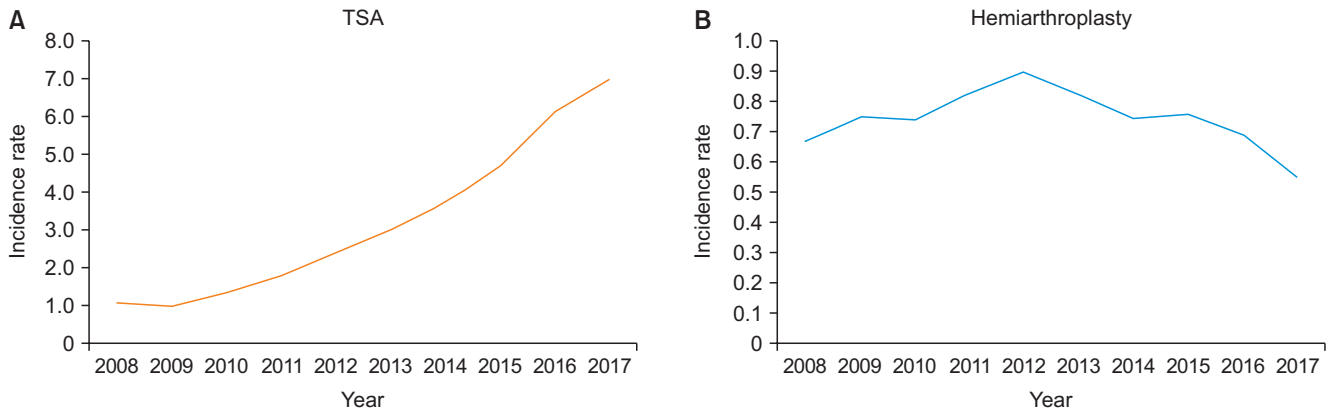

Fig. 2. Incidence rates of total shoulder arthroplasty (TSA; A) and hemiarthroplasty (B).

Table 6. Proportion of Total Shoulder Arthroplasty by Healthcare Institution Type

Healthcare institution type	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Tertiary hospital	30.02	21.62	26.98	28.72	25.79	24.13	23.74	22.55	22.94	21.41
General hospital	38.79	32.85	37.67	36.04	32.45	30.47	30.49	31.06	31.59	30.11
Hospital	21.83	29.31	30.23	32.95	39.62	44.20	43.48	44.26	43.80	46.27
Clinic	9.36	16.22	5.12	2.29	2.13	1.20	2.29	2.13	1.67	2.20
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Table 7. Proportion of Hemiarthroplasty by Healthcare Institution Type

Healthcare institution type	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Tertiary hospital	26.90	27.81	26.91	22.44	22.22	20.54	15.28	19.74	16.15	19.50
General hospital	46.52	47.19	35.69	46.63	46.71	42.05	45.84	42.86	43.34	47.87
Hospital	23.73	23.31	35.41	28.93	29.25	35.70	37.80	35.06	39.09	31.56
Clinic	2.85	1.69	1.98	2.00	1.81	1.71	1.07	2.34	1.42	1.06
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

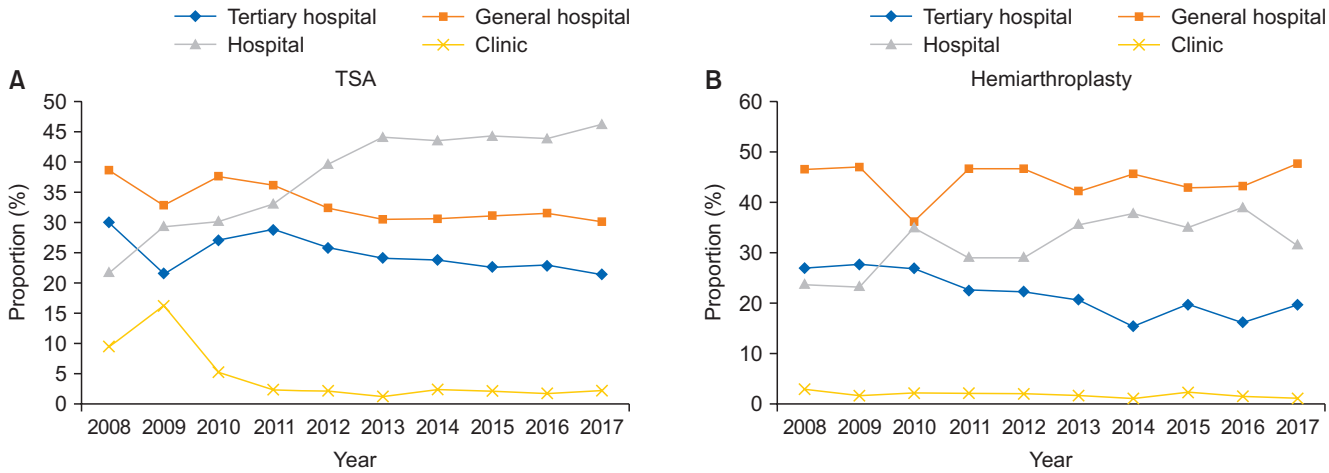

Fig. 3. Proportion of total shoulder arthroplasty (TSA; A) and hemiarthroplasty (B).

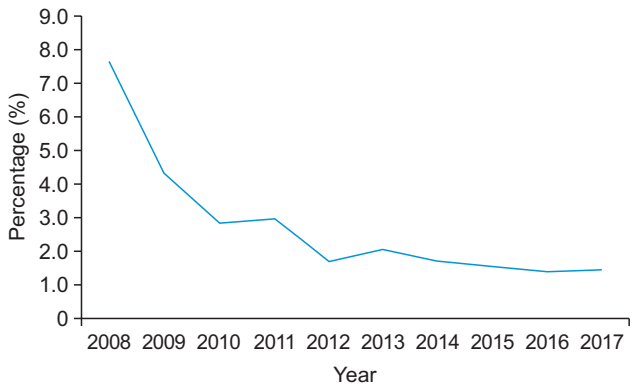

Fig. 4. Annual burden of revision arthroplasty.

divided by the number of TSA (primary and revision), was 2.1%. As shown in Fig. 4, the changes in the revision burden by year gradually dropped from 7.7% in 2008 to 1.4% in 2017. The common reason for revision shoulder arthroplasty was infection (152 patients, 35.3%), followed by mechanical complications, including implant loosening (83 patients, 19.3%), fracture (35 patients, 8.14%), and instability (8 patients, 1.86%) (Table 8). However, the number of patients classified into others due to unavailable diagnosis codes related to revision shoulder arthroplasty was 152 (35.3%), which showed the highest rate similar to revision by an infection. Since we had regarded the cases in this group as those with missing codes or improperly entered codes, we did not analyze cases classified as others.

Table 8. Demographic Characteristics of Revision Cases

Characteristics	Revision
Total	430
Age (yr)	69.2 ± 11.1
< 65	88 (20.5)
65–74	201 (46.7)
> 74	141 (32.8)
Sex	
Male	113 (26.3)
Female	317 (73.7)
Healthcare institution type	
Tertiary hospital	167 (38.8)
General hospital	145 (33.7)
Hospital	109 (25.3)
Clinic	9 (2.1)
Primary indication	
Other	152 (35.3)
Infection	152 (35.3)
Mechanical complication	83 (19.3)
Fracture	35 (8.1)
Instability	8 (1.9)

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

DISCUSSION

The average age of patients who underwent shoulder arthroplasty in South Korea from 2008 to 2017 was 71.8 years, and over twice as many women as men received the surgery. These results are similar to those of other national

epidemiologic studies performed in other countries.[3,4,7] The incidence of primary shoulder arthroplasty increased each year during the study period in South Korea, with an exponential increase year by year. The incidence of shoulder arthroplasty in 2017 was nearly sevenfold higher than that in 2008, and the incidence per 100,000 population was nearly over 6.5 times of that in 2008. Meanwhile, the mean incidence of primary shoulder HA was only 367 cases each year (SD, 46.1), with no major change during the observational period; instead, the incidence per 100,000 population decreased consistently starting 2012.

According to data on the Website of Statistics Korea (http://www.kosis.kr), the aged population in South Korea (above 65 years) increased by 43% from 5 million in 2008 to 7.17 million in 2017. The proportion of the aged population in the entire population increased from 10.5% in 2008 to 14% in 2017. However, the 1.4-fold increase in the aged population over these 9 years does not explain the sevenfold increase in TSA over the same period. Therefore, under the hypothesis that certain factors may have caused changes in and the expansion of the indications for shoulder arthroplasty, we examined the diagnosis codes for TSAs performed during the first 3 years (2008–2010) and the last 3 years (2015–2017) of the observational period. As shown in Fig. 5, while osteoarthritis (519 cases, 31.7%) was the most common diagnosis from 2008 to 2010, rotator cuff tears (3,958 cases, 43.5%) were most common from 2015 to 2017, followed by osteoarthritis (3,734 cases, 41.0%). However, anatomical TSA is rarely performed to treat rotator cuff tears. Reverse TSA, as designed by Grammont,[8] is used as an effective treatment option to lift the arms in cases of irreparable rotator cuff tears or to treat arthritis accompanied by a superiorly displaced humerus due to rotator cuff insufficiency.[9-15] Kim et al.[3] examined the rate of shoulder arthroplasty performed in the United States from 1993 to 2008, and their findings confirmed the rapidly increasing trend of TSA in contrast to the gradually increasing trend of HA. They also concluded that the introduction of reverse TSA, which was approved by the Food and Drug Administration in 2003, explains the rapid rise in TSA. In South Korea, reverse TSA was introduced in 2007, but is included in the TSA code (N2071, N2076) without any distinction from anatomical TSA. Thus, the introduction of the reverse prosthesis and the expansion of indications may have had decisive effects on the rapid rise in the rate of TSA in South Korea.

While general hospitals with over 100 inpatient beds performed most TSAs in 2008 (38.8%), hospitals with a 30- to 100-bed capacity performed the largest number of TSAs from 2012 onwards. In 2017, hospitals performed nearly half of the TSAs. Tertiary hospitals, such as major university hospitals with teaching affiliations, are usually the first to implement new surgical procedures. As the number of surgeons familiar with the surgical procedure increases, smaller medical institutions (general hospitals and hospitals) also start using the new surgical procedures. The fact that the percentage of TSAs performed by smaller medical institutions such as hospitals has increased as the TSA rate has increased suggests that TSA is becoming popular in Korea. Although the rate of TSA performed in clinics was decreasing, the absolute number of TSA in clinics was relatively constant during the whole investigated time. The tendency of decrease of TSA in clinics is due to the increasing number of TSA performed in larger hospitals (hospitals to tertiary hospitals). It can be inferred from this statistics that the most striking change during the survey period was in medical centers larger than hospitals and it was mainly due to institutes with 30 to 100 beds.

HA tended to be constant or decreasing in hospitals of all sizes, and the proportion was high in hospitals or general hospitals and low in tertiary hospitals and clinics. Fracture was the most common cause of HA, followed by osteoarthritis, which showed a marked difference from the indications of TSA, which were mostly osteoarthritis and rotator cuff tears. When considering the age at which the operation was performed, there was a difference in the rate of those under 65 years with TSA (12.07%) and in the rate

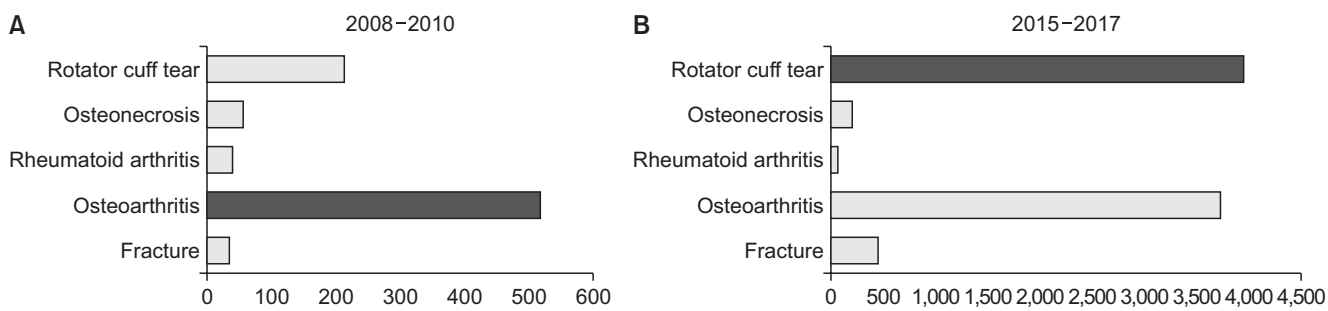

Fig. 5. Leading causes of total shoulder arthroplasty in 2008–2010 (A) and in 2015–2017 (B).

of those under 65 years with HA (25.67%). This is consistent with the trend that HA is mainly used in patients with intact rotator cuff and glenoid.

According to the findings of this study, the revision burden in Korea was 2.1% from 2008 to 2017, which gradually decreased each year and finally reached 1.4% in 2017. As the revision burden calculation does not continuously track whether a particular patient underwent revision, it is appropriate to consider that the revision rate of reverse TSA, which had been introduced in South Korea and used in the middle period, was not reflected in this outcome. In the future, several factors are expected to influence the revision burden: (1) the addition of recent revision cases, (2) slowdown in the rise of reverse TSA procedures, and (3) differences in the revision rate between the reverse design and the anatomical design.[16]

To the best of our knowledge, there have been very few nationwide epidemiologic studies on the shoulder arthroplasty revision burden. From 2005 to 2006, the shoulder arthroplasty revision burden was reported to be 7.3% in Germany.[4] In the United States, the revision burden was found to be 12.4% from 2001 to 2010,[17] and it was 9.4% in France in 2015.[18] Although the reason for the relatively low revision burden of shoulder arthroplasty in South Korea is unclear, this trend is also commonly seen in other major joint surgeries, such as hip and knee arthroplasties.[19-23]

The most common indication for revision was infection and others (152 patients, 35.3%) in our study. However, the most commonly reported indication for revision in shoulder arthroplasty is component loosening,[24-26] and infection has been reported to account for only 3%–5% of failures after shoulder arthroplasty.[27-30] Given that there were 152 patients classified as others resulting from the entry of an incorrect diagnosis code, we concluded that the results are unreliable because there were too many code entry errors in the data related to revision, and we did not perform further analyses. A well-designed large scale cohort study on the cause of revision is needed in the future.

Our study has some limitations. First, it is not possible to compare our findings with the data from other countries because, in our study, we only calculated the crude incidence without standardizing the age. However, this did not affect the aim of the study, which was to identify changes in the trends of shoulder arthroplasty over time. Second, there were more code entry errors than we expected, and there were noticeably more in the data from the first 3 years and in the revision-related data. As code entry errors decrease the overall reliability of the results, accuracy must be improved in the future to increase the value of big data resources. Third, we did not perform further analyses because the anatomical design and reverse design, which should have been classified as different categories, were given the same TSA code. Because the mechanisms, indications, and anticipated complications of the two surgical procedures are entirely different, diagnosis codes should be distinguished as soon as possible, allowing the study of individual surgical procedure. Finally, we analyzed revision arthroplasty as a group without discrimination of prior arthroplasty due to inherent limitation of big data. However, our purpose was to identify the national trend of arthroplasties, so we believe that this paper can contribute to providing a national trend at least. The revision rate according to each operation seems to require further research.

Between 2008 and 2017, the total count, incidence, and distribution of TSAs performed in South Korea increased rapidly, unlike those of shoulder HA. These findings may be explained by the introduction and propagation of reverse TSA, which also contributed to the decrease in the revision burden over the same period.

CONFLICT OF INTEREST

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

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