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Choice of Hospital for Revision Total Hip Replacement

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Background: Little is known about how often patients have revision total hip replacement in the same hospital in which they had the primary procedure.

Methods: We examined Medicare claims data to identify patients who had primary total hip replacement from July 1995 to June 1996 and subsequently had revision through December 31, 2006. We examined whether the revision was performed in the same or different hospital from the primary procedure, with different hospitals being categorized as being in a lower, a higher, or the same hospital volume stratum. Hospital strata included twenty-five or fewer cases of total hip replacement annually in the Medicare population, twenty-six to fifty cases, fifty-one to 100 cases, and >100 cases. We calculated the number of revisions generated (primary procedures eventuating in revision) by hospitals in each volume stratum and the number of revisions performed in these hospitals.

Results: Of 4448 revision procedures, 3306 (74%) were performed in hospitals in the same volume stratum as the hospital where the primary procedure was performed. Four hundred twenty-nine revisions (9.6%) were performed in a lower-volume hospital, and 713 (16%) were performed in a higher-volume hospital. Thirty-one (3%) of 960 patients who had revision within one year after the primary total hip replacement had the revision in a lower-volume center, compared with 204 (15%) of 1393 who had revision more than six years after the primary procedure (odds ratio = 4.6; 95% confidence interval, 3.0 to 6.8). The ratio of revisions performed to revisions generated was 1.21 for the highest-volume centers and 0.86 for the lowest-volume centers.

Conclusions: Of 4448 revisions examined in this study, 429 (<10%) were performed in centers with a lower volume of total hip replacement than the center at which the initial hip replacement was performed, whereas 713 (16%) were performed in higher-volume centers. Higher-volume centers performed 21% more revisions than they generated (531 revisions performed, compared with 438 generated). These data will help to inform health-care policy with regard to the utilization of resources for revision total hip replacement.

Osteoarthritis affects >27 million adults in the United States (U.S.) and millions more worldwide¹. The hip is a frequent site of involvement. As there is no established disease-modifying osteoarthritis drug, total hip replacement is the definitive treatment for severe hip osteoarthritis. Total hip replacement effectively relieves pain and improves functional status in >90% of patients². However, the implants may fail, leading to pain and associated disability, prompting consideration of revision total hip replacement. The Swedish and Finnish hip registries have reported ten-year prosthetic survival rates of 90% to

95%³⁻⁶. Even with these favorable implant survival rates, revision total hip replacement is performed frequently. In 2007, >33,000 patients in the U.S. had a revision total hip replacement⁷. At a cost of over \$30,000 per case⁸, revision total hip replacement consumes substantial health-care resources.

Hospital volumes of primary and revision total hip replacement are associated inversely with the rates of complications and mortality following these procedures^{2,9-11}. We are aware of no published data on how often patients who undergo revision total hip replacement utilize the same hospital as the one that was used

Disclosure: In support of their research for or preparation of this work, one or more of the authors received, in any one year, outside funding or grants in excess of \$10,000 from the National Institutes of Health (NIH P60 AR 47782, NIH K24 O2123, NIH K24 AR057827). Neither they nor a member of their immediate families received payments or other benefits or a commitment or agreement to provide such benefits from a commercial entity.

TABLE 1 Annual Total Hip Replacement Volume of Hospitals Performing Primary and Subsequent Revision Total Hip Replacement in United States Medicare Population, Stratified by Volume of Primary Total Hip Replacement

	Number (%) of Patients Having Revision in Same Hospital as Primary Procedure*
Total hip replacement volume§ of hospital where primary total hip replacement was performed	
≤25	940 (55%)
26 to 50	809 (67%)
51 to 100	774 (71%)
>100	320 (73%)
Total no. of patients	2843 (64%)
Total no. of hospitals (revision procedures)	

*The second column of the table is a subset of Columns 3 through 6. For example, of 1710 patients having primary total hip replacement in hospitals with a volume of ≤25, 1208 had revision in centers with a volume of ≤25, including 940 who had revision in the same hospital as the one in which they had had the primary procedure. †The percentages in Columns 3 through 6 are based on the total in Column 7. ‡Darker shading indicates that revision total hip replacement was performed in a hospital in lower-volume stratum than the hospital where the primary procedure was performed (429 revisions; 9.6%). No shading indicates that the primary and subsequent revision total hip replacements were performed in hospitals in same volume stratum (3306 revisions; 74%). Lighter shading indicates that revision total hip replacement was performed in a hospital in higher-volume stratum than the hospital where the primary total hip replacement was performed (713; 16%). §Hospital volume of primary elective total hip replacement in U.S. Medicare population.

for the primary total hip replacement or whether those who undergo revision at a different center go to a higher or a lower-volume hospital than the one that was used for the primary total hip replacement. The question is important from a health policy standpoint as payers strive to develop programs that make optimal use of centers with the best outcomes after total hip replacement. The volume data suggest the hypothesis that patients who have revision total hip replacement in a different hospital than the one in which they had the primary procedure are more likely to undergo the revision in a higher-volume center. If this were true, higher-volume hospitals would perform a disproportionate number of revision procedures. To our knowledge, these hypotheses have never been addressed rigorously. These hypotheses provide the focus for the present study.

Materials and Methods

We performed a retrospective cohort study. The sources of data included Medicare Hospital (Part A) claims from 1995 through 2006 as well as Medicare Provider (Part B) claims from 1995 through 1996.

Patients were included in this analysis if they underwent a primary total hip replacement from July 1, 1995, to June 30, 1996, and if they had revision total hip replacement from the time of the primary total hip replacement to December 31, 2006. The procedures used to assemble the cohort of patients who had primary total hip replacement during this one-year period have been described previously^{9,12}. Patients were eligible for inclusion in the parent primary total hip replacement cohort if they had both ICD-9 (International Classification of Diseases, Ninth Revision) and CPT (Current Procedural Terminology) procedure

codes for primary total hip replacement during the specified period. They were excluded if they were less than sixty-five years old; had bilateral total hip replacement, hemiarthroplasty, or conversion of hemiarthroplasty to total hip replacement; or had a diagnosis of hip fracture, cancer, or hip infection. Revision total hip replacement was identified with use of Medicare A (hospital) data with the ICD-9 procedure code 81.53. (Starting October 1, 2005, the ICD-9 procedure codes for revision total hip replacement changed to 00.70 to 00.73.) We censored patients if they had a second primary total hip replacement after the index procedure because it would be unclear in these instances whether a subsequent revision total hip replacement pertained to the index primary procedure or the second primary procedure.

The total hip replacement volume of the hospitals in which the patients had primary and revision total hip replacement procedures was calculated as the volume of all primary total hip replacements performed in the hospital among Medicare beneficiaries from July 1995 to June 1996. Approximately 65% of primary total hip replacements in the U.S. were performed in the Medicare population during the study period¹². We used primary total hip replacement volume as the indicator of hospital volume for revision total hip replacement procedures because primary total hip replacement volume is highly correlated with revision volume and is considerably more stable as primary procedures are five times more frequent⁹.

Patient age, gender, and race were obtained from Medicare claims. (Race was coded as white, black, and other or unknown). Comorbidity was assessed with the Charlson Comorbidity Index, modified for use with claims data^{13,14}. We used claims data to identify subjects who had a change in the first three digits of their

TABLE I (continued)

Number (%)† of Patients Categorized by Total Hip Replacement Volume of Hospital Where Subsequent Revision Total Hip Replacement Was Performed‡				Total No. of Patients	Total No. of Hospitals (Primary Procedures)	Ratio of Revisions Performed to Revisions Generated
≤25	26 to 50	51 to 100	>100			
1208 (71%)	206 (12%)	198 (12%)	98 (6%)	1710	1055	0.86
126 (10%)	911 (75%)	114 (9%)	63 (5%)	1214	436	1.03
103 (9%)	98 (9%)	851 (78%)	34 (3%)	1086	218	1.09
39 (9%)	40 (9%)	23 (5%)	336 (77%)	438	39	1.21
1476 (33%)	1255 (28%)	1186 (27%)	531 (12%)	4448		
888	421	220	39		1748 (primary), 1568 (revision)	

home zip code between the time of the primary total hip replacement and the time of the revision total hip replacement, indicating that they had moved.

Our overall analytic strategy was to compare the association between total hip replacement volume of the hospital where the primary procedure was performed and the volume of the hospital where the revision was performed. Hospital volume was divided into four groups according to the number of primary total hip replacements done in the hospital in the Medicare population in the year from July 1995 to June 1996: twenty-five or fewer, twenty-six to fifty, fifty-one to 100, and >100. For each hospital volume stratum, we calculated the ratio between the number of revisions that hospitals in the stratum performed among patients in our cohort and the number of revisions that hospitals in the volume stratum “generated” in the cohort. We calculated revisions “generated” as the number of primary total hip replacements that hospitals in the stratum performed during the study period that eventuated in total hip replacement revision. We used contingency tables to characterize patients as having had revision surgery at a hospital in a lower-volume stratum than the one where they had the primary total hip replacement as compared with a hospital in the same stratum or in a higher-volume stratum. Factors associated with the performance of total hip replacement in a lower-volume hospital were identified with use of odds ratios and the chi-square statistic. Independent correlates of having total hip replacement in a lower-volume hospital were identified with use of multivariate logistic regression. P values of <0.05 were regarded as significant.

We are aware that the ICD-9 code for revision total hip replacement does not specify laterality. Thus, there is a risk that a revision total hip replacement was actually performed on the contralateral hip and not the index hip. To determine whether this might be a source of bias, we conducted a validation analysis with use of more detailed data that included laterality. A separate component of this project includes a review of medical records on a subset of the subjects described in the present study. The medical records data permitted us to identify and exclude patients who had contralateral revisions. In this restricted cohort of

263 subjects with confirmed revisions of the index hip, we performed similar analyses of the volume distribution of hospitals used for revision total hip replacement among patients who had the primary and revision procedures in different hospitals.

Source of Funding

Funding for the study was provided by the National Institute of Arthritis and Musculoskeletal and Skin Diseases, National Institutes of Health. The funding source had no role in the conduct of the study.

Results

The parent cohort of patients undergoing total hip replacement from July 1, 1995, to June 30, 1996, included 58,521 individuals. After the exclusion of those who had a second primary total hip replacement before a revision, 4460 patients were identified as having had a revision total hip replacement through December 31, 2006. Twelve of these patients were excluded from these analyses because the volume of the hospital where they had the revision could not be determined with our data. Thus, the analytic sample consisted of 4448 patients. Of these, 2680 patients (60%) were female, 1339 (30%) were less than seventy-five years old, 4166 (94%) were white, 235 (5%) had poverty-level income (eligible for Medicaid), and 556 (13%) had a Charlson comorbidity score of ≥2.

Of the 4448 revisions, 3306 (74%) were performed in a hospital in the same volume category as the primary procedure. Of these, 2843 (64% of the total cohort) were performed in the same hospital and 463 (10%) were performed in a different hospital in the same volume stratum. Another 429 (9.6%) were performed in a lower-volume hospital, and 713 (16%) were performed in a higher-volume hospital (Table I).

Ratio of Revisions Performed to Revisions Generated

Hospitals that performed twenty-five or fewer primary total hip replacements in the Medicare population during the study year (N = 21,068) accounted for 1710 failed primary total hip replacements that went on to revision in this dataset. These same

hospitals performed 1476 revisions. Thus, the ratio of revisions performed to revisions “generated” was 1476:1710, or 0.86. Analogously, hospitals that performed twenty-six to fifty total hip replacements in Medicare recipients (N = 16,649) accounted for 1214 failed primary total hip replacements that went on to revision. These hospitals performed 1255 revisions. Thus, the ratio of revisions performed to revisions “generated” was 1255:1214, or 1.03. Similarly, hospitals that performed fifty-one to 100 total hip replacements in Medicare recipients (N = 14,915) accounted for 1086 failed total hip replacements that went on to revision. These hospitals performed 1186 revisions, leading to a ratio of revisions performed to revisions “generated”

of 1186:1086, or 1.09. Finally, hospitals that performed >100 total hip replacements per year in the Medicare population (N = 5889) accounted for 438 of the primary total hip replacements that went on to revision in this cohort. These hospitals performed a total of 531 revision total hip replacement procedures. The ratio of revisions performed to revisions generated by these high-volume hospitals was 531:438, or 1.21 (Table I).

Factors Associated with Use of a Different Center for Revision Total Hip Replacement

Sex, race, Medicare buy-in status (a proxy for low income), and comorbidity were not associated with having revision in a lower-

TABLE II Association Between Patient Characteristics and Use of Hospital in Lower-Volume Stratum versus Same or Higher-Volume Stratum for Revision Total Hip Replacement

	Same or Higher-Volume Hospital (N = 4019) (no. of patients)	Lower-Volume Hospital (N = 429) (no. of patients)	Univariate Odds Ratio (95% Confidence Interval)	Multivariate* Odds Ratio (95% Confidence Interval)	Total (N = 4448) (no. of patients)
Race†					
White	3768 (90%)	398 (10%)	1.0		4166
Black	181 (90%)	21 (10%)	1.1 (0.7 to 1.7)		202
Other	40 (85%)	7 (15%)	1.7 (0.7 to 3.7)		47
Medicare buy-in					
No	3803 (90%)	410 (10%)	1.0		4213
Yes	216 (92%)	19 (8%)	0.8 (0.5 to 1.3)		235
Sex					
Female	2422 (90%)	258 (10%)	1.0		2680
Male	1597 (90%)	171 (10%)	1.0 (0.8 to 1.2)		1768
Charlson comorbidity score					
0 or 1	3515 (90%)	377 (10%)	1.0		3892
≥2	504 (91%)	52 (9%)	1.0 (0.7 to 1.3)		556
Age at revision					
65 to 74 yr	1421 (92%)	118 (8%)	1.0	1.0	1539
75 to 84 yr	2184 (90%)	255 (10%)	1.4 (1.1 to 1.8)	1.0 (0.8 to 1.3)	2439
>85 yr	414 (88%)	56 (12%)	1.6 (1.2 to 2.3)	1.0 (0.7 to 1.5)	470
Duration between primary and revision procedures					
<1 yr	929 (97%)	31 (3%)	1.0	1.0	960
1 to <3 yr	899 (93%)	65 (7%)	2.2 (1.4 to 3.4)	2.2 (1.4 to 3.3)	964
3 to 6 yr	1002 (89%)	129 (11%)	3.9 (2.6 to 5.8)	3.6 (2.4 to 5.5)	1131
>6 to 11 yr	1189 (85%)	204 (15%)	5.1 (3.5 to 7.6)	4.6 (3.0 to 6.8)	1393
Changed zip code between primary and revision procedures‡					
No	3780 (91%)	359 (9%)	1.0	1.0	4139
Yes	239 (77%)	70 (23%)	3.1 (2.3 to 4.1)	2.3 (1.7 to 3.1)	309

*Adjusted for age at revision and variable with univariate associations at $p < 0.05$. †Data on race were missing for thirty-three patients, including thirty patients from the same or higher-volume hospitals and three patients from lower-volume hospitals. ‡Zip code changed at third digit.

volume center (Table II). The only factors associated with the utilization of a lower-volume hospital for revision total hip replacement were a longer duration between the primary and revision procedures, an older age at the time of revision, and a change in zip code at the third digit. When these three factors were entered into a logistic regression model, age at the time of revision was no longer associated with having revision in a low-volume center. The effect of duration since the time of the prior primary procedure persisted (odds ratio for more than six to eleven years as compared with zero to one year = 4.6; 95% confidence interval, 3.0 to 6.8), as did the effect of a change in zip code at the third digit (odds ratio, 2.3; 95% confidence interval, 1.7 to 3.1).

In a sensitivity analysis, we performed similar analyses among 263 patients who, on review of medical records, had a bona fide revision of the index procedure. In the claims cohort, the ratio of patients who had revision total hip replacement in a larger-volume center than the center where they had had the primary procedure to those who had revision in a lower-volume center was 713:429, or 1.66 (Table I). In the medical records review sample, in which all revisions were performed on the index side, the analogous ratio was similar: 26:19, or 1.37 (see Appendix).

Discussion

We examined Medicare claims data on a cohort of 4448 patients who had a primary total hip replacement from July 1995 to June 1996 and went on to have a revision procedure over the subsequent decade. The operations were performed at hospitals of various sizes throughout the U.S. We found that one-third of the patients had revision procedures at a different hospital than the one where they had the primary total hip replacement and that one-third of that subgroup of patients (one-tenth of the entire cohort) had the revision procedures at a lower-volume center than the one where they had the primary procedure. Patients with a longer elapsed time between the primary and revision procedures were more likely to switch to a lower-volume hospital, as were patients who changed address between the time of the primary procedure and the revision.

The number of revisions performed in the cohort and the number of primary total hip replacements that eventuated in revision were not distributed evenly across volume strata. We found that the highest-volume hospitals performed 21% more revision total hip replacements than they generated. Similarly, in the lowest-volume hospitals, the number of revisions performed was 14% lower than the number of revisions generated. This issue is pertinent because of the documented associations between a lower volume of revision total hip replacement and an increased risk of adverse outcomes⁹.

We are not aware of any previous studies that have examined the patterns of hospitalization for both primary and subsequent revision total hip replacements in patients who had both operations. Our data support the view that high-volume centers perform a greater number of revision procedures than they generate with the failure of primary procedures¹⁵. However, the ratios of revisions performed to revisions generated

varied within a narrow range, from 1.21 for the highest-volume centers to 0.86 for the lowest-volume centers. Whether these departures from proportionality merit policy response is an important subject for debate, which can now be informed by these national, population-based data. The policy issues are also framed by the observation that the outcomes of revision total hip replacement are better in hospitals that perform a high volume of these procedures annually⁹.

The primary limitation of the present study arises from the fact that the coding for revision total hip replacement in Medicare claims does not indicate laterality. Patients who had primary total hip replacement in 1995 to 1996 and revision total hip replacement over the subsequent decade may have had the index primary procedure in one hip and the revision in the other. We reduced the level of ambiguity by excluding patients who had a second primary procedure after the index primary total hip replacement. However, we cannot ascertain with claims data which patients had a primary contralateral total hip replacement before the index total hip replacement, and the laterality of the revision in such cases is unknown. We performed a validation analysis among a subset of patients in whom we confirmed the side of revision with medical records data. This analysis, while based on a small sample, also suggested that patients who switched hospitals were more likely to have revision in a higher-volume center than the one in which they had the primary procedure than they were to have the revision in a lower-volume center. We also note that even in instances in which the revision and index primary procedures are done on different sides, the pattern of hospital use for the primary and revision total hip replacements remains policy-relevant. An additional limitation is our inability to determine the exact procedure performed, such as liner exchange, modular component exchange, or revision of one or both components.

Finally, we recognize that the surgeon may play an important role in a patient's choice of hospital and that patients may switch hospitals simply to follow their surgeon. We could not identify the surgeon and therefore could not discern whether the patient simply switched surgeons. We could not examine changes in surgeon volume between the primary and subsequent revision surgery with our data. We suggest that these questions relating to surgeon volume are important areas for future research.

We conclude that patients undergoing revision total hip replacement have the procedure in the same hospital as the one in which they had primary total hip replacement in about two-thirds (64%) of cases. Those who switch hospitals for the revision surgery typically undergo revision at a similar-volume or larger-volume hospital than the one in which they had their primary procedure. A longer duration between the primary procedure and the subsequent revision is associated with having the revision in a lower-volume center. Hospitals that perform >100 total hip replacements per year in the Medicare population appear to perform 21% more revisions than they generate. These observations will be useful as policy-makers debate the manner in which to obtain the optimal outcomes for patients needing both primary and revision total hip arthroplasty.

Appendix

eA A table showing hospital volume for primary and revision surgery among 263 patients with confirmed revisions of index primary total hip replacement is available with the electronic version of this article on our web site at jbjs.org (go to the article citation and click on "Supporting Data"). ■

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