Fractures of the proximal humerus are relatively common. They represent 5% of all fractures and are the third most common fracture in patients older than 65 years. Of these fractures, the literature reports that historically 80% have been nondisplaced or minimally displaced and treated nonoperatively. It has been estimated that there will be a 3-fold increase in their incidence during the next 30 years as the US population ages. In 2008 alone, there were 184,300 emergency department visits for proximal humerus fractures. Rates of proximal humerus fractures reported for women and men older than 70 years per 100,000 population have been 424 and 150, respectively. Assuming no changes in age-specific or sex-specific incidence, it has been projected that, by 2030, there will be 275,000 emergency department visits for proximal humerus fractures annually. According to the Centers for Medicare & Medicaid Services, in 2012 there were 50,516,440 Medicare beneficiaries, a number that is expected to continue to grow.

Traditionally, open reduction and internal fixation (ORIF) or hemiarthroplasty (HEMI) was the most common surgical treatment and remained constant. Reverse total shoulder arthroplasty (RTSA) increased by 406% and HEMI decreased by 47%. Compared with younger patients, older patients were more likely to undergo HEMI or RTSA than to undergo ORIF for isolated fractures and fracture dislocations. Charges and reimbursements from Medicare increased over time. The charge to reimbursement gap increased from 87% in 2005 to 104% in 2012. Charges were higher for RTSA than for ORIF or HEMI. Nonoperative management was the treatment of choice for 85% of proximal humerus fractures in the elderly; however, there was a trend toward higher rates of surgery. The RTSA rate increased and the HEMI rate decreased, while ORIF remained constant. There was an increasing charge to reimbursement ratio for all procedure types. [Orthopedics. 2017; 40(4):e641-e647.]
(HEMI) have been the mainstays of operative treatment. Südkaerp et al reported a 34% complication rate for ORIF with locking plates, with 40% of these complications being attributed to incorrect surgical technique. Hemiarthroplasty has been an attractive option for elderly patients with complex 3- or 4-part fractures but has had mixed functional results. Antuña et al and Robinson et al have shown that HEMI can provide satisfactory pain relief; however, shoulder motion, function, and power are less predictable. Tuberosity malposition at final evaluation has been shown to be present in up to 50% of hemiarthroplasty cases and has been correlated with unsatisfactory results.

The current type of RTSA was introduced in Europe by Grammont and became commercially available in 1991. The US Food and Drug Administration approved its use in November 2003. The indications for RTSA continue to expand.

In this study, the PearlDiver database (PearlDiver Technologies, West Conshohocken, Pennsylvania), the world’s largest online repository of medical records, was used to analyze recent trends in surgical management of proximal humerus fractures in the elderly. This health care database contains de-identified medical charge, International Classification of Diseases, Ninth Revision (ICD-9) code, and Current Procedural Terminology (CPT) code information for the entire US Medicare population. The authors hypothesized that RTSA has increased in incidence while HEMI has decreased and ORIF has not changed. Reverse total shoulder arthroplasty had previously been recommended for patients older than 70 years; however, the authors hypothesized that the use of RTSA is increasing among patients younger than 70 years. The authors expected higher rates of RTSA in fracture dislocations compared with isolated fractures. In addition, the authors examined the concomitant dislocations on treatment patterns, as this can affect humeral head viability. Rates of each surgery within age subgroups were explored. Cost trend data regarding Medicare charges and reimbursements are presented.

**Materials and Methods**

Medicare claims data from 2005 to 2012 were queried. The number of patients with ICD-9 codes for proximal humerus fractures was recorded for each year. The ICD-9 codes for proximal humerus fractures (ICD-9 codes 812.00 through 812.09) and dislocations (ICD-9 codes 831.00 through 831.03) were used to establish the patient population. From this population, 3 primary study groups were created using surgical procedure-appropriate ICD-9 and CPT codes (ORIF: ICD-9 code 79.31 and CPT code 23615; HEMI: ICD-9 code 81.81 and CPT code 23470; RTSA: ICD-9 codes 81.80 and 81.88 and CPT code 23472). The CPT code 23615 for ORIF includes closed reduction and percutaneous pinning. Surgical procedures performed within 12 months of injury were included. Prior to 2011, there was no specific ICD-9 code for RTSA. Primary total shoulder arthroplasty for proximal humerus fractures is rare, as the glenoid is typically uninvolved. For the purposes of this analysis, the authors assumed that, during the study period, fractures treated with total shoulder arthroplasty were treated with RTSA. The assumption was also made that minimally invasive techniques such as intramedullary fixation, screw osteosynthesis,
and percutaneous pinning were coded using the open reduction code.

For each of the study groups, inpatient facility costs and reimbursement data related to ICD-9 procedure codes were obtained from the database. The inpatient data included costs related to the procedure as well as inpatient admissions but not to care after hospital discharge. Data specific to surgical fees and implant costs were not available.

Statistical analysis was performed using JMP version 10.0 software (SAS Institute Inc, Cary, North Carolina). Chi-square likelihood ratio testing was performed with each procedure (ORIF, HEMI, and RTSA) weighted separately by annual frequency, costs, and reimbursements to determine trends over time. Chi-square analysis was also used to look for differences in age group proportions between procedure types. One-way analysis of variance was performed to assess for differences in charges and reimbursement between procedures. Charges and reimbursement analyses used annual averages for each procedure type because data for individual cases were not available.

RESULTS

There were a total of 750,426 proximal humerus fractures (mean, 93,803 fractures per year) among the Medicare population from 2005 to 2012. There were 2219 fracture dislocations and 91,584 isolated fractures per year on average. The totals for each year can be found in Figure 1.

The rates of operative treatment for each year were calculated (Figure 2). Nonoperative management was the treatment of choice in 85% of the cases with all years combined. Fracture dislocations were more commonly treated with surgery than were isolated fractures (19.2% vs 15.5%, respectively; P < .001). The rate of operative vs nonoperative management increased significantly over time for all fractures, isolated fractures, and fracture dislocations (P < .001).

From 2005 to 2012, the rates of RTSA increased for all fractures (406%, P < .0001), fracture dislocations (309%, P < .0001), and isolated fractures (415%, P < .001) (Figure 3). The rates of HEMI decreased during the same period for all fracture groups by 47% (P < .001). There was no statistically significant change in the rates of ORIF. For all fractures in 2005, the RTSA rate was 3.6% and the HEMI rate was 37.5%. In 2012, the RTSA rate increased to 18.0%, nearly equaling the HEMI rate of 19.8%.

The study population was subdivided into patient age groups for each year from 2005 to 2012 (Figure 4). For isolated fractures, ORIF was the most common procedure among all age groups, but was
relatively less common in patients 85 years and older (61.1%) than in patients younger than 65 years (72.4%). Arthroplasty (Hemi plus RTSA) became more common as patients aged. For all patients older than 70 years with fracture dislocations, arthroplasty (Hemi plus RTSA) was more common than ORIF, with arthroplasty being performed in 55% of the cases.

On comparison of patients 70 years and older with patients younger than 70 years for all fractures, patients 70 years and older were significantly more likely to undergo RTSA than were younger patients ($P<.001$) (Figure 5). Reverse total shoulder arthroplasty procedures consistently charged more on annual averages than ORIF or Hemi procedures during this period (overall averages of $60,503$, $47,800$, and $53,686$, respectively). Average Medicare reimbursements for ORIF, Hemi, and RTSA were $10,368$, $12,133$, and $11,972$, respectively. Medicare reimbursements were significantly lower than charges, and this gap increased by 87% to 104% depending on surgery type from 2005 to 2012.

**Discussion**

Numerous factors dictate the optimal surgical treatment of proximal humerus fractures in the elderly population. Patient characteristics as well as surgeon experience and training are among those factors. This study showed a stable percentage of ORIF, a declining percentage of Hemi, and a rising percentage of RTSA in the Medicare population. As expected, younger patients are more likely to undergo ORIF than arthroplasty because of function, bone quality, and concerns regarding the longevity of the reverse prostheses. Nonoperative treatment continues to be the method of choice in the majority of cases.
Since FDA approval of RTSA, there has been an exponential increase in its use. Among all operatively treated proximal humerus fractures in 2005, RTSA was the procedure of choice in 3.6% of the cases. There was a 5-fold increase to 18.0% in 2012. Although the changes in trends will likely plateau, if RTSA continues to grow at its current exponential rate, it could account for up to 43% of proximal humerus fracture procedures within the next 5 years. The 2012 RTSA rate of 18.0% nearly surpassed the HEMI rate of 19.8%. If data from 2015 had been available, the authors predict that RTSA would have been performed more commonly than HEMI. There was a similar increase in both isolated fractures and fracture dislocations. The rates of ORIF remained relatively constant: 59.0% in 2005 and 62.1% in 2012. Hemiarthroplasty was performed less commonly in 2012 than in 2005: 19.8% and 37.5%, respectively. Patients with fracture dislocations were 67% more likely to undergo RTSA than were those patients with isolated fractures each year, presumably due to theoretical incompetence of the rotator cuff from the dislocation.

The variable results with ORIF and HEMI for proximal humerus fractures, specifically in the elderly, have led to a growing trend of RTSA because of more reliable results. As surgeons become more experienced with RTSA, the authors hypothesize that there will be a continued increase in the use of RTSA for the treatment of proximal humerus fractures. Acevedo et al also reported that fellowship-trained shoulder surgeons were 20 times more likely to use RTSA for a proximal humerus fracture than were non-shoulder surgeons. Although cases during boards collection are often performed under narrow indications, this could suggest that lack of familiarity with the procedure may be a barrier to its use for proximal humerus fractures, particularly in complex fracture situations.

Two other recent studies have also investigated the trends for use of surgery for proximal humerus fractures in the US population. Rosas et al described a total of 32,150 proximal humerus fractures treated operatively from 2009 to 2012. There was an average of 54,649 proximal humerus fractures per year, with HEMI being more common than both RTSA and ORIF. During the study period, the HEMI rate decreased, the RTSA rate increased, and the ORIF rate remained relatively stable. Han et al described operative management of proximal humerus fractures in the Medicare population from 2005 to 2012, reporting a total of 259,506 fractures during the study period. The mean number of fractures per year was 32,438. Open reduction and internal fixation was the most commonly used surgical procedure, comprising 60% of the surgical cases in 2012. Nonoperative treatment was used 67% of the time, contradicting the current study’s finding of nonoperative management in 85% of proximal humerus fractures.

In the current study, ORIF was the most commonly used operative treatment for proximal humerus fractures. This is in contrast to the study by Rosas et al, which found HEMI to be the most commonly used surgical procedure. One possible reason for these contrasting findings may be the prior authors’ exclusion of the ICD-9 procedural codes during query of the Medicare database.

A primary strength of the current study was the inclusion of a much higher number of proximal humerus fractures compared with prior studies, likely the result of using a more accurate data query algorithm. This study had a total of 750,426 fractures, with a mean of 93,803 per year. The study by Rosas et al had a total of 218,595 fractures, with a mean of 54,649 per year. The study by Han et al recorded a total of 259,506 fractures, with a mean of 32,438 per year. The current data are in more agreement with the previous body of literature regarding frequency and rates of nonoperative vs operative treatment. Thus, the authors assume that the current data are likely to more accurately reflect...
current treatment strategies. The current data also highlight the difficulties encountered in database research. A strength of this study was the large numbers related to the nationwide database of Medicare diagnosis and billing codes. The entire Medicare population was included; thus, a large portion of the elderly population in the United States was encompassed in the analysis. The current data on fracture dislocations and year by year comparisons based on age are unique.

To the authors’ knowledge, this study is the first to describe the use of surgery for proximal humerus fractures in patients younger than 70 years compared with patients 70 years and older. Previous literature recommended that RTSA be reserved for patients older than 70 years. Therefore, the current authors further subdivided treatment groups into age younger than 70 years and age 70 years or older.

They hypothesized that use of RTSA would increase in both age subgroups during the study period, and this hypothesis held true. There was a clear preference to perform RTSA in more elderly patients, with the incidence of RTSA in patients younger than 70 years increasing 244% from 2005 to 2012 and the incidence of RTSA in patients 70 years and older increasing 480% during this period.

Multiple studies have shown RTSA to be cost-effective in the long-term compared with HEMI for rotator cuff arthropathy. To the current authors’ knowledge, no other studies have investigated the total charges per inpatient episode and total reimbursements by inpatient episode made by Medicare for operative treatment of proximal humerus fractures. Their results show that RTSA has higher inpatient charges than HEMI or ORIF. This may be related to the cost of the implants, surgical costs, or the likelihood that patients undergoing RTSA are more elderly. A more elderly and comorbid population could require more preoperative testing, a higher level of care, and longer stays. Additional literature regarding referral patterns, costs, and patient outcomes could refine the discussion of whether these procedures should be reserved for higher-volume centers.

Data regarding hospital revenue and reimbursement are obscure, especially with retrospective database studies. However, the authors’ results revealed a large gap between average hospital charges and average Medicare reimbursements for all surgery types ($49,000 to $64,000 in 2012). This gap reflects the loss of potential revenue that hospitals sustain by treating Medicare patients vs privately insured patients. The gap steadily widened from 2005 to 2012, resulting in an 87% to 104% increase. Although both charges and reimbursements increased during this period, reimbursement increases lagged behind hospital charge increases. If these trends were to continue at their current rate, a deficit as high as $100,000 to $130,000 between hospital charges and Medicare reimbursements could be seen by 2020. Such a deficit would create strong economic incentives against operative treatment of proximal humerus fractures in Medicare patients. The Proximal Fracture of the Humerus Evaluation by Randomization (PROFHER) trial randomized surgical vs nonsurgical management. Only patients who underwent HEMI or ORIF were included; patients who underwent RTSA were not. The PROFHER trial did not show a significant difference in patient-reported clinical outcomes 2 years from fracture occurrence in 250 patients treated at 32 United Kingdom hospitals. A follow-up study showed that current surgical trends in the United Kingdom were not cost-effective. With published studies questioning the clinical benefit and cost-effectiveness of surgical management, Medicare reimbursements will likely continue to decline, especially in light of the US federal deficit. Reimbursements should therefore continue to be monitored.

This study had several limitations, many of which are inherent to a retrospective database investigation. Patient characteristics such as height, weight, body mass index, and activity level were not recorded. Radiographs and classification of fracture types were not available. Age range, rather than exact age, was reported. These unavailable factors contribute to surgeons’ preoperative decision making. Because this was an investigation of surgical trends using retrospective data, patient outcomes and complications could not be assessed. The codes in the Medicare claims data were established by professional coders and not by practicing physicians, which may introduce inaccuracies between treatment rendered and codes selected. Open reduction and internal fixation and closed reduction and percutaneous pinning share a CPT code, 23615. The authors assumed that all fractures treated with CPT code 23472 and ICD-9 code 81.80 (total shoulder arthroplasty) during the study represented RTSA. This assumption may be incorrect, which would have led to an overestimation of the number of RTSAs performed, particularly before the dedicated RTSA ICD-9 code was introduced in 2011.

**Conclusion**

The rates of operative management for proximal humerus fractures in the Medicare population increased significantly from 2005 to 2012. The frequency of ORIF performed for proximal humerus fractures in the Medicare population has remained constant. In those patients who are deemed candidates for arthroplasty, the use of RTSA is increasing while the use of HEMI is decreasing.

**References**

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