Improved Short-Term Outcomes following Orthognathic Surgery Are Associated with High-Volume Centers

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Background: Previous studies assessing outcomes following orthognathic surgery rely primarily on single-center/surgeon experience. In addition to issues of generalizability, these studies are limited in evaluating the effect of operative volume on patient outcomes.

Methods: Orthognathic procedures were identified in the 1999 to 2011 Healthcare Cost and Utilization Project Nationwide Inpatient Sample. Outcomes included occurrence of any in-hospital complication, extended length of stay (>2 days), and increased costs (>$10,784). High-volume hospitals were defined as the 90th percentile of case volume or higher (>31 cases/year). Univariate and multivariate analyses were conducted to identify independent predictors of outcomes. Trend analyses were performed to assess changes in the annual rate of patients treated at high-volume hospitals over the study period.

Results: Among 101,692 orthognathic surgery patients, 19.6 percent underwent concurrent ancillary procedures (i.e., genioplasty, rhinoplasty, or septoplasty), and 37.6 percent underwent double-jaw surgery. Fifty-three percent were treated at high-volume hospitals. High-volume hospitals more often performed ancillary procedures (21.4 percent versus 17.4 percent; $p < 0.001$) and double-jaw surgery (41.3 percent versus 33.4 percent; $p < 0.001$). After adjustments for clinical and hospital characteristics, patients treated at high-volume hospitals were less likely to experience any complication (OR, 0.75; 95 percent CI, 0.70 to 0.81; $p < 0.001$) and extended length of stay (OR, 0.71; 95 percent CI, 0.68 to 0.75; $p < 0.001$). There was a 2 percent annual increase in the rate of patients treated at high-volume hospitals over the study period (incidence rate ratio, 1.02; 95 percent CI, 1.01 to 1.03; $p < 0.001$).

Conclusions: The majority of orthognathic cases nationwide are performed at a small number of high-volume hospitals. These hospitals discharge patients earlier, perform more complex procedures, and have fewer complications. (*Plast. Reconstr. Surg.* 138: 273e, 2016.)

CLINICAL QUESTION/LEVEL OF EVIDENCE: Risk, III.

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RISK

Since the earliest account of mandibular osteotomies performed by Simon P. Hullihen to treat a severely burned child with contractures, severe prognathism, and lower lip ectropion in 1848, orthognathic surgery has become routinely performed in craniofacial, oral, and maxillofacial surgery.[1–3] For patients with severe dentofacial abnormalities, mandibular and/or maxillary osteotomies allow for bony movements that restore facial proportions, correct occlusal relations, normalize dynamics of respiration, and improve their quality of life.[4–9] Orthognathic surgery is technically demanding. Successful execution relies on an intricate understanding of facial and occlusal anatomy,

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and necessitates a coordinated, multidisciplinary approach to postoperative care.

There is a growing interest in identifying provider and hospital characteristics associated with improved patient outcomes for surgical procedures. Many investigators have considered the role of procedure volume in optimizing patient outcomes and costs of care, offering a potential opportunity for quality improvement.[10,11] Increased operative volume has been associated with benefits in both short-term morbidity and mortality for patients undergoing various surgical procedures.[10,12–17] In the field of orthognathic surgery, however, there has been a paucity of studies assessing the association between procedure volume and patient outcomes. Furthermore, relatively little is known regarding the epidemiology and national trends of orthognathic surgery in the United States.

The importance of investigating population-level data as they relate to orthognathic surgery lies in the opportunity to provide patients and surgeons with generalizable information to guide preoperative risk discussions, to gain a better understanding of those factors that affect outcomes, and to provide insights that will facilitate quality improvement. The objectives of this study were to evaluate the associations between hospital orthognathic procedure volume and patient outcomes, including both clinical and economic outcomes, among patients in the United States from 1999 to 2011. We also aimed to identify nationwide trends in the regionalization of orthognathic surgery to high-volume hospitals.

PATIENTS AND METHODS

Data Source and Analytic Cohort

This study was conducted under Yale Human Investigation Committee/Institutional Review Board exemption number 1509016546. A cross-sectional analysis of the Nationwide Inpatient Sample database for the years 1999 to 2011 was conducted to compare short-term outcomes following orthognathic surgery between high-volume and low-volume hospitals for orthognathic surgery. This database was also used to evaluate nationwide trends in the proportion of patients treated at high-volume hospitals over the study period. Sponsored by the Agency for Healthcare Research and Quality, the Nationwide Inpatient Sample is composed of hospital inpatient data and developed in conjunction with the Healthcare Cost and Utilization Project.[18] The Nationwide Inpatient Sample represents the largest collection of all-payer inpatient care data in the United States, including over 1000 hospitals in 45 states and over 8 million inpatient hospital stays annually. Clinical outcomes and patient comorbidities are defined using *International Classification of Diseases, Ninth Revision* diagnosis and *International Classification of Diseases, Ninth Revision, Clinical Modification* procedure codes, which are overseen by the National Center for Health Statistics and the Centers for Medicare & Medicaid Services.

For the purpose of this study, discharge weights included in the Nationwide Inpatient Sample database were used to scale the study sample to national estimates. After considering hospital characteristics, discharge weights are calculated by dividing the number of universal discharges, as estimated by the American Hospital Association data, in a particular stratum of hospitals by the number of Nationwide Inpatient Sample discharges in the stratum. Cost data were obtained through the Nationwide Inpatient Sample supplemental cost-to-charge ratio files for the years 2001 to 2011. Inpatient costs were estimated by the total charges for each inpatient stay multiplied by the hospital-specific all-payer inpatient cost-to-charge ratio.[19] Costs were corrected for inflation and adjusted to 2011 dollars using rates from the Bureau of Labor Statistics.[20]

The analytic cohort was initially defined as any patient who underwent an orthognathic procedure (*International Classification of Diseases, Ninth Revision, Clinical Modification* codes 76.62 to 76.66) during the study period. Patients were further categorized into three mutually exclusive diagnostic categories according to *International Classification of Diseases, Ninth Revision* diagnosis codes associated with their inpatient admission. The three diagnostic categories were occlusion (524.01 to 524.04, 524.11, 524.12, 524.19, 524.21 to 524.24, 524.26 to 524.30, 524.39, and 520.6), apnea (327.20, 327.23, 780.57, and v44.0), and congenital (749.0, 749.00 to 749.04, 749.1, 749.11 to 749.14, 749.2, 749.21 to 749.25, 253.0, 754.0, 755.55, 755.59, 756.0, 756.83, 759.82, and 759.89). Patients who underwent an orthognathic surgical procedure without an associated diagnosis code were excluded from this study.

Study Outcomes

The primary outcomes of this study were any complication, extended length of stay, and increased costs. Any complication was defined as the occurrence of a procedure-related complication (i.e., wound dehiscence, wound infection, hemorrhage/hematoma, transfusion, and other procedural complications) or a systemic complication (i.e., venous thromboembolic disease, hypotensive complications, cardiovascular, respiratory, urinary, and stroke). Given its nonnormal distribution, length of stay was defined as a binary outcome, less than or equal to 2 days or greater than 2 days, based on the median length of stay of all included patients. Similarly, given its nonnormal distribution, inpatient cost was defined as a binary outcome, less than or equal to \$10,784 or greater than \$10,784, based on the median inpatient costs of all included patients.

Study Variables

Patient age was presented as both continuous and binary variables, with pediatric patients defined as younger than 18 years and adults as 18 years or older. Additional sociodemographic variables provided by the Nationwide Inpatient Sample database included patient gender, race (white, black, Hispanic, and other, which included but was not limited to, Asians, Pacific Islanders, and Native Americans), payer (private insurance, Medicare, Medicaid, self-pay, and other, which included by was not limited to worker's compensation, Title V, and other governmental programs), and socioeconomic quartiles based on median household income percentages by zip code (0 to 25th, 26th to 50th, 51st to 75th, and 76th to 100th percentiles).

Comorbidity was determined using the Deyo modification of the Charlson Comorbidity Index.[21,22] The principal procedure was defined as a single-jaw or double-jaw procedure based on isolated or concurrent *International Classification of Diseases, Ninth Revision, Clinical Modification* procedure codes specifying maxillary and mandibular orthognathic procedures. Concurrent ancillary procedures such as genioplasty (76.67 and 76.68), rhinoplasty (21.84 to 21.87), and septoplasty (21.88) were also identified.

Hospital characteristics provided by the Nationwide Inpatient Sample database including teaching status, region, location, and bedsize were determined through the American Hospital Association Annual Survey of Hospitals and included in the database. Teaching hospitals were defined by having an American Medical Association–approved residency program, membership in the Council of Teaching Hospitals, or having a ratio of full-time–equivalent interns and residents to beds of 0.25 or higher.[23] Hospital region (Northeast, Midwest, South, and West) was defined by the U.S. Census Bureau. Hospital bedsize was categorized by the Nationwide Inpatient Sample according to the number of short-term acute beds in a hospital and adjusted for hospital location.

Hospital orthognathic procedure volume was defined using the annual aggregate number of cases performed per hospital included in the Nationwide Inpatient Sample database. High-volume hospitals were defined a priori as those exceeding the 90th percentile for annual orthognathic procedure volume (>31 cases annually).

Statistical Analysis

Univariate analyses of the independent variables by outcomes of interest were performed with Pearson chi-square analyses for categorical variables and independent samples *t* tests for continuous variables. A modified Poisson regression was used for analysis of trends, measuring changes in rate over time. For the primary outcomes of interest, logistic regression models were performed to adjust for independent variables. Covariates were based on clinical significance and statistical significance in the univariate analyses. Cases with missing information were excluded from univariate and multivariate analyses. All statistical tests were two-sided, with significance set a priori at $p < 0.05$. Statistical analyses were performed using SAS version 9.3 (SAS Institute, Inc., Cary, N.C.). This study was deemed exempt from institutional review board approval because the Healthcare Cost and Utilization Project Nationwide Inpatient Sample is a public database without personal identifying information.

RESULTS

The analytic cohort included 101,692 patients who underwent an orthognathic procedure during the study period. Patients treated at high-volume hospitals were more likely to be older individuals with private insurance and in the top quartile of median income by zip code (Table 1). There were no differences noted in comorbidity between patients treated at high-volume and low-volume hospitals; however, individuals treated at high-volume hospitals were more likely to have undergone double-jaw orthognathic surgery and ancillary procedures.

The median number of cases performed annually at participating hospitals during the study period was five cases, with an interquartile range of 12. Fifty-three percent of cases were performed at high-volume hospitals (Fig. 1). Approximately

Table 1. Comparison of Patient and Hospital Characteristics by Hospital Orthognathic Procedure Volume Status According to the Healthcare Cost and Utilization Project Nationwide Inpatient Sample from 1999 to 2011*

Characteristic	Low-Volume (%)†	High-Volume (%)‡	*p*§
No.	47,550	54,142	
Sociodemographic			
Mean age ± SD, yr	24 ± 28	25 ± 28	<0.001
Female sex	26,913 (57.6)	30,607 (57.9)	0.258
Race			<0.001
White	28,257 (79.3)	29,742 (76.3)	
Black	1730 (4.9)	1701 (4.3)	
Hispanic	3040 (8.5)	3962 (10.2)	
Other	2585 (7.3)	3572 (9.2)	
Payer			<0.001
Private insurance	38,061 (80.4)	45,940 (84.9)	
Medicare	648 (1.4)	523 (1.0)	
Medicaid	4939 (10.4)	4562 (8.4)	
Self-pay	1517 (3.2)	1552 (2.9)	
Other	2196 (4.6)	1508 (2.8)	
Income quartile			<0.001
0–25th	5615 (12.1)	4632 (8.7)	
26th–50th	9809 (21.1)	7721 (14.6)	
51st–75th	12,057 (25.9)	12,289 (23.1)	
76th–100th	18,995 (40.9)	28,492 (53.6)	
Clinical			
Charlson Comorbidity Index			0.295
None	43,530 (91.5)	49,663 (91.7)	
≥ Low	4021 (8.5)	4480 (8.3)	
Principal procedure			
Mandible only	15,185 (31.9)	14,058 (26.0)	<0.001
Maxilla only	16,476 (34.7)	17,703 (32.7)	<0.001
Double-jaw	15,889 (33.4)	22,382 (41.3)	<0.001
Ancillary procedures			
Genioplasty	5922 (12.5)	8961 (16.6)	<0.001
Rhinoplasty	378 (0.8)	407 (0.8)	0.428
Septoplasty	2112 (4.4)	2173 (4.0)	<0.001
Hospital			
Teaching hospital	26,103 (55.0)	39,976 (73.8)	
Region			<0.001
Northeast	8573 (18.0)	10,778 (19.9)	
Midwest	12,445 (26.2)	9447 (17.5)	
South	15,335 (32.3)	18,325 (33.8)	
West	11,198 (23.5)	15,592 (28.8)	
Location			<0.001
Urban	43,770 (92.3)	53,817 (99.4)	
Rural	3660 (7.7)	325 (0.6)	
Bedsize			<0.001
Small	6895 (14.5)	2635 (4.9)	
Medium	11,953 (25.2)	9241 (17.1)	
Large	28,582 (60.3)	42,266 (78.1)	

*Cases with missing information are excluded. Given in absolute numbers and as a percentage of patients in that characteristic group.
§χ^2 for categorical variables, *t* test for continuous variables.

50 percent of hospitals performed fewer than six cases annually. High-volume hospitals were more likely to be teaching hospitals located in urban settings and with large bedsizes. Approximately 25 percent of orthognathic surgery patients were treated at hospitals performing fewer than 14 cases annually.

The total complication rate was 5.4 percent among the analytic cohort. In unadjusted analyses, pediatric orthognathic surgery patients were more likely to experience any complication (5.9 percent versus 5.1 percent; $p < 0.001$), an extended length of stay (21.7 percent versus 14.2 percent; $p < 0.001$), and increased costs (51.8 percent versus 49.2 percent; $p < 0.001$) (Table 2). Comorbidity was associated with the occurrence of any complication (9.7 percent versus 5.0 percent; $p < 0.001$), extended length of stay (26.2 percent versus 15.9 percent; $p < 0.001$), and increased costs (55.8 percent versus 49.5 percent; $p < 0.001$). Although undergoing a double-jaw orthognathic operation was not associated with complications, it was associated with extended length of stay (17.4 percent versus

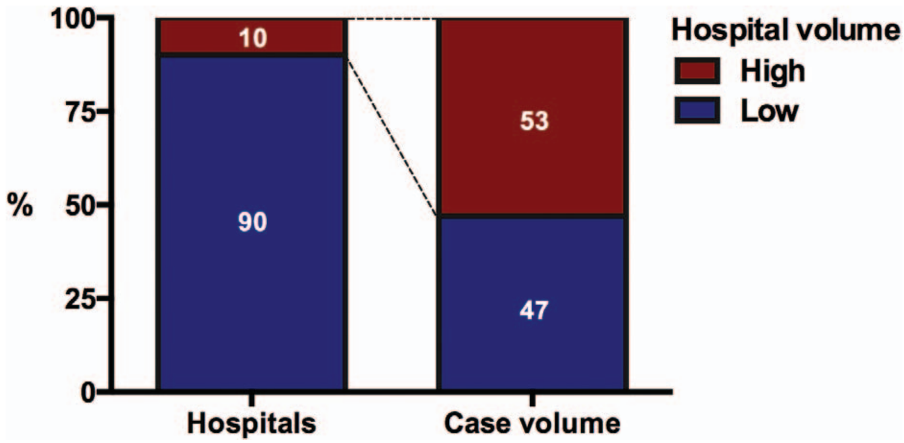

Fig. 1. Distribution of hospitals by annual orthognathic procedure volume status and corresponding distribution of patients among total analytic cohort.

16.3 percent; $p < 0.001$) and increased costs (65.3 percent versus 40.9 percent; $p < 0.001$). Similarly, although undergoing an ancillary procedure was not associated with increased complications, it was associated with extended length of stay (20.8 percent versus 15.9 percent; $p < 0.001$) and increased costs (60.7 percent versus 47.7 percent; $p < 0.001$).

Orthognathic surgery patients treated at high-volume hospitals were less likely to experience any complication (4.8 percent versus 6.0 percent; $p < 0.001$) and extended length of stay (14.8 percent versus 19.0 percent; $p < 0.001$) (Table 3). Patients who underwent isolated mandible orthognathic procedures at high-volume hospitals were less likely to experience any complication (5.3 percent versus 6.2 percent; $p < 0.001$), extended length of stay (14.8 percent versus 19.9 percent; $p < 0.001$), and increased costs (33.0 percent versus 37.1 percent; $p < 0.001$). Patients who underwent isolated maxillary orthognathic procedures at high-volume hospitals were less likely to experience any complication (4.5 percent versus 6.0 percent; $p < 0.001$), an extended length of stay (14.0 percent versus 16.8 percent; $p < 0.001$), and increased costs (44.1 percent versus 48.2 percent; $p < 0.001$). Patients who underwent double-jaw procedures at high-volume hospitals were less likely to experience any complication (4.7 percent versus 5.8 percent; $p < 0.001$) and an extended length of stay (15.4 percent versus 20.3 percent; $p < 0.001$).

In multivariable logistic regression models, patients treated at high-volume hospitals remained less likely to experience any complication (OR, 0.75; 95 percent CI, 0.70 to 0.81; $p < 0.001$) (Table 4). Similar associations were noted for patients who underwent isolated mandible (OR, 0.71; 95 percent CI, 0.62 to 0.82; $p < 0.001$) or isolated maxilla procedures (OR, 0.78; 95 percent CI, 0.69 to 0.89; $p < 0.001$). Patients who underwent double-jaw procedures at high-volume hospitals were also less likely to suffer any complication in adjusted analyses (OR, 0.75; 95 percent CI, 0.67 to 0.85; $p < 0.001$). Similar associations were noted for adjusted models predicting extended length of stay. After adjustment for sociodemographic, clinical, and hospital characteristics, patients treated at high-volume centers were more likely to experience increased inpatient costs (OR, 1.23; 95 percent CI, 1.18 to 1.29; $p < 0.001$).

An analysis of nationwide trends in the rate of patients treated at high-volume hospitals over the study period demonstrated a 2 percent increase annually (incidence rate ratio, 1.02; 95 percent CI, 1.01 to 1.03; $p < 0.001$).

DISCUSSION

Over the past century, orthognathic surgery has become a standard of care in the management of significant mandibular and maxillary abnormalities. In the United States, we identified 101,692 patients who underwent single-jaw or double-jaw orthognathic procedures over a 13-year period. The majority of orthognathic cases nationwide were performed by a small number of high-volume hospitals. For patients treated at high-volume hospitals, we demonstrated improved short-term outcomes, namely, fewer medical and surgical complications and shorter length of stay. Furthermore, the associations between hospital volume and short-term outcomes remained in a subgroup analyses of patients who underwent isolated mandibular, isolated maxillary, and

Table 2. Unadjusted Outcomes following Orthognathic Surgery by Patient and Hospital Characteristics*

Characteristic	Any Complication		Extended LOS (>2 days)		Increased Costs (>$10,784)†	
	%	p‡	%	p‡	%	p‡
Sociodemographic						
Age group		<0.001		<0.001		<0.001
Pediatric	5.9		21.7		51.8	
Adult	5.1		14.2		49.2	
Sex		<0.001		<0.001		<0.001
Male	6.4		18.4		52.4	
Female	4.8		16.0		48.6	
Race		<0.001		<0.001		<0.001
White	5.3		17.1		51.9	
Black	8.2		21.4		52.7	
Hispanic	6.6		22.1		57.6	
Other	6.1		16.6		55.1	
Payer		<0.001		<0.001		<0.001
Private insurance	4.6		14.6		49.2	
Medicare	17.7		34.2		62.1	
Medicaid	10.0		32.5		57.2	
Self-pay	4.6		14.4		41.1	
Other	6.2		21.6		52.7	
Income quartile, %		<0.001		<0.001		<0.001
0–25th	6.5		23.1		49.7	
26th–50th	6.0		19.1		52.4	
51st–75th	5.6		17.8		50.5	
76th–100th	4.7		13.6		48.8	
Clinical						
Diagnosis group		<0.001		<0.001		<0.001
Occlusion	4.4		13.5		48.0	
Apnea	11.4		43.2		67.3	
Congenital	13.9		37.7		60.6	
Charlson Comorbidity Index		<0.001		<0.001		<0.001
None	5.0		15.9		49.5	
≥ Low	9.7		26.2		55.8	
Principal procedure		0.055		<0.001		<0.001
Single-jaw	5.5		16.3		40.9	
Double-jaw	5.2		17.4		65.3	
Ancillary procedure		0.337		<0.001		<0.001
No	5.3		15.9		47.7	
Yes	5.5		20.8		60.7	
Hospital						
Teaching hospital		<0.001		<0.001		<0.001
No	4.8		11.9		48.6	
Yes	5.7		19.4		50.8	
Region		<0.001		<0.001		<0.001
Northeast	4.5		17.6		44.4	
Midwest	4.6		15.3		42.2	
South	6.0		18.2		51.9	
West	5.8		15.6		58.7	
Location		<0.001		<0.001		<0.001
Urban	5.4		16.6		49.8	
Rural	4.1		20.3		56.4	
Bedsize		<0.001		<0.001		<0.001
Small	5.2		18.9		57.1	
Medium	6.2		18.7		59.8	
Large	5.1		15.9		46.3	

LOS, length of stay.
*Cases with missing information are excluded. Given in absolute numbers and as percentage of patients in that characteristic group.
†For Healthcare Cost and Utilization Project Nationwide Inpatient Sample 2001 to 2011 only; adjusted for inflation to 2011 dollars.
‡χ^2 for categorical variables.

double-jaw procedures. Our findings show that patients treated at high-volume hospitals also were more likely to undergo double-jaw and concurrent ancillary procedures, such as genioplasty and septoplasty.

Among our cohort, the prevalence of short-term procedural and/or medical complications following orthognathic surgery was 5.4 percent and the median length of stay was 2 days. In the existing literature, there is a broad array of

Table 3. Unadjusted Outcomes by Hospital Orthognathic Procedure Volume Group

	Low-Volume (%)	High-Volume (%)	p*
All patients (n = 101,693)			
Any complication	6.0	4.8	<0.001
Extended LOS (>2 days)	19.0	14.8	<0.001
Increased costs (>$10,784)†	50.4	49.8	0.146
Mandible only (n = 29,243)			
Any complication	6.2	5.3	<0.001
Extended LOS (>2 days)	19.9	14.8	<0.001
Increased costs (>$10,784)†	37.1	33.0	<0.001
Maxilla only (n = 34,179)			
Any complication	6.0	4.5	<0.001
Extended LOS (>2 days)	16.8	14.0	<0.001
Increased costs (>$10,784)†	48.2	44.1	<0.001
Double-jaw (n = 38,271)			
Any complication	5.8	4.7	<0.001
Extended LOS (>2 days)	20.3	15.4	<0.001
Increased costs (>$10,784)†	65.0	65.4	0.437

LOS, length of stay.
†For Healthcare Cost and Utilization Project Nationwide Inpatient Sample 2001 to 2011 only; adjusted for inflation to 2011 dollars.
*χ^2 for categorical variables

reported complications following orthognathic surgery.[24–27] Intraoperative complications include hemorrhage, obstruction of airway, neurosensory disturbance, unfavorable splits, and creation of oroantral communications. Postoperative complications include infection, avascular necrosis of segments, relapse, and temporomandibular joint dysfunction. Generally, the rate of complications is considered very low, and the prevalence of complications among patients included in our study is consistent with previous studies. Regarding length of stay, Posnick et al. reported that 83 percent of patients undergoing double-jaw surgery with osseous genioplasty stayed 2 nights or less in the hospital. This is comparable to the 82.6 percent rate that we found for patients undergoing double-jaw surgery at high-volume centers. Furthermore, our data regarding short-term costs expand on and update prior reports of hospital charges for patients undergoing orthognathic procedures.[28–30]

Hospital volume reflects both hospital-based services and the procedure volume of individual surgeons.[14] It is unclear whether the associations between increased volume and short-term outcomes shown for orthognathic surgery are attributable to technical expertise, integration of more advanced technologies, or the efficacy and implementation of complex care practices. Orthognathic surgery is technically demanding; therefore, it is reasonable to suggest that surgical technique may lead to shorter operative time and reduced risk for general medical complications. It is also possible that high-volume centers benefit from access to newer, more advanced technologies, such as three-dimensional planning and three-dimensional printing, that may improve outcomes. In addition, hospital care processes may contribute to improved patient outcomes. It is important for future studies to elucidate the potential causes of the volume-outcome relationship in orthognathic surgery. Without a better understanding of these relationships, it is difficult to know how best to use these findings to improve outcomes.

The two primary approaches to implement these findings to improve outcomes are quality improvement and selective referral to high-volume centers. We favor quality improvement through increasing training opportunities at the residency and fellowship level. In the field of orthognathic surgery, we do not favor selective referral because it may affect patient choice and limit access to care in cases of significant travel burden.

Table 4. Adjusted Analyses of Hospital Orthognathic Procedure Volume Status*

	Any Complication†			Extended LOS (>2 days)‡			Increased Cost (>$10,784)§		
Variable	OR	95% CI	p	OR	95% CI	p	OR	95% CI	p
All patients									
High-volume	0.75	0.70–0.81	<0.001	0.71	0.68–0.75	<0.001	1.23	1.18–1.29	<0.001
Mandible only									
High-volume	0.71	0.62–0.82	<0.001	0.57	0.52–0.63	<0.001	0.98	0.90–1.07	0.700
Maxilla only									
High-volume	0.78	0.69–0.89	<0.001	0.78	0.72–0.85	<0.001	1.36	1.26–1.46	<0.001
Double-jaw									
High-volume	0.75	0.67–0.85	<0.001	0.73	0.68–0.79	<0.001	1.43	1.34–1.54	<0.001

LOS, length of stay.
*Reference value was low volume.
†Adjusted for age, gender, race, insurance status, income quartile, Charlson Comorbidity Index, teaching status, rural location, region, bedsize, and clinical diagnostic group.
‡Adjusted for age, gender, race, insurance status, income quartile, Charlson Comorbidity Index, ancillary procedure, teaching status, rural location, region, bedsize, and clinical diagnostic group.
§Adjusted for age, gender, race, insurance status, income quartile, Charlson Comorbidity Index, ancillary procedure, teaching status, rural location, region, bedsize, and clinical diagnostic group.

At present, there are few studies evaluating the association between procedure volume and both clinical and economic outcomes for orthognathic surgery. Furthermore, relatively little is known regarding the regionalization and distribution of orthognathic surgery in the United States. In a prior study using data from the National Health Service in England from 1997 to 2006, Moles and Cunningham demonstrated an association between decreased length of stay and hospital unit volume.[31] However, these authors were unable to comment on clinical and cost outcomes over the study period. Our study provides further support that patients treated at high-volume hospitals are more likely to experience a shorter inpatient stay. Furthermore, we found an improved short-term complication profile at high-volume hospitals.

Our study suggests that in the United States from 1999 to 2011, there was a gradual regionalization of orthognathic procedures to high-volume centers. Using the Nationwide Inpatient Sample database for the years 2000 to 2008, Allareddy et al. did not show a regionalization of orthognathic surgery to teaching hospitals.[32] Importantly, they did not evaluate hospital volume in their trend analyses. It is likely that patient selection may explain discrepancies in our findings, given that we did not include patients who underwent genioplasty alone in our analyses.

Despite fewer complications and shorter length of stay, our data suggest that patients undergoing orthognathic procedures at high-volume hospitals are more likely to have increased costs associated with their hospital stay. A cost benefit of high-volume centers is not well established in the current literature. It has been suggested that high-volume centers may use discretionary procedures more often, resulting in increased costs.[11] In our analyses, we were able to adjust for patient comorbidity, hospital characteristics, and the inclusion of concurrent ancillary procedures (i.e., genioplasty, rhinoplasty, and septoplasty) with index orthognathic procedures. It is possible that organization size and ensuing complexity have resulted in increased costs of care at high-volume centers. For example, these hospitals may be more likely to use predefined postoperative protocols that include early involvement of other specialties such as speech therapy and axial imaging to evaluate the new maxillary-mandibular relationship. As new technologies such as three-dimensional planning and three-dimensional printing for splint fabrication have become increasingly available, early adopters are likely to be at teaching institutions with sufficient case volume to merit the necessary investment in time to master this new technique. These factors may also contribute to increased costs at high-volume centers.

Using nationwide data from a 13-year study period, our study benefited from a large sample size and data collected from diverse health care settings. As a result, we were able to estimate nationwide trends in orthognathic surgery and to identify generalizable associations. However, this study is not without limitations, including those inherent in any administrative database. In addition to the potential for coding errors at individual hospitals, the patient sample was not randomized and, thus, unmeasured variables may affect the associations we identified between hospital volume and patient outcomes. In addition, we were unable to determine individual surgeon procedure volume and specialty training, and information regarding the use of medical and surgical technologies in the perioperative period. Future studies should evaluate the association between procedure volume and long-term patient-reported and objective outcomes, such as improved occlusion for mastication, dynamics of respiration, facial proportions, and quality of life.

CONCLUSIONS

The majority of orthognathic operations nationwide are performed at a small number of high-volume hospitals. These hospitals appear to discharge patients earlier, perform more complex procedures, and have fewer complications. There was regionalization of orthognathic procedures in the United States to high-volume hospitals over the study period. These findings should be used as a basis to improve practices and access to high-quality care.

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