The Epidemiology of Revision Total Hip Arthroplasty in the United States

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Background: Understanding the causes of failure and the types of revision total hip arthroplasty performed is essential for guiding research, implant design, clinical decision-making, and health-care policy. The purpose of the present study was to evaluate the mechanisms of failure and the types of revision total hip arthroplasty procedures performed in the United States with use of newly implemented ICD-9-CM (International Classification of Diseases, Ninth Revision, Clinical Modification) diagnosis and procedure codes related specifically to revision total hip arthroplasty in a large, nationally representative population.

Methods: The Healthcare Cost and Utilization Project Nationwide Inpatient Sample database was used to analyze clinical, demographic, and economic data from 51,345 revision total hip arthroplasty procedures performed between October 1, 2005, and December 31, 2006. The prevalence of revision procedures was calculated for population subgroups in the United States that were stratified according to age, sex, diagnosis, census region, primary payer class, and type of hospital. The cause of failure, the average length of stay, and total charges were also determined for each type of revision arthroplasty procedure.

Results: The most common type of revision total hip arthroplasty procedure performed was all-component revision (41.1%), and the most common causes of revision were instability/dislocation (22.5%), mechanical loosening (19.7%), and infection (14.8%). Revision total hip arthroplasty procedures were most commonly performed in large, urban, nonteaching hospitals for Medicare patients seventy-five to eighty-four years of age. The average length of hospital stay for all types of revision arthroplasties was 6.2 days, and the average total charges were $54,553. However, the average length of stay, average charges, and procedure frequencies varied considerably according to census region, hospital type, and type of revision total hip arthroplasty procedure performed.

Conclusions: Hip instability and mechanical loosening are the most common indications for revision total hip arthroplasty in the United States. As further experience is gained with the new diagnosis and procedure codes specifically related to revision total hip arthroplasty, this information will be valuable in directing future research, implant design, and clinical decision-making.

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

Total hip arthroplasty is one of the most clinically successful and cost-effective interventions in health care, with numerous investigators reporting excellent long-term results in terms of reducing pain and improving function and quality of life in patients with debilitating hip disease[1-3]. However, despite continual changes in surgical technique and implant design, the revision total hip arthroplasty burden (defined as the percentage of revision total hip arthroplasty cases as a function of all total hip arthroplasty cases) in the United States has not decreased over time[4]. Factors related to patient selection, including an increase in

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the number of total hip arthroplasty procedures performed in younger, more active patients, and implant longevity have led to a steady increase in the volume of revision total hip arthroplasty procedures performed in the United States in recent years[5]. Furthermore, recent population-based estimates have suggested that the number of revision total hip arthroplasty procedures is expected to grow substantially over the next several decades[6].

In 2005, on the basis of a request from a group of orthopaedic and health services researchers, the Centers for Medicare and Medicaid Services and the National Center for Health Statistics implemented a series of changes to the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) diagnosis and procedure codes related to failed total joint replacements and revision total joint arthroplasty procedures (Table I)[7,8]. The motivations for the requested coding changes were (1) to facilitate quality improvement through a better understanding of the mechanisms of failure following total joint arthroplasty, (2) to provide more accurate and descriptive data inputs for a United States Joint Replacement Registry, and (3) to provide more precise and relevant economic data to enable payers to predict resource utilization related to specific diagnoses and types of revision total joint arthroplasty procedures. Although these new codes were introduced in October 2005, it is unclear how commonly and appropriately they are being used by surgeons and administrative coding personnel and therefore what value they will provide in terms of elucidating the mechanisms of failure and the types of revision total joint arthroplasty procedures performed in the United States.

The purpose of the present study was to investigate trends in diagnosis, procedure frequency, demographic characteristics, and resource utilization according to the type of revision total hip arthroplasty procedure and to evaluate utilization of the newly adopted ICD-9-CM diagnosis and procedure codes related to revision total hip arthroplasty in administrative claims submissions.

TABLE I ICD-9-CM Diagnosis and Procedure Codes Related to Revision Total Hip Arthroplasty, Introduced on October 1, 2005*

ICD-9-CM diagnosis codes
996.41: Mechanical loosening of prosthetic joint
996.42: Dislocation of prosthetic joint
996.43: Prosthetic joint implant failure/breakage
996.44: Periprosthetic fracture around prosthetic joint
996.45: Periprosthetic osteolysis
996.46: Articular bearing surface wear of a prosthetic joint
996.47: Other mechanical complication of prosthetic joint implant
ICD-9-CM procedure codes
00.70: Revision of both acetabular and femoral components
00.71: Revision of acetabular component (includes femoral head)
00.72: Revision of femoral component (includes acetabular liner)
00.73: Isolated revision of head, liner
84.56: Insertion of cement spacer
84.57: Removal of cement spacer

*ICD-9-CM = International Classification of Diseases, Ninth Revision, Clinical Modification.

Materials and Methods

The Nationwide Inpatient Sample was used to identify revision total hip arthroplasty procedures performed in the United States between October 1, 2005, and December 31, 2006, with use of the ICD-9-CM procedure codes 00.70 (all-component revision), 00.71 (acetabular component revision), 00.72 (femoral component revision), 00.73 (isolated acetabular liner/femoral head revision), 80.05 (arthrotomy/removal of prosthesis), and 81.53 (revision total hip arthroplasty, not otherwise specified). The Nationwide Inpatient Sample is a stratified, statistically valid survey of hospitals conducted by the federal Healthcare Cost and Utilization Project[9]. Hospitals within the sampling frame are stratified according to census regions, ownership (e.g., public, private), location (rural, urban), teaching status, and size (number of beds). Hospitals are randomly selected to achieve an approximately 20% sample of the universe of hospitals in each stratum. Sampling weights are provided to produce the national estimates. All discharge records from each of the selected hospitals are collected and form part of the Nationwide Inpatient Sample file for a given year. In 2006, the Nationwide Inpatient Sample had a sample size of approximately 8 million records from 1045 hospitals in thirty-eight states, representing approximately 20% of all discharges from community hospitals in the United States, regardless of payment source. Because of the large size of the database, the Nationwide Inpatient Sample is particularly well suited for epidemiological studies related to specific procedures or diseases in the national population.

The prevalence of revision total hip arthroplasty procedures was calculated with use of the Nationwide Inpatient Sample for population subgroups in the United States that were stratified according to age, sex, diagnosis, census region, primary payer class, and hospital characteristics (including size, location [e.g., urban or rural], and teaching status). Hospital size (small, medium, or large) is defined by the Healthcare Cost and Utilization Project according to the number of short-term acute-care beds in a hospital, and it varies according to census region, location (urban or rural), and teaching status. The classification of the hospital as "urban" or "rural" is defined by the location of the hospital. A hospital that is located in a metropolitan "core based statistical area" as defined in the 2000 census is considered "urban," and one that is not in a metropolitan "core based statistical area" is considered "rural." The cause of failure, the average length of hospital stay, and total charges also were determined for each type of revision total hip arthroplasty procedure. Because of the relatively short time period of data collection (fifteen months), the total charges were not adjusted for inflation.

Source of Funding

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TABLE II ICD-9-CM Diagnosis Codes Associated with Revision Total Hip Arthroplasty Procedures*†

Diagnosis Codes	Total, All Revisions	Type of Revision					
		00.70: All-Component Revision	00.71: Acetabular Component Revision	00.72: Femoral Component Revision	00.73: Isolated Head/Liner Revision	80.05: Arthrotomy/ Removal of Prosthesis	81.53: Hip Revision, Not Otherwise Specified
None of 996.41 to 996.49	13,240 (25.8%)	4626 (21.9%)	696 (10.6%)	1386 (20.5%)	1213 (18.7%)	3361 (71.8%)	1563 (32.0%)
996.41: Mechanical loosening	10,096 (19.7%)	4821 (22.8%)	1583 (24.2%)	1664 (24.7%)	911 (14.1%)	333 (7.1%)	646 (13.2%)
996.42: Dislocation	11,560 (22.5%)	4199 (19.9%)	2156 (33.0%)	1288 (19.1%)	2128 (32.8%)	546 (11.7%)	1057 (21.7%)
996.43: Implant failure	5102 (9.9%)	2572 (12.2%)	705 (10.8%)	579 (8.6%)	687 (10.6%)	107 (2.3%)	373 (7.6%)
996.44: Periprosthetic fracture	3192 (6.2%)	1066 (5.1%)	118 (1.8%)	1265 (18.7%)	210 (3.2%)	143 (3.0%)	330 (6.8%)
996.45: Periprosthetic osteolysis	3390 (6.6%)	1588 (7.5%)	531 (8.1%)	291 (4.3%)	711 (11.0%)	69 (1.5%)	158 (3.2%)
996.46: Bearing surface wear	2573 (5.0%)	1026 (4.9%)	522 (8.0%)	128 (1.9%)	730 (11.3%)	5 (0.1%)	132 (2.7%)
996.47: Other mechanical problem	3528 (6.9%)	1723 (8.2%)	420 (6.4%)	373 (5.5%)	413 (6.4%)	107 (2.3%)	442 (9.0%)
996.49: Other mechanical complication	3691 (7.2%)	1718 (8.1%)	501 (7.7%)	480 (7.1%)	372 (5.7%)	150 (3.2%)	418 (8.6%)
996.66: Infection/ inflammation	7614 (14.8%)	1794 (8.5%)	306 (4.7%)	552 (8.2%)	693 (10.7%)	3478 (74.3%)	446 (9.1%)

*ICD-9-CM = International Classification of Diseases, Ninth Revision, Clinical Modification. †The values are expressed as the number of procedures, with the percentage of the total number of revisions with the specified procedure code in parentheses.

Results

The total sample in the analysis included 51,345 revision total hip arthroplasty procedures in patients with a mean age of 67.1 years. Men constituted 42.9% of the sample. The total number of hip revisions was captured by the presence of any one of the ICD-9-CM codes described in the Materials and Methods section (81.53, 80.05, 00.70 to 00.73). With regard to coding, 81.4% of all total hip arthroplasty revisions were coded with use of one of the newly implemented ICD-9-CM procedure codes, 74.2% of all total hip arthroplasty revisions were coded with use of one of the newly implemented ICD-9-CM diagnosis codes, and 14.8% of all total hip arthroplasty revisions were coded as infections.

Causes of Revision Total Hip Arthroplasty (Table II)

The most common causes of revision total hip arthroplasty were instability/dislocation (22.5%), mechanical loosening (19.7%), and infection (14.8%). Instability/dislocation was also the most common reason for acetabular revision (33.0%) and isolated head and liner exchange (32.8%). Mechanical loosening was the most common indication for all-component revision (22.8%) and for isolated femoral component revision (24.7%). Infection was by far the most common reason for arthrotomy and removal of the prosthesis (74.3%).

Demographic and Procedure Characteristics

The most common type of revision total hip arthroplasty procedure reported during the time period under study was all-component revision (41.1%), followed by femoral component revision (13.2%), acetabular component revision (12.7%), and isolated femoral head and acetabular liner exchange (12.6%) (Table III). Overall, revision total hip arthroplasty procedures were most commonly reported in the seventy-five to eighty-four-year-old age group (27.0%), whereas acetabular component revisions were reported more commonly in the sixty-five to seventy-four-year-old age group (25.8%) and the seventy-five to eighty-four-year-old age group (25.7%), and procedures involving arthrotomy/removal of the prosthesis were reported most commonly in younger patients (those with an age of less than fifty-five years) (25.7%) (see

TABLE III Demographic Data on Revision Total Hip Arthroplasty Procedures*

Code	Total	Sex	
		Female	Male
00.70: All-component revision	21,047 (41.1%)	11,754 (40.2%)	9294 (42.3%)
00.71: Acetabular component revision	6525 (12.7%)	3976 (13.6%)	2548 (11.6%)
00.72: Femoral component revision	6738 (13.2%)	4087 (14.0%)	2652 (12.1%)
00.73: Isolated head/liner revision	6469 (12.6%)	3601 (12.3%)	2868 (13.0%)
80.05: Arthrotomy/removal	4678 (9.1%)	2415 (8.3%)	2263 (10.3%)
81.53: Hip revision, not otherwise specified	4862 (9.5%)	2948 (10.1%)	1914 (8.7%)
Other combinations	913 (1.8%)	472 (1.6%)	440 (2.0%)
Total	51,231 (100.0%)	29,252 (100.0%)	21,979 (100.0%)

*The values are expressed as the number of procedures, with the percentage of the number of revisions in patients of the specified sex in parentheses.

Appendix). The majority of revision total hip arthroplasty procedures (55.7%) were reported in urban nonteaching hospitals, compared with 36.4% in urban teaching hospitals and only 7.9% in rural hospitals (see Appendix). The greatest percentage of revision total hip arthroplasty procedures (63.9%) were reported in large hospitals, whereas only 12.8% were reported in small hospitals (see Appendix). Medicare was the primary payer for 64.0% of revision total hip arthroplasty procedures, whereas Medicaid patients accounted for only 4.5% of all revisions (Table IV).

Resource Utilization

The average length of stay in the hospital for all types of revision total hip arthroplasty procedures was 6.2 days; the longest length of stay (11.8 days) was associated with arthrotomy/removal of the prosthesis, whereas the shortest length of stay (5.0 days) was associated with isolated head and liner exchange (see Appendix). The highest average billed charges ($69,380) were associated with arthrotomy/removal of the prosthesis, whereas the lowest average billed charges ($42,245) were associated with isolated head and liner exchange. The average billed charges for all types of revision total hip arthroplasty procedures were $54,553.

Geographic Variation

The highest volume of revision total hip arthroplasty procedures was reported in the South (36.7%), and the lowest volume of revision procedures was reported in the Northeast (17.0%) (see Appendix). The length of stay and the total charges also differed according to census region (see Appendix). The shortest average length of stay (5.6 days) was reported in the Midwest, whereas the longest average length of stay (6.8 days) was reported in the Northeast. The average total charges for revision total hip arthroplasty procedures were highest in the West ($67,779), where they were 1.4 times the average total charges for revision total hip arthroplasty procedures in the Midwest ($47,504).

TABLE IV Frequencies of Revision Total Hip Arthroplasty Procedures According to Primary Payer Class*

Code	Primary Payer Class				
	Medicare	Medicaid	Private	Other	Total
00.70: All-component revision	13,237 (62.8%)	940 (4.5%)	5975 (28.3%)	926 (4.4%)	21,079 (100.0%)
00.71: Acetabular component revision	4010 (61.4%)	267 (4.1%)	1963 (30.1%)	292 (4.5%)	6532 (100.0%)
00.72: Femoral component revision	4762 (70.6%)	233 (3.5%)	1522 (22.6%)	227 (3.4%)	6744 (100.0%)
00.73: Isolated head/liner revision	4069 (62.9%)	201 (3.1%)	1982 (30.6%)	221 (3.4%)	6474 (100.0%)
80.05: Arthrotomy/removal	3041 (65.1%)	400 (8.6%)	1066 (22.8%)	165 (3.5%)	4672 (100.0%)
81.53: Hip revision, not otherwise specified	3150 (64.7%)	242 (5.0%)	1299 (26.7%)	181 (3.7%)	4871 (100.0%)
Other combinations	535 (59.2%)	43 (4.8%)	285 (31.6%)	40 (4.5%)	904 (100.0%)
Total	32,804 (64.0%)	2327 (4.5%)	14,092 (27.5%)	2052 (4.0%)	51,275 (100.0%)

*The values are expressed as the number of procedures, with the percentage of the number of procedures with the specified procedure code in parentheses.

Discussion

Despite the excellent long-term results that have been reported in association with primary total hip arthroplasty, failure of the arthroplasty and revision total hip arthroplasty remain substantial clinical challenges for orthopaedic surgeons and their patients. Furthermore, despite the many changes in surgical technique and implant design that have occurred over the past several decades, the incidence of revision total hip arthroplasty procedures in the United States is on the rise[5]. Understanding the causes of total hip arthroplasty failure and the types of revision total hip arthroplasty procedures being performed is essential for improving long-term patient outcomes. Similar to the findings of previous observational cohort studies[1,10] and registry reports[11,12] that have implicated aseptic loosening, bearing surface wear, and osteolysis as the primary causes of total hip arthroplasty failure, our data indicate that mechanical loosening is a common indication for revision total hip arthroplasty in the United States. However, despite numerous case series in the literature documenting lower dislocation rates in association with enhanced soft-tissue repair techniques and the use of large-diameter femoral heads[13-16], hip instability/dislocation was the primary indication reported for a large percentage (22.5%) of revision total hip arthroplasty procedures. These findings suggest that additional research is necessary to understand the current causes of total hip arthroplasty instability and to enhance stability following total hip arthroplasty through design factors (e.g., the use of large-diameter femoral heads) and additional advances in surgical technique and perioperative patient activity protocols.

Previous investigators have attempted to elucidate the mechanisms of total hip arthroplasty failure and the types of revision total hip arthroplasty procedures performed in the United States with use of institution-specific registries[1,10] and single-surgeon case series[17]. Although these reports provide valuable insight into the causes of total hip arthroplasty failure, their generalizability may be limited by their small sample size, narrow geographic inclusion criteria, and exclusion of data from community hospitals, where a majority of total hip arthroplasty procedures are performed in the United States. On the other hand, administrative databases such as the Nationwide Inpatient Sample and the Medicare Provider Analysis and Review databases offer very large, nationally representative samples and therefore can be useful for evaluating the epidemiology of relatively rare events such as revision total hip arthroplasty. However, the value of administrative databases as a tool for clinical research is limited by the specificity and accuracy of the administrative codes that are used to classify the diagnosis and procedure under study.

Prior to October 2005, nearly all patients with a failed total hip arthroplasty were assigned an ICD-9-CM diagnosis code of 996.4 (complication of an internal orthopaedic device), regardless of the mechanism of failure. Also, all revision total hip arthroplasty procedures were grouped under a single ICD-9-CM procedure code (81.53, revision total hip arthroplasty), regardless of the type or complexity of the revision procedure performed. The lack of differentiation between the cause of failure and the type of revision total hip arthroplasty procedure substantially limited the value of administrative databases in studying the epidemiology of revision total hip arthroplasty. However, the introduction of new, more specific and clinically relevant ICD-9-CM diagnosis and procedure codes in October 2005 has made it possible to use administrative databases such as the Nationwide Inpatient Sample to characterize the epidemiology of revision total hip arthroplasty in a large, nationally representative population.

Our analysis suggests that the rate of adoption of the new revision total hip arthroplasty-related ICD-9-CM diagnosis and procedure codes by hospital administrative coding personnel is relatively high but could be improved with additional education and training regarding the appropriate use of these new codes. Specifically, it appears that some of the codes may be ambiguous as currently defined (e.g., ICD-9-CM diagnosis code 999.43, "implant failure"), which may be creating some confusion among both clinicians and coding personnel. Furthermore, it is possible, and even probable, that certain head and liner exchange procedures are being incorrectly coded by hospital coding personnel as all-component revisions, which could be artificially inflating the prevalence of all-component revision procedures. Also, it must be noted that the diagnosis codes are not mutually exclusive, which may lead to some ambiguity regarding the indication for revision surgery. For example, a patient may experience mechanical loosening of the prosthesis due to bearing surface wear and osteolysis. As all three of these causes of failure (mechanical loosening, bearing surface wear, and osteolysis) have unique ICD-9-CM diagnosis codes, any or all of them may be coded in the administrative data. Ideally, the primary cause of failure (mechanical loosening) would be coded as the primary diagnosis, and the secondary causes of failure (wear and osteolysis) would be coded as the secondary diagnoses. The value of these new administrative codes in further elucidating the mechanisms of total hip arthroplasty failure and in monitoring trends in failure rates and specific types of revision procedures is dependent on a clear understanding of the description and the intended meaning of each code, accurate and unambiguous clinical documentation in the medical record, and appropriate use of the new codes when submitting administrative claims related to revision total hip arthroplasty procedures.

The United States is currently the only developed country in the world that does not have a national joint replacement registry[18]. Although the newly implemented ICD-9-CM diagnosis and procedure codes used in the present study represent valuable tools for evaluating the mechanisms of total joint arthroplasty failure and would provide more accurate inputs for a United States Joint Replacement Registry, they should not be considered an acceptable substitute for a true registry as they lack essential information regarding the specific implants used in a procedure and other vital clinical information.

Although the use of administrative databases for clinical research has inherent limitations related to the uncertain accuracy of coding related to both the diagnosis (e.g., cause of failure) and the type of revision procedure performed, they

also provide certain advantages over single-center case series because of the inclusion of a large number of patients with diverse clinical and demographic profiles from a broad range of geographic locales and hospital settings. This increases the external validity and generalizability of the findings. Furthermore, they are currently being used by public reporting agencies to assess provider performance, and therefore it is essential for clinicians to familiarize themselves with the strengths and limitations of these types of administrative data. ICD-9-CM diagnosis and procedure codes submitted with hospital administrative claims are derived by hospital administrative personnel from clinical documentation, including operative notes and discharge summaries. As a result, it is imperative for clinicians to be familiar with the terminology used in the specific diagnosis and procedure codes related to revision total hip arthroplasty in order to improve their clinical documentation and therefore the accuracy of the administrative claims data.

Our findings are also limited by a relatively short time period of data collection (fifteen months), but this limitation is somewhat mitigated by the large number of revision total hip arthroplasty procedures (>50,000) included in our analysis and the high rate of utilization of the new administrative codes during the time period under study. Additional study will be necessary to verify the accuracy of the administrative codes (vis-à-vis their correlation with clinical documentation) and to determine if our findings persist in larger data sets encompassing longer time periods. As additional experience is gained with the new ICD-9-CM diagnosis and procedure codes related to revision total hip arthroplasty, valuable insights will be gained into total hip arthroplasty failure mechanisms, which may help to guide future research, implant design, clinical decision-making, and health-care policy related to total hip arthroplasty.

Appendix

eA Tables showing additional information regarding patient demographics, hospital characteristics, procedure frequencies, and resource utilization by procedure type are available with the electronic versions of this article, on our web site at jbjs.org (go to the article citation and click on "Supplementary Material") and on our quarterly CD/DVD (call our subscription department, at 781-449-9780, to order the CD or DVD). ■

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