

# Increased Surgical Volume Is Associated with Lower THA Dislocation Rates

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The presumed correlation between an increasing volume of health care procedures and an improvement in outcomes is sometimes referred to as the practice-makes-perfect effect. Growing interest in outcomes-based research has led to numerous papers examining this relationship for various surgical procedures, including total hip arthroplasty. The results of these studies have important implications for consumers, providers, and healthcare financiers. Accordingly, we review the literature to date examining surgeon and hospital volume effects on hip arthroplasty outcomes, with a specific focus on the effects of volume on dislocation. A systemic review of the literature demonstrates a substantial positive association between surgical volumes and improvement in most THA outcomes, including dislocation; that is, increasing surgical volume is associated with lower dislocation rates. This correlation appears to be stronger and is more clearly established for surgeon volumes than it is for hospital volumes.

**Level of Evidence:** Therapeutic study, level III (systematic review). See Guidelines for Authors for a complete description of levels of evidence.

The presumed correlation between an increasing volume of health care procedures and an improvement in outcomes is sometimes referred to as the practice-makes-perfect effect. Since the 1970s, a number of authors have examined how the volume of services delivered by an individual provider or by a hospital relates to the effectiveness of those services.<sup>3,10</sup> Nearly all investigators have found a

positive relationship between the two, but the majority have focused on general surgical conditions, such as coronary arteriography, coronary bypass graft, myocardial infarction, inguinal hernia, carotid endarterectomy, cancer surgery, and cataract surgery.<sup>3,7,18</sup> Few have focused specifically on orthopaedic procedures but, over the past decade, increasing interest in outcome-based research has led to the appearance of a number of such studies in the arthroplasty literature.

Total hip arthroplasty (THA), which is performed more than 200,000 times annually in the United States and nearly always on an elective basis, is ideal for the study of volume-outcome effects.<sup>1,9</sup> Determination of a relationship between surgical volumes and THA outcomes could have important ramifications on physician training and practice patterns, consumer choices, and health care resource distribution. Because of this, our aim was to review the current literature evaluating the effects of surgeon and hospital volume on THA outcomes, specifically dislocation rates. To do so, PubMed and Medline searches were performed for all English-language articles with keyword combinations of surgical volume and total hip arthroplasty, or surgical volume and dislocation. One hundred sixty three papers were returned, for all of which the abstracts were obtained and reviewed. Only 17 of those papers actually addressed the parameters of interest, specifically discussing the relationship between surgeon or hospital surgical volumes and hip replacement outcomes. Detailed analyses of the 17 papers, and of all other potentially useful papers referenced in those 17, yielded only three studies statistically assessing dislocation rates as a function of surgeon volume (Table 1), and only two assessing dislocation rates as a function of hospital volume (Table 2). Although the available studies used different inclusion, stratification, and outcome criteria, making a true meta-analysis impossible, by considering these studies together with other less rigorous papers a number of important trends become evident.

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**TABLE 1. Studies in which Surgeon Volume and Dislocation Rate Are Compared**

Study	Number of THAs Studied	Surgeon Stratification (annual procedures)	Dislocation Rate
Hedlundh et al <sup>6</sup>	4230 primary THAs	0–15	5.0%
		16–30	3.2%
		> 50	2.6%
Katz et al <sup>7</sup>	58,521 primary THAs	1–5	4.2%
		6–10	3.4%
		11–25	2.6%
		26–50	2.4%
		> 50	1.5%
Solomon et al <sup>17</sup>	5211 primary THAs	1–5	6.2%*
		6–10	3.7%*
		11–25	2.0%*
		26–50	1.6%*
		> 50	0.9%*
Katz et al <sup>7</sup>	12,956 revision THAs	1–3	9.1%
		4–10	8.7%
		> 10	6.1%

\*Included patients with dislocation or deep wound infection; THA = total hip arthroplasty

### Effects of Surgeon Volume

One of the earliest studies of the effects of procedural volume on THA outcomes was published in 1987 in the quality control and business administration literature. Fowles et al<sup>5</sup> examined the 2- to 3-year outcomes of more than 1300 primary and revision THAs performed by 399 surgeons in northern California in 1980 in patients covered by Medicare. Complications were classified as major (all repeat operations for component exchange or removal), minor (readmissions for dislocation or minor surgery), and death. Although no statistical analysis was provided, the authors found a correlation between surgeon volume and death and between surgeon volume and major complica-

tion. No correlation, however, was noted between volume and minor complications (including dislocation). The authors found 144 surgeons (36%) did only one hip replacement in a patient covered by Medicare during the year and 96% of surgeons did 10 or fewer. This finding would later be confirmed in a number of other studies.

Nearly 10 years later, Salai et al<sup>14</sup> compared two age-matched groups of approximately 65 patients in whom cemented Charnley arthroplasties had been done at a single institution. The first group of surgeries was done between 1969 and 1973, whereas the second group of surgeries was done from 1984 to 1989. Markedly decreased operative times (110 minutes versus 170 minutes),

**TABLE 2. Studies in which Hospital Volume and Dislocation Rate Are Compared**

Study	Number of THAs Studied	Hospital Stratification (annual procedures)	Dislocation Rate
Katz et al <sup>7</sup>	58,521 primary THAs	1–10	4.4%
		11–25	3.8%
		25–50	2.9%
		51–100	2.5%
		> 100	2.2%
Solomon et al <sup>17</sup>	5211 primary THAs	1–25	3.6%*
		26–100	2.8%*
		> 100	1.4%*
Katz et al <sup>7</sup>	12,956 revision THAs	1–5	9.8%
		6–10	8.6%
		11–25	8.4%
		26–50	7.0%
		> 50	4.2%

\*Included patients with dislocation or deep wound infection

operative blood loss (650 mL versus 1100 mL), need for revision (one patient versus nine patients) and occurrence of dislocation (none versus five) were found in the latter group. These results occurred despite the fact that the latter procedures primarily were done by supervised residents, whereas the former procedures were done by attending surgeons, suggesting increased experience with the prosthesis and procedure had led to improved outcomes.

A number of authors have assessed the effects of volume on general complications and morbidity rates. Kreder et al<sup>9</sup> evaluated the hospital discharge registry for Washington State from 1988 to 1991. Emergent procedures, revisions, fractures, and tumor cases were excluded. For 8,774 THAs, death, infection or revision for any reason occurring within 3 months and 1 year were measured. Patients of low-volume surgeons (defined as the 40<sup>th</sup> percentile and below, equal to two or fewer THAs per year) had higher risk profiles in terms of comorbidities and age, but even after adjustment for those factors, patients fared worse for all outcomes compared with patients of higher volume surgeons. Patients treated by a low-volume surgeon were 10 times more likely to be readmitted for infection and three times more likely to have a revision than those treated by a surgeon who did 10 or more procedures per year. Around the same time as that study, Lavernia and Guzman<sup>10</sup> published a report based on the 1992 Florida hospital discharge database. This study included primary and revision THAs, but also primary and revision total knee arthroplasties. More than 22,000 cases were included, with outcome measurements specified as mortality rates and all coded complications. Surgeon volume was divided into three arbitrary groups (< 10 arthroplasties, 10–99 arthroplasties, or > 100 arthroplasties annually). Sixty-two percent of surgeons did fewer than 10 such procedures per year, only 2% of surgeons fell into the highest strata, and the overall complication rate and mortality rate increased with each decreasing volume level. Likewise, Fender et al<sup>4</sup> did 5-year clinical and radiographic followups of 497 Charnley hip prostheses in a British regional hip register. The main outcome determinant was surgical failure, which included those patients who had revision, those awaiting revision, and those with radiographic failure. The risk of failure for those surgeons whose practices had done fewer than 30 THA procedures annually was four times greater (16% versus 4%) than those whose practices had 60 or more THAs done there per year. Failure etiologies were not specified and no specific information was provided on dislocation rates. The authors also did not examine the number of procedures done by each individual surgeon specifically; it is conceivable a firm's practice volume is not a precise indicator of an individual surgeon's volume.

Contradictory studies, however, were published in 2002. In a study of 1810 consecutive THAs at 27 Minnesota hospitals in 1991 and 1992, operative complications were classified as mild or serious, with subluxation and dislocation considered serious.<sup>19</sup> Although surgeons who did more procedures exhibited a trend toward fewer operative complications, results were not consistent and not statistically significant. The authors did note potential confounders in this instance, such as the homogeneity of surgeons included in the study (many of the academic and community surgeons trained in the same programs) and the lack of any adjustments for the potential increased complexity of cases handled by surgeons with a higher volume of patients having THA.

In the first direct examination of the volume-dislocation relationship, Hedlundh et al<sup>6</sup> collected the operating notes from three Swedish surgery centers over a period of approximately 10 years, covering more than 4230 THAs. In this cohort, he found nearly double the rate of dislocation (5.0%) for surgeons who did fewer than 15 THAs annually compared with the dislocation rate (2.6%) for surgeons who did more than 50 procedures annually. The risk of dislocation decreased by 50% for every 10 THAs done annually, with rates reaching a plateau after 30 or more procedures per annum. These authors also documented a higher dislocation rate for those cases done by surgeons in the first year of practice compared with those done by more experienced surgeons.

The most in-depth and rigorous investigations of the THA volume-outcome relationship have been done by Katz, Losina and colleagues.<sup>7,8,11</sup> They used the entire set (or certain subsets) of THAs done on patients covered by Medicare between July 1995 and June 1996. The most general investigation analyzed early failures of the 57,000 primary THA procedures from this group.<sup>11</sup> A poor outcome was defined as failure requiring revision in the 4-year followup period, but these failures were not separated into groups such as those caused by instability or dislocation. Revision rates were much higher for surgeons who did a low volume of THAs (defined as fewer than 12 procedures per year; more than 50% of surgeons fell into this category) only in the 18-month period immediately after surgery, whereas for the period between 19 and 48 months after surgery, no association was found between surgeon volume and arthroplasty failure.

Most applicable to this discussion, however, are two studies from 2001 and 2002. In the first, Katz et al<sup>7</sup> studied more than 70,000 primary and revision procedures done during that 1995-1996 period. Their analyses were adjusted for the type of arthritis, age, gender, and other patient comorbidities. More than 1/2 of the primary procedures and more than 3/4 of the revisions were performed by surgeons who did 10 or fewer procedures per year.

Overall dislocation rates within the first 90 days after surgery were 3.1% for primary THAs, but were 4.2% for surgeons who did 10 or fewer THAs annually and 1.5% or lower for surgeons who did 50 or more THAs per year. For revision procedures, the overall dislocation rate was 8.31%, but was 9.1% for surgeons who did three or fewer annual revisions and 6.1% for those who did 10 or more. Importantly, the effects of surgeon volume were independent of hospital volume; similar effects were found for surgeon volume even when stratified within low-volume, medium-volume, and high-volume facilities. No plateau effect was noted as dislocation rates improved even among the highest divisions of surgeon volume. In addition, similar but less dramatic effects were noted for the other outcomes measured, including mortality, pulmonary embolism, and deep infections. Similarly, Solomon et al<sup>17</sup> assessed only the 5211 patients covered by Medicare who had THAs in Colorado, Pennsylvania, and Ohio during 1995 and 1996.<sup>17</sup> Volume was stratified into surgeons who did fewer than 5, 6 to 10, 11 to 25, 26 to 50, and more than 50 THAs per year. The primary outcome of the study was the occurrence of a perioperative adverse event, defined in this study as a deep wound infection or dislocation within 90 days of surgery. Unfortunately, the two types of events were not analyzed individually, but decreases in the number of adverse events occurred with each increasing level of surgical volume studied. The risk of dislocation or infection for the lowest-volume group was more than six times that of the greatest-volume group.

### Effects of Hospital Volume

Less data exists regarding the effects of hospital THA volume on general complications or dislocation specifically. A number of the previously mentioned studies also included information on hospital caseloads, including the studies by Kreder et al<sup>9</sup> and Lavernia and Guzman.<sup>10</sup> Kreder et al<sup>9</sup> found no consistent effects of hospital volumes on mortality, infection, or revision. In his 6-month follow-up of Minnesota THAs, Thompson et al<sup>19</sup> also found no general correlation between hospital volume and the complication rate. Meanwhile, Lavernia and Guzman<sup>10</sup> classified hospital volumes in the same manner they did for surgeon volumes (fewer than 10, 10-99, or greater than 100 cases per year) and determined hospitals in the lowest volume stratification had higher complication rates than both of the groups. Exact complication rates were not provided.

Two additional studies were published in the late 1990s. Espehaug et al<sup>2</sup> presented a study based on 39,505 THAs reported to the Norwegian Arthroplasty Register from 1988 to 1996.<sup>2</sup> Outcomes, indicated by revision for any cause, were compared based on results from local, central, and university hospitals. Although no differences in the

revision rate as a result of hospital volume was noted for cemented prostheses, the revision rate for uncemented components was 12% in hospitals that performed fewer than 10 procedures per year versus 5% in those hospitals in which more than 84 THAs were done annually. Unfortunately, a breakdown of the revision etiologies such as infection or dislocation was not provided. In addition, the authors acknowledged the university hospitals, where overall volume was lower, seemed to treat patients with complex clinical scenarios. Authors of another investigation, based on diagnosis-related codes and International Classification of Diseases (ICD-9) procedure codes for all Medicare data for 1993 and 1994, examined in-house and 30-day mortality as a result of hospital volume.<sup>18</sup> Low-volume hospitals (fewer than 25 THAs annually) had a nearly four times greater in-house mortality (1.99%) and three times greater 30-day mortality rate (3.51%) compared with high-volume facilities in which more than 199 procedures were done per year (0.56% and 1.05%, respectively).

In 2004, Sharkey et al<sup>15</sup> reported on the early (within 6 months after surgery) complication and mortality rates for a single institution in which more than 1000 THAs are done annually.<sup>15</sup> For a 12-month period during 1998 and 1999, 1000 procedures were done with a dislocation rate of 0.1% in primary THAs (1 of 786) and 1.4% for revision THAs (3 of 214). This is in comparison to the overall dislocation rate of 3.1% for Medicare primary THAs from 1995 to 1996.<sup>12</sup> Although no control group was provided, the authors indicate these rates and the overall complication rates are lower than general published rates for hospitals in which few arthroplasties are done and are similar to other high-volume centers.

One recent study, based on 31,745 THAs in the Norwegian Hip Registry from 1987 to 2001, related operative times to hip survival.<sup>16</sup> The mean operative time for all cases was 96 minutes. Compared with cases lasting 71 to 90 minutes, however, cases lasting longer than 150 minutes had increased revision rates because of dislocation (1.7 times more likely for cemented implants and 2.8 times more likely for uncemented implants). Although an immediate correlation of surgeon or hospital volume was not provided, operative times were related directly to hospital volume. Average operative times were 25 to 35 minutes shorter for hospitals in which more than 200 THAs were done annually versus those hospitals in which 10 or fewer THAs were done, indirectly implying that for hospitals in which more THAs were done, operative times were shorter and revision rates were correspondingly lower.

Katz and colleagues have also examined the volume-outcome relationship for hospitals. In a study by Solomon et al,<sup>17</sup> 69% fewer adverse events occurred in hospitals in which more than 100 procedures were done per year com-

pared with those hospitals in which fewer than 25 THAs were done per year.<sup>17</sup> In addition, many hospital characteristics highly correlated with increased volume, including urban setting, medical school affiliation, presence of an orthopaedic residency program, and dedicated orthopaedic nursing unit. When surgeon volume was added to the analysis, however, it remained the strongest predictor of adverse events and accounted for nearly all correlation between hospital volume and outcomes. Conversely, in the report on 70,000 THAs done in patients covered by Medicare, the dislocation rate was approximately 50% less for hospitals in which 50 or more procedures were done per year versus those hospitals in which fewer than 10 THAs were done.<sup>7</sup> This was true for primary and revision procedures. In this case, hospital volume was significant even after controlling for surgeon volume.

## DISCUSSION

In this paper, we sought to summarize and review the effects of surgeon and hospital volume on general outcomes and, more specifically, dislocation rates after THA. Considered as a whole, the current literature unmistakably indicates a strong positive association between surgical volumes and improvement in most THA outcomes, including dislocation. This correlation is more clearly established for surgeon volumes than it is for hospital volumes.

A number of limitations to these studies must be considered, however. First, the direction of causality is not clear. It is not certain that increasing volume for an individual surgeon or hospital will necessarily improve that entity's outcomes. Rather than a practice-makes-perfect effect, it is conceivable that for physicians and hospitals with better outcomes, volume is higher because patients seek out care at these more reputable facilities. This is the so-called selective referral hypothesis.<sup>3</sup> It also is likely, to a degree, that increasing experience improves a surgeon's ability to select patients who likely will have a good outcome.<sup>13</sup> In addition, the patient characteristics of high-volume and low-volume providers often are dissimilar.<sup>9</sup> Evidence exists that lower-volume surgeons operate on patients with greater risks of complications, making inferences about surgical volume difficult to formulate.<sup>9,13</sup> Many authors have not considered or controlled for this. Most authors also have focused only on patients who are covered by Medicare. Medicare data omit important information, including surgical details, preoperative comorbidities, and functional status, hindering the ability to assess the complexity of a given surgery fully.<sup>1,7</sup> It is also possible some surgeons with small Medicare caseloads care for considerable numbers of patients with other insurers; Medicare case counts will not necessarily reflect the overall volume for these providers.

To date, no one has clearly correlated hospital or surgeon volumes with more subjective outcomes. In another study, Katz et al<sup>8</sup> examined patient satisfaction and function in the same Medicare population from 1995 to 1996. Although patient satisfaction was somewhat higher at 3 years for those patients who had surgery at high-volume centers and by high-volume surgeons, objective functional outcome as indicated by Harris hip scores was not affected. It is not clear why patient satisfaction would differ when functional outcomes were similar, although it is conceivable high-volume centers have more refined protocols that minimize patient inconvenience.

It is important for researchers to conduct further studies on dislocation and other complications and the mechanisms by which increased surgical volume may be influencing these outcomes. Intraoperative technical issues, improvements in the health care team, variations in postoperative treatment, and many other controllable factors might contribute to such findings. Nearly 2/3 of all THAs are done by surgeons who do 10 procedures per year or fewer.<sup>7,9,10</sup> Might there be discreet volume thresholds above which further improvements in outcome are no longer realized? Some authors have suggested a plateau exists after 15 to 30 procedures per year,<sup>6,7</sup> but other studies show no such threshold.<sup>9,17</sup> Regardless, the literature to date strongly indicates higher-volume surgeons and hospitals have better outcomes and, more specifically, lower dislocation rates, after THA. Because of this, the public availability of surgical volume information, potential legal risks to low-volume providers, and possible benefits of health care regionalization are important issues to consider. The results of continued studies will have important practical implications for consumers, providers, and healthcare financiers.

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