Trends and Variation in Incidence, Surgical Treatment, and Repeat Surgery of Proximal Humeral Fractures in the Elderly

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Background: The treatment of proximal humeral fractures in the elderly remains controversial. Options include non-operative treatment, open reduction with internal fixation (ORIF), and hemiarthroplasty. Locking plate technology has expanded the indications for ORIF for certain fracture types in osteoporotic bone. This study was performed to characterize the incidence, treatment, and revision surgery of proximal humeral fractures according to geographic region both before (1999 to 2000) and after (2004 to 2005) the introduction of locking plates.

Methods: We used a 20% sample of Medicare Part-B data and the Medicare denominator file for the years 1998 to 2006. Proximal humeral fractures were identified by Common Procedural Terminology codes for treatment, categorized as nonoperative, ORIF, or hemiarthroplasty. Geographic variation in treatment type was determined with use of 306 hospital referral regions. Odds ratios for revision surgery were calculated by the need for repeat surgery within one year of the index procedure. Rates were adjusted for age, sex, race, and comorbidities.

Results: There were 14,774 proximal humeral fractures in the 20% sample from 1999 to 2000 (an estimated total of 73,870 fractures) and 16,138 fractures in the sample from 2004 to 2005 (an estimated total of 80,690 fractures). The overall age, sex, and race-adjusted incidence of proximal humeral fractures was unchanged from 1999 to 2005 (2.47 vs. 2.48 per 1000 Medicare beneficiaries; $p = 0.992$). However, the absolute rate of surgically managed proximal humeral fractures rose 3.2 percentage points from 12.5% to 15.7%, a relative increase of 25.6% ($p < 0.0001$). The relative increase in the percentage of fractures treated with ORIF was 28.5% ($p < 0.0001$), while the percentage of fractures treated with hemiarthroplasty increased 19.6% ($p < 0.0001$). There were large regional variations in the proportion treated surgically (range, 0% to 68.18%). The rates of repeat surgery were significantly higher in 2004 to 2005 compared with 1999 to 2000 (odds ratio = 1.47, $p = 0.043$).

Conclusions: Although the incidence of proximal humeral fractures in the elderly did not change from 1999 to 2005, the rate of surgical treatment increased significantly. The marked regional variation in the rates of surgical treatment highlights the need for better consensus regarding optimal treatment of proximal humeral fractures. Additional research is needed to help to determine which fractures are best treated operatively in order to maximize outcome and minimize the need for revision surgery.

Level of Evidence: Therapeutic Level II. See Instructions to Authors for a complete description of levels of evidence.

Proximal humeral fractures account for 4% to 5% of all fractures, with only hip and distal radial fractures in the elderly being more common. Humeral fractures often require hospitalization and/or rehabilitation care¹⁻⁶. While most proximal humeral fractures are minimally displaced and can be

treated nonoperatively, the treatment of displaced fractures is controversial and includes nonoperative management, percutaneous fracture fixation, open reduction and internal fixation (ORIF), and arthroplasty⁷⁻¹³. The recent development of locking plate technology has expanded the indications of ORIF for certain

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fracture types, especially in those with osteoporotic bone¹⁴. Advances in techniques of percutaneous pinning have been used effectively for proximal humeral fractures with adequate bone stock. Shoulder and elbow fellowships have rapidly expanded recently, as well. To date, there have been no prospective randomized studies that have determined which treatment achieves the best outcome for proximal humeral fractures in the elderly¹⁵.

There is marked variation in the rates of orthopaedic surgical procedures among different geographic regions of the United States^{5,16-18}. The degree of regional variability correlates inversely with the level of scientific evidence and consensus of the medical community regarding the most appropriate care for a given condition^{17,19}. Interventions that have a strong evidence base and enjoy a consensus among the medical community, such as antibiotic administration for serious infection or surgical fixation of hip fractures, exhibit minimal regional variation in treatment²⁰. On the other hand, procedures without high-quality literature supporting a consensus treatment, such as lumbar spine fusion, exhibit wide variation regionally¹⁷. Because there is poor consensus in the literature on the optimal treatment of proximal humeral fractures, we hypothesized that there would be significant regional variation in management. If a wide regional variation in the management of proximal humeral fractures exists, there is a compelling argument that additional research funding is needed to conduct high-quality studies to determine the optimal management of proximal humeral fractures in Medicare patients so that a consensus can be achieved.

The study of current practice patterns is important for the treatment of common orthopaedic conditions because these are important public health issues. As the population is aging, the management of fragility fractures is becoming a greater burden on the health-care system. Clinically, it is important to know what the odds of repeat surgery are after initial surgery so we can counsel patients accurately. If ORIF results in more repeat surgery, the increased cost and morbidity may be considered in determining the best treatment for a patient in the absence of high-quality data to support one technique over another. Furthermore, if the odds of repeat surgery are increasing over time, this should be studied.

The specific aims of this study were (1) to determine the incidence of proximal humeral fractures in the United States Medicare population both nationally and regionally, (2) to determine regional variability in treatment patterns of proximal humeral fractures, and (3) to compare the rates of revision surgery for ORIF and humeral head replacement. Our hypothesis was that the percentage of fractures treated surgically had increased in recent years and that this expansion in indications had led to an increased rate of revision surgery. We chose to look at rates in 1999 to 2000 and compare them with rates in 2004 to 2005 because locking plates were introduced between these time periods.

Materials and Methods

Data Source

Data were obtained with use of a 20% sample of Medicare Part-B data and the Medicare denominator file for the years 1998 through 2006.

Inclusion and Exclusion Criteria

The target population of interest consisted of the patients between the ages of sixty-five and ninety-five who sustained a proximal humeral fracture in the years 1999, 2000, 2004, and 2005. Proximal humeral fractures were identified by Current Procedural Terminology (CPT) codes for treatment, which were categorized as nonoperative, ORIF, or humeral head replacement (Table I). Since this was designed as a cohort study, inclusion criteria required that each identified patient be enrolled in Medicare in the year prior to and following their proximal humeral fracture.

Data from the year preceding each study period (i.e., 1998 and 2003) were required to ensure that the observed proximal humeral fracture was not a recurrent coding of a fracture that occurred during the previous year. Data from the year following each study period (i.e., 2001 and 2006) were required to allow for evaluation of the need for repeat surgery following the index proximal humeral fracture. Exclusion criteria are summarized in Table II and were based on specific International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) or CPT codes that suggested pathologic fracture, prophylactic treatment of an impending pathologic fracture, or chronic sequelae of a proximal humeral fracture such as treatment of malunion or nonunion. Since a primary purpose of this study was to evaluate for differential rates of repeat surgery across time and for different treatment approaches, and because the two time periods were constructed by combining adjacent years (1999 with 2000, and 2004 with 2005), an exclusion criterion included the patients who sustained a proximal humeral fracture in both years (i.e., in 1999 and 2000, or in 2004 and 2005). In this way, all identified complications within one year after the index proximal humeral fracture could be related only to the index fracture.

Information System

General demographic data on patient age, sex, race, and health status (determined with use of the ten variables described within the method of Iezzoni et al.²¹) were captured. Patient age was classified into three categories (sixty-five to seventy-four years, seventy-five to eighty-four years, and eighty-five to ninety-nine years). Sex was classified into female or male, and race was classified into three categories (white, black, and other). These data were used to adjust for age, sex, and race in a manner consistent with the methods used in the *Dartmouth Atlas of Health Care* projects²². Rates of repeat surgery for surgically treated fractures were referenced to time from treatment and categorized as having occurred within thirty days, ninety days, and one year after the index fracture surgery. Rates of repeat surgery were calculated for revision ORIF or humeral head replacement and reoperation for other reasons such as adhesive capsulitis or infection (Table III). Repeat surgery was used as a surrogate for a complication or failure of the index procedure, but it should be noted that repeat surgery and complications may not be equal since many complications do not require repeat surgery. Implant removal alone was not considered repeat surgery or a complication because fractures

TABLE I CPT Codes Used to Define Proximal Humeral Fractures and Treatment Groups*

CPT Code	Description
Nonoperative treatment of proximal humeral fracture	
23600	Closed treatment of proximal humeral (surgical or anatomic neck) fracture without manipulation
23605	Closed treatment of proximal humeral (surgical or anatomic neck) fracture with manipulation
23620	Closed treatment of greater humeral tuberosity fracture without manipulation
23625	Closed treatment of greater humeral tuberosity fracture with manipulation
23665	Closed treatment of shoulder dislocation, with fracture of greater humeral tuberosity, with manipulation
23675	Closed treatment of shoulder dislocation, with surgical or anatomic neck fracture, with manipulation
Operative treatment of proximal humeral fracture (no joint replacement)	
23615	Open treatment of proximal humeral (surgical or anatomic neck) fracture, with or without internal or external fixation, with or without repair of tuberosity(s)
23630	Open treatment of greater humeral tuberosity fracture, with or without internal or external fixation
23670	Open treatment of shoulder dislocation, with fracture of greater humeral tuberosity, with or without internal or external fixation
23680	Open treatment of shoulder dislocation, with surgical or anatomic neck fracture, with or without internal or external fixation
Humeral head replacement for proximal humeral fracture	
23616	Open treatment of proximal humeral (surgical or anatomic neck) fracture, with or without internal or external fixation, with or without repair of tuberosity(s), with proximal humeral prosthetic replacement
*CPT = Current Procedural Terminology.	

treated with percutaneous pinning typically undergo planned pin removal. We used codes for ORIF or humeral head replacement with a code for implant removal at the same setting as an indicator of a complication.

Regional variation in fracture incidence and treatment type was assessed for 306 hospital referral regions as described

by Wennberg and Cooper²². The Centers for Medicare and Medicaid Services guidelines require that rates be censored in any hospital referral region if the raw counts are less than twelve in order to protect individual patient privacy. Single-year hospital referral region rates were calculated, but as a large fraction of the sample would have been censored because of low

TABLE II Exclusion Criteria

Code*	Description
ICD-9-CM code	
140-239.9	All neoplasms
733.1, 733.10, 733.13, 733.95	Pathologic fracture, including unspecified site (733.10)
733.8, 733.81, 733.82	Nonunion or malunion of fracture
CPT code	
20670, 20680	Hardware removal
*ICD-9-CM = International Classification of Diseases, Ninth Revision, Clinical Modification, and CPT = Current Procedural Terminology.	

TABLE III CPT Codes Used to Define Revision Surgery*

CPT Code	Description
20670 or 20680 and 23615, 23630, 23670, 23680, or 23616	Removal of hardware and ORIF or HHR on same date
23030, 23031, 23035, 23040, 29820, 29821, 29822, 29823	Irrigation and debridement of shoulder infection
23020, 23700, 29825	Shoulder capsular release
*CPT = Current Procedural Terminology, ORIF = open reduction and internal fixation, and HHR = humeral head replacement.	

TABLE IV Incidence of Proximal Humeral Fractures and Percentage of Fractures in Each Treatment Group

Treatment Categories	Cohorts (%)		Difference (percentage points)	Relative Change (%)	P Value
	1999-2000 (N = 14,774)	2004-2005 (N = 16,138)			
Nonoperative	87.46	84.28	-3.18	-3.64	<0.0001
Operative	12.54	15.72	3.18	25.36	<0.0001
Open reduction and internal fixation	8.1	10.41	2.31	28.52	<0.0001
Humeral head replacement	4.44	5.31	0.87	19.59	<0.0001

numbers within some individual hospital referral regions, it was decided that the 1999 year be combined with 2000 and the 2004 year be combined with 2005.

Analysis

Descriptive statistics summarizing patient demographics for the two time cohorts were assessed with use of Pearson chi-square tests for the entire sample and for the subset of Medicare beneficiaries who were treated operatively. A p value of ≤ 0.05 was considered significant. The Pearson chi-square statistic is used to test the hypothesis of no association between two samples.

Rates of proximal humeral fractures were calculated by counting the incidence of each event and dividing by the total number of Medicare beneficiaries in the given year. These rates were then adjusted for patient age, sex, and race categories as described above with use of the indirect method described by Wennberg and Cooper²². These adjusted rates were then summarized for each time period and broken down by hospital referral regions. To calculate regional variation in surgical treatment, the proportion of proximal humeral fractures treated operatively was determined by dividing the total number of proximal humeral fractures treated with surgery by the number of proximal humeral fractures occurring in each individual hospital referral region. Rates within any given hospital referral region are based on the patient's home zip code, independent of where they were treated.

Rates of repeat surgery were calculated as a proportion of the fractures treated surgically. Logistic regression was used to compare revisions relative to treatment and time adjusted for the covariates of patient age group, sex, race, and the ten

Iezzoni comorbidity indices²¹. These were reported as odds ratios for the differences in proportions of observed complications and mortality.

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TABLE V Demographic Data on All Patients with Proximal Humeral Fractures

Variable	1999-2000 Cohort (N = 14,774) (%)	2004-2005 Cohort (N = 16,138) (%)	P Value
Age group			<0.293
65-74 yr	29.11	29.86	
75-84 yr	43.46	43.28	
85-99 yr	27.43	26.86	
Sex			<0.013
Male	14.7	15.72	
Female	85.3	84.28	
Race			<0.341
White	94.95	94.83	
Black	2.44	2.68	
Other	2.61	2.50	

TABLE VI Demographic Data on Patients Who Had Surgery for Proximal Humeral Fractures

Variable	1999-2000 Cohort (N = 1852) (%)	2004-2005 Cohort (N = 2537) (%)	P Value
Age group			<0.33
65-74 yr	34.07	35.28	
75-84 yr	45.57	46.12	
85-99 yr	20.36	18.6	
Sex			<0.745
Male	15.33	14.98	
Female	84.67	85.02	
Race			<0.311
White	94.44	95.35	
Black	2.43	2.13	
Other	3.13	2.52	

Results

Incidence

There were 14,774 proximal humeral fractures in the 20% sample of patients enrolled in Medicare Part B from

1999 to 2000 (with an estimated total of 73,870 fractures in the 100% sample). In 2004 to 2005, there were 16,138 proximal humeral fractures (with an estimated total of 80,690 fractures in the 100% sample) (Table IV). The incidence rate did not change, since the overall number of beneficiaries increased as well, with no difference in overall patient age, sex, and race-adjusted incidence of proximal humeral fractures from the 1999 to 2000 period to the 2004 to 2005 period (2.47 vs. 2.48 per 1000 Medicare beneficiaries; $p = 0.992$).

Demographic Data

Table V summarizes and compares demographic differences for these two cohorts. In both time periods, the majority of fractures (85%) occurred in women and whites (95%). The average patient age at time of fracture was seventy-nine years, with the seventy-five to eighty-four-year age group having the highest proportion of proximal humeral fractures. No significant difference was detected between the two time periods with regard to patient age ($p = 0.293$).

Table VI lists the demographic characteristics of patients with surgically treated fractures in 1999 to 2000 and 2004 to 2005. In 1999 to 2000, 12.5% of the proximal humeral fractures were treated surgically compared with 15.7% in 2004 to 2005

TABLE VII Regions with Highest and Lowest Percentages of Proximal Humeral Fractures Treated Surgically

1990-2000 Cohort		2004-2005 Cohort	
Region	Proportion of Fractures Treated Surgically (%)	Region	Proportion of Fractures Treated Surgically (%)
Highest 10 regions			
San Jose, CA	46.67	Duluth, MN	68.18
Alameda County, CA	43.75	Tyler, TX	59.09
Reno, NV	40.91	Santa Rosa, CA	52.94
Rapid City, SD	38.46	Fresno, CA	50.00
Little Rock, AR	36.84	Mesa, AZ	50.00
Medford, OR	33.33	Modesto, CA	47.62
Modesto, CA	33.33	Redding, CA	43.75
Alexandria, LA	33.33	Munster, IN	42.86
Bryan, TX	33.33	Tacoma, WA	42.86
Beaumont, TX	31.82	Reno, NV	42.11
Lowest 10 regions			
Pontiac, MI	0	Altoona, PA	0
Elmira, NY	0	Sioux City, IA	0
Meridian, MS	0	Dearborn, MI	2.86
Petoskey, MI	0	Pontiac, MI	3.23
San Angelo, TX	0	Springfield, MA	3.70
Lawton, OK	0	Hickory, NC	4.55
Victoria, TX	0	Florence, SC	4.55
Lafayette, IN	0	Sayre, PA	4.62
Waco, TX	0	Des Moines, IA	4.88
Waterloo, IA	0	Providence, RI	5.04

($p < 0.0001$), an absolute increase of 3.2 percentage points. This represents a 25.6% relative increase in the surgical treatment of proximal humeral fractures (1852 fractures [12.50%] were treated surgically in 1999 to 2000 compared with 2537 fractures [15.72%] treated surgically in 2004 to 2005). The rate of ORIF increased from 8.10% to 10.41%, a relative increase of 28.5%.

The rate of humeral head replacement increased from 4.44% to 5.31%, a relative increase of 19.6% ($p < 0.0001$) (Table IV).

Regional Variation

The rate of proximal humeral fractures classified by hospital referral region and adjusted for patient age, sex, and race varied

Fig. 1

Rates of proximal humeral fractures per 1000 Medicare enrollees by hospital referral region in 2004-2005.

thirteenfold in 1999 to 2000, from a low of 0.43 fracture per 1000 beneficiaries in Great Falls, Montana, to 5.47 fractures in Covington, Kentucky. In 2004 to 2005, the regional variation for proximal humeral fractures varied ninefold, from a low of 0.57 in Neenah, Wisconsin, to a high of 4.97 in Lake Charles, Louisiana (Fig. 1).

There was also a wide regional variation for surgical treatment of proximal humeral fractures in the assessment of

specific hospital referral regions adjusted for age, sex, and race. In 1999 to 2000, there was a large regional variation in the overall percentage of surgically treated proximal humeral fractures from 0% in multiple regions to 46.67% in San Jose, California. In 2004 to 2005, the surgical rates ranged from 0% in multiple regions to 68.18% in Duluth, Minnesota (Fig. 2). Table VII lists the ten highest and lowest hospital referral regions by the proportion of all proximal humeral fractures

Fig. 2

Rates of proximal humeral fractures treated surgically by hospital referral region in 2004-2005.

TABLE VIII Complication Rates After Open Reduction and Internal Fixation Compared Those After Humeral Head Replacement

	Adjusted Analysis*				
	Odds Ratio	95% Confidence Interval		Chi Square	P Value
		Lower Limit	Upper Limit		
Revision surgery					
Revision rate at 30 days					
ORIF vs. HHR (total)	1.99	0.8	4.94	2.2	0.138
ORIF vs. HHR 1999-2000	1.39	0.37	5.29	0.24	0.627
ORIF vs. HHR 2004-2005	2.84	0.83	9.76	2.76	0.097
Revision rate at 90 days					
ORIF vs. HHR (total)	2.79	1.16	6.72	5.25	0.022
ORIF vs. HHR 1999-2000	2.33	0.66	8.23	1.71	0.191
ORIF vs. HHR 2004-2005	3.36	0.99	11.35	3.79	0.052
Revision rate at 1 year					
ORIF vs. HHR (total)	3.38	1.42	8.03	7.58	0.006
ORIF vs. HHR 1999-2000	2.93	0.85	10.12	2.88	0.09
ORIF vs. HHR 2004-2005	3.9	1.16	13.04	4.87	0.027
Overall reoperations					
Reoperation at 30 days					
ORIF vs. HHR (total)	1.6	0.83	3.07	1.98	0.159
ORIF vs. HHR 1999-2000	1.38	0.49	3.89	0.36	0.548
ORIF vs. HHR 2004-2005	1.86	0.85	4.09	2.38	0.123
Reoperation at 90 days					
ORIF vs. HHR (total)	2.47	1.42	4.31	10.18	0.001
ORIF vs. HHR 1999-2000	2.39	0.97	5.85	3.62	0.057
ORIF vs. HHR 2004-2005	2.56	1.33	4.93	7.89	0.005
Reoperation at 1 year					
ORIF vs. HHR (total)	1.95	1.35	2.82	12.64	0
ORIF vs. HHR 1999-2000	2.17	1.19	3.95	6.34	0.012
ORIF vs. HHR 2004-2005	1.76	1.15	2.69	6.76	0.009
All reoperations 1999-2000 vs. 2004-2005	1.47	1.01	2.12	4.11	0.043

*Adjusted analysis was a logistic regression of outcome on treatment (open reduction and internal fixation [ORIF] or humeral head replacement [HHR]) by time (1999-2000 or 2004-2005 years). Adjusting factors were patient age group (65 to 74 years, 75 to 84 years, and 85 to 99 years), sex (male or female), race (white or nonwhite), and lezzoni risk factors 1 to 10 (malignant cancer or leukemia, chronic pulmonary disease, coronary artery disease, congestive heart failure, peripheral vascular disease, severe chronic liver disease, diabetes [end organ damage], chronic renal failure, dementia, diabetes [without organ failure]), with each coded as 0/1 for not present/present. Chi-square statistics are part of the logistic regression modeling used to generate adjusted odds ratios. The accompanying 95% confidence intervals are useful to determine if the estimated odds ratio is significant at $p < 0.05$.

treated surgically. The Pearson correlation between the age, sex, and race-adjusted ratios of operative and nonoperative treatment at the hospital referral region level was 0.43 ($p = 0.0001$).

Revision Surgery

Overall reoperation rates at one year were significantly higher in 2004 to 2005 compared with 1999 to 2000 (odds ratio = 1.47, $p = 0.043$) (Table VIII). In 2004 to 2005, the patients treated with ORIF were more likely to undergo a revision at ninety days (odds ratio = 3.36, $p = 0.052$) and at one year (odds ratio = 3.90, $p = 0.027$) (Table VIII). Revision rates were reported as

odds ratios of the fractures treated surgically rather than as an absolute number.

Discussion

The adjusted incidence of proximal humeral fractures remained constant through the study period. The overall fracture rate was highest in individuals who were seventy-five to eighty-four years old, female, and white. These findings are similar to those of Barrett et al.²³, who found that white women were at highest risk for sustaining a fragility fracture. There continued to be approximately a tenfold range in regional variation in fracture incidence, with a low of 0.43 fracture per

1000 beneficiaries in Great Falls, Montana, and a high of 5.47 in Covington, Kentucky, in 1999 to 2000 and 0.57 in Neenah, Wisconsin, to 4.97 in Lake Charles, Louisiana, in 2004 to 2005. These data corroborate the findings of Karagas et al.²⁴, who found that proximal humeral fractures are more common in the eastern U.S. than in the western. Regional variations in rates have been found in hip and ankle fractures^{5,24-27}. The etiology of the regional variation of fracture incidence despite age, sex, and race adjustment is unclear. Possible contributors may be geographic environment and/or weather²⁸, nutritional differences²⁹ leading to changes in bone metabolism, or patient factors, such as level of activity and overall health status.

In our study, 87% of the proximal humeral fractures in 1999 to 2000 and 84% of the fractures in 2004 to 2005 were treated nonoperatively. This confirms prior studies showing that the majority of proximal humeral fractures in the elderly continue to be treated nonoperatively^{4,25,30-32}. Although the incidence of proximal humeral fractures has remained stable, there has been a 25% relative increase in the proportion of proximal humeral fractures treated surgically over the study period 1999 to 2005.

The relative proportion of ORIF increased 29%, compared with a relative increase of 20% for humeral head replacement ($p < 0.0001$). Significant regional variation was also seen in the surgical treatment of proximal humeral fractures, with a twenty to thirtyfold range. Although the rates of proximal humeral fractures seem to be more concentrated within the eastern half of the U.S., surgical treatment appears to be more evenly distributed throughout the country. Similar variations have been observed in the treatment of ankle fractures as studied by Koval et al.⁵, who found as much as a fivefold difference in terms of operatively treated ankle fractures, depending on the region of the country in which the patient was treated.

The decision for surgery depends on the variations in clinical decision making on the part of the physician as well as the patient's perceived risks and benefits²⁷. There has not been a consensus on the appropriate treatment for displaced proximal humeral fractures in the elderly^{2,31-36}. The Cochrane review on interventions for proximal humeral fractures in 2003 identified twelve randomized studies on proximal humeral fractures³⁴. These studies were limited by their small size and methodological weaknesses. Eight studies evaluated nonoperative treatment, three compared operative and nonoperative management, and one compared humeral head replacement and tension-band wiring. Their conclusion was that there was insufficient evidence available to determine whether operative intervention produced better long-term outcomes compared with nonoperative management.

Historically, the literature has provided contradictory guidance on the management of proximal humeral fractures. In 1970, Neer first compared operative and nonoperative treatment of proximal humeral fractures³⁷ and found that, for certain types of proximal humeral fractures, surgery was preferable. In 1997, Zyto et al. performed a randomized clinical trial comparing nonoperative management and tension-band

osteosynthesis for displaced three and four-part proximal humeral fractures³⁶. They found that operative management resulted in a higher rate of complications without better functional results. To our knowledge, there are no prospective randomized studies in which current ORIF methods with percutaneous pinning or a locking plate are compared with humeral head replacement or nonoperative treatment. Retrospective studies, however, have shown improved pain relief with variable functional improvement for either treatment^{7-12,14,33,35-38}. Our study found that the surgical management of proximal humeral fractures is increasing over time. In particular, treatment with ORIF appears to be increasing compared with humeral head replacement. This may be due to new technology and techniques, to new understanding of the importance of accurate reduction of the greater tuberosity for shoulder function, or to increasing numbers of fellowship-trained surgeons technically able to perform these new and sometimes complicated procedures. Other possible explanations are changing patterns of fracture complexity and changes in patient expectations.

With the increase in operative treatment for proximal humeral fractures, there has also been an increase in the rate of repeat operations per operatively treated fracture. There was a significantly greater rate of revision surgery in 2004 to 2005 compared with 1999 to 2000. We found that patients undergoing initial ORIF were proportionally more likely to have revision surgery than were patients undergoing initial hemiarthroplasty. Potential explanations include changing operative indications, increasing complexity of the technical aspects of surgery, and decreased willingness of both surgeons and patients to accept inferior outcomes. For example, for complex fractures that would have had humeral head replacement in the past, ORIF is now a viable option because of locking plates and percutaneous pinning.

The goal of this study was not to adjudicate current practice patterns. The data demonstrated significant regional variation in clinical practice patterns in the treatment of proximal humeral fractures. When there is significant variation, it is often indicative of a lack of scientific data and consensus in the medical community regarding optimal treatment. For example, in the *Dartmouth Atlas of Musculoskeletal Health Care*, Weinstein and Birkmeyer showed that the regional variation of hip fracture treatment is minimal, since there is consensus that hip fractures are optimally treated surgically²⁷. This study shows that the treatment of proximal humeral fractures is at the opposite end of the spectrum, with wide variation indicating a lack of such consensus. The most appropriate rate of surgical treatment is not known, and this study does not attempt to define such a precise rate, but the study does highlight the need for improved scientific data regarding the treatment of proximal humeral fractures in order to improve consensus and decrease the regional variation present.

This study is an observational study, attempting to determine what is actually occurring in the U.S. with respect to proximal humeral fractures in the elderly, not necessarily what is the "right" treatment. One of the strengths of the use of the

Medicare database in this study was the large number of patients available for inclusion. However, it represents only a 20% sample of Medicare beneficiaries and may not be representative of the entire Medicare population. Another limitation of the study is the fact that data on the functional outcomes of patients are not available in the Medicare database, so it is not possible to make recommendations regarding the best management of proximal humeral fractures in the elderly. Furthermore, it should be noted that repeat surgery was used as a surrogate for complications or failure of the index surgery. This is certainly not a substitute for clinical or patient-derived assessment of the outcome of the surgical procedure. It is possible that this methodology understates successful outcomes or underestimates complications or poor outcomes that either do not require revision surgery or cannot be improved on by revision surgery. It is important to emphasize that we are unable to make conclusions regarding outcome because our dataset does not include pain, function, or satisfaction scores.

Because there is no specific CPT code for ORIF with a locking plate, it is not possible to directly measure the number of locking plates applied in the two time periods. The observed increase in ORIF coding could be due to the introduction of locking plate technology or advances in percutaneous pinning techniques over this time period, but there is no way to confirm or refute these possibilities with the data sources used here.

Another limitation is that the coding within the Medicare database does not specify whether the right or left arm was involved. This could affect the final end counts of our sample if simultaneous bilateral proximal humeral fractures occurred or if unrelated irrigation and debridement or capsular release was performed on the nonfractured shoulder within one year of

fracture surgery. A further weakness of the study is that use of Medicare data does not allow for fracture classification or degree of displacement. It is possible that some regions had a higher proportion of displaced three and four-part fractures, which led to increased rates of surgical treatment.

In conclusion, the incidence of proximal humeral fractures in the elderly did not change between 1999 and 2005. However, the rate of surgical treatment, both ORIF and humeral head replacement, increased significantly. Marked regional variations in the rates of surgical treatment highlight the need for better consensus regarding optimal treatment of proximal humeral fractures. A higher rate of revision surgery was found in 2004 to 2005, which may indicate that increased surgical aggressiveness brings with it a cost in terms of increased complications or poor outcomes requiring additional surgery. Additional research is needed to help to determine which fractures are best treated operatively in order to maximize outcome and minimize the need for repeat surgery. ■

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