Comparison of Fusion Rates Based on Graft Material Following Occipitocervical and Atlantoaxial Arthrodesis in Adults and Children

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BACKGROUND: Fusion rates following rigid internal instrumentation for occipitocervical and atlantoaxial instability approach 100% in many reports. Based on this success and the morbidity that can be associated with obtaining autograft for fusion, surgeons increasingly select alternative graft materials.

OBJECTIVE: To examine fusion failure using various graft materials in a retrospective observational study.

METHODS: Insurance claims databases (Truven Health MarketScan[®] [Truven Health Analytics, Ann Arbor, Michigan] and IMS Health Lifelink/PHARMetrics [IMS Health, Danbury, Connecticut]) were used to identify patients with CPT codes 22590 and 22595. Patients were divided by age (≥ 18 yr = adult) and arthrodesis code, establishing 4 populations. Each population was further separated by graft code: group 1 = 20938 (structural autograft); group 2 = 20931 (structural allograft); group 3 = other graft code (nonstructural); group 4 = no graft code. Fusion failure was assigned when ≥ 1 predetermined codes presented in the record ≥ 90 d following the last surgical procedure.

RESULTS: Of 522 patients identified, 419 were adult and 103 were pediatric. Fusion failure occurred in 10.9% (57/522) of the population. There was no statistically significant difference in fusion failure based on graft material. Fusion failure occurred in 18.9% of pediatric occipitocervical fusions, but in 9.2% to 11.1% in the other groups.

CONCLUSION: Administrative data regarding patients who underwent instrumented occipitocervical or atlantoaxial arthrodesis do not demonstrate differences in fusion rates based on the graft material selected. When compared to many contemporary primary datasets, fusion failure was more frequent; however, several recent studies have shown higher failure rates than previously reported. This may be influenced by broad patient selection and fusion failure criteria that were selected in order to maximize the generalizability of the findings.

KEY WORDS: Occipitocervical fusion, Atlantoaxial fusion, Claims data, Administrative data, Craniocervical junction

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Fusion rates following internal fixation and fusion for occipitocervical and atlantoaxial instability approach 100%.^{1–6} Recent studies, however, reported a lower fusion rate of 89% in pediatric patients.^{7,8} While structural autograft has historically been associated with the highest rates of fusion, acquisition of the graft can be associated with morbidity and prolonged operative time.^{9–11} Based on published reports

and anecdotal experience, we hypothesized that there is no significant difference in fusion failure rates in patients undergoing occipitocervical or atlantoaxial fusion based on the graft material selected.

Insurance claims databases offer accessible, longitudinal data regarding a large number of subjects. MarketScan[®] (Truven Health Analytics, Ann Arbor, Michigan) and PHARMetrics/Lifelink (IMS Health, Danbury, Connecticut) datasets have been utilized for this purpose.^{12–25} They contain deidentified, longitudinal, patient-level, compliant with the

ABBREVIATION: ASD, adjacent segment disease.

TABLE 1. Datapoints Collected for Each Record

Subject identification number
Date of index arthrodesis
Date of encounter
Gender
Subject age (years)
Fusion code (up to 2)
Graft code (up to 3)
Other code (ie Halo, up to 4)

Health Insurance Portability and Accountability Act of 1996. Both include private and Medicaid claims from >80 million unique patients. We used data from these resources to assess whether a difference in fusion failure could be associated with selected graft material at the time of primary fusion.

METHODS

The subject population was identified from MarketScan® (Truven Health Analytics) and PHARMetrics/Lifelink (IMS Health) insurance claims databases. Data from MarketScan® included claims with an initial date of service between 2003-mid 2009. Data from PHARMetrics/Lifelink included a 10% random sample of the full dataset of claims with a date of service from 2000 to 2010 (Table 1).

Study Population

The population is the US noninstitutionalized managed care population, which is not significantly different in gender or age from the US population. Subjects were identified by the presence of a current procedural terminology-4 (CPT-4) code documenting occiput-C2 (22590) or C1 to C2 arthrodesis (22595; Table 1). Patients were required to have >12 mo continuous enrollment after the index surgery in the health plans as indicated by a monthly enrollment. Age was calculated in years at procedure date, assuming a July 1 birthdate, to maintain compliance with subject deidentification. A data set was generated from each database and then merged. Reviewing patient demographics and surgery dates ensured nonduplication of patients. No patients were deemed to be identical. The merged dataset was then stratified into 4 datasets based on index procedure code (22590: occipitocervical arthrodesis or 22595: atlantoaxial arthrodesis) and age (≤ 18 yr or > 18 yr). Failure of fusion was defined as the presence of a code consistent with repeat surgical intervention (Table 2) at ≥ 90 d after the index, or most recent, procedure. This could include extension of the previous fusion and/or redo of the previous fusion. Lack of indicators for failure was considered to indicate success. Subjects had >12-mo follow-up. Each index procedure was assigned to 1 of 4 categories based on the graft code(s) that were coincident with the index arthrodesis (Table 3). Records containing >1 graft code were categorized hierarchically where the presence of a code placing a record into Group 1 (structural autograft) superseded one placing it into Group 2 (structural allograft) based on the principle that structural autograft represents the current clinical standard and that structural allograft should be distinguished from nonstructural graft. Patient consent was not required.

Statistical analysis was performed using SAS® 9.3 (SAS® Institute, Cary, North Carolina). Frequencies, proportions, and measures of central

tendency were used to describe study results and chi square analysis was used to evaluate bivariable associations. Fisher's exact tests were used when appropriate. Statistical significance was set at a value of $P < .05$.

RESULTS

Of 522 subjects identified, 244 (46.7%) were male and the mean age was 43.1 yr (Table 4). The adult cohort (age ≥ 18 yr) included 419 subjects (80.3%). The overall failure rate was 10.9% ($n = 57$), with a median time to reoperation of 191.5 d.

Occipitocervical Group

One hundred seventy-three adults and fifty-eight children underwent occipitocervical arthrodesis (CPT-4 22590; Table 5). In the adult cohort, failure ranged from 0% to 13.9%, with an overall rate of 9.2% (Figure). The median time to reoperation was 232.5 d (range 97-910). Subaxial extension of the index fusion (code 22600, Table 2) was identified in 120/173 (69.4%). There was no statistically significant difference in failure rates among the 4 groups ($P = .46$). Group 1/structural autograft composed 22.5% (39/173) of the cohort, Group 2/structural allograft, 7.5% (13/173), Group 3/nonstructural graft, 49.1% (85/173), and Group 4/no graft documented, 20.8% (36/173).

In the pediatric cohort, fusion failure ranged from 6.3% to 25.9%, with an overall rate of 18.9% (Figure). The median time to reoperation was 441 d (range 103-712). Subaxial extension of the index fusion was identified in 20/58 (34.5%). No statistically significant difference was found in failure rates among the 4 groups ($P = .40$). Group 1/structural autograft composed 46.6% (27/58) of the cohort, Group 2/structural allograft, 6.9% (4/58), Group 3/nonstructural graft, 27.6% (16/58), and Group 4/no graft documented, 18.9% (11/58).

Atlantoaxial Group

Two hundred forty-six adults and forty-five children underwent atlantoaxial arthrodesis (CPT-4 22595; Table 6). In the adult cohort, fusion failure ranged from 6.2% to 17.1%, with an overall rate of 10.2% (Figure). The median time to reoperation was 264 d (range 97-1290). No statistically significant differences were found in failure rates among the groups ($P = .21$). Group 1/structural autograft composed 35.0% (86/246) of the cohort, Group 2/structural allograft, 14.2% (35/246), Group 3/non structural graft, 32.9% (81/246), and Group 4/no graft documented, 17.9% (44/246).

In the pediatric cohort, failure ranged from 0% to 14.3%, with an overall rate of 11.1% (Figure). The median time to reoperation was 180 d (range 107-1030). No statistically significant difference in failure rates was found among the graft groups ($P = 1.00$). Group 1/structural autograft composed 37.8% (17/45) of the cohort, Group 2/structural allograft, 11.1% (5/45), Group 3/nonstructural graft, 35.6% (16/45), and Group 4/no graft documented, 15.6% (7/45).

TABLE 2. Current Procedural Terminology-4 (CPT-4) Codes Assessed in Analysis

Arthrodesis codes	
22590—Arthrodesis, posterior technique, craniocervical (Occiput-C2)	
22595—Arthrodesis, posterior technique, Atlas/Axis (C1-2)	
Graft codes	
Structural	
20938—Autograft structural, bicortical or tricortical through separate incision	
20931—Allograft, structural, for spine surgery only	
Nonstructural	
20930—Allograft, morselized, or placement of osteopromotive material, for spine surgery only	
20936—Autograft for spine surgery only, local, obtained from same incision	
20937—Autograft morselized, through separate skin or fascial incision	
Additional relevant codes	
22840—Posterior Nonsegmental instrumentation (atlantoaxial TAS)	
22310—Closed treatment of vertebral body fracture, without manipulation, requiring and including manipulation or bracing	
22315—Closed treatment of vertebral fracture and/or dislocation requiring casting or bracing, with and including casting and/or bracing, with or without anesthesia, by manipulation with traction	
22318—Open treatment of Odontoid Fracture, anterior	
22326—Open Treatment and/or reduction vertebral fracture, posterior approach, 1 segment, cervical	
22548—Arthrodesis, Anterior Transoral, Clivus, C1, C2	
22600—Arthrodesis, posterior, single level cervical below C2	
20661 or 20664 (thin skull osteology)—Application of Halo, including removal	
20665—Removal of Halo placed by another physician	
20670—Removal of Implant; superficial	
20680—Removal of Implant; deep	
22841—Internal spinal fixation by wiring of spinous processes	
22842—Posterior segmental instrumentation 3 to 6 vertebral segments	

TABLE 3. Graft Groups Based on Material Employed

Graft group	Code	Meaning
1	20938	Structural autograft
2	20931	Structural allograft
3	Other	Nonstructural, Any
4	None	None documented

Codes Indicating Failure

In many cases, multiple codes indicated failure of fusion. The mean number of codes per failure ranged from 1.27 (pediatric occipitocervical) to 2.40 (pediatric atlantoaxial). In both of the atlantoaxial fusion groups, 1 code was present more often than any other, while in the occipitocervical groups, there was no single code that was most common (Table 7). In the adult atlantoaxial group, 20680 (removal of implant; deep), was coded in 11/25 (44.0%) failures. In the pediatric atlantoaxial group, 22595 (arthrodesis, posterior technique, Atlas/Axis) was coded in 4/5 (80.0%) failures.

DISCUSSION

Using data from 2 commercially available claims datasets to derive surgical cohorts, no significant difference was found in the

TABLE 4. Description of Cohort (n = 522)

Characteristic	% (n)
Male gender	46.7 (244)
Age cohort	
Pediatric (0-18 yr)	19.7 (103)
Adult (19+ yr)	80.3 (419)
Mean age, yr (SD)	43.1 (20.1)
Procedure	
Adult occipitocervical	33.1 (173)
Adult atlantoaxial	47.1 (246)
Pediatric occipitocervical	11.1 (58)
Pediatric atlantoaxial	8.6 (45)
Graft type	
Structural autograft	32.4 (169)
Structural allograft	10.9 (57)
Nonstructural	37.9 (198)
None documented	18.8 (98)
Overall failure rate	10.9 (57)
Median days at failure (IQR, n = 57)	191.5 (109-484.5)

IQR, interquartile range; SD, standard deviation

rates of fusion failure following occipitocervical or atlantoaxial arthrodesis based on the type of graft material selected. To our knowledge, this represents the first published experience using insurance claims data to analyze clinical outcomes following

TABLE 5. Occipitocervical Arthrodesis Failure Rates by Graft Group

Graft group	No fail (%)	Fail (%)	Total	P-value
Age = Adult (>18 yr)				
Structural autograft (Group 1)	37 (94.9)	2 (5.1)	39	
Structural allograft (Group 2)	13 (100.0)	0 (0.0)	13	
Nonstructural, any (Group 3)	76 (89.4)	9 (10.6)	85	
None documented (Group 4)	31 (86.1)	5 (13.9)	36	
Total	157 (90.8)	16 (9.2)	173	.46
Age = Child (0-18 yr)				
Structural autograft (Group 1)	20 (74.1)	7 (25.9)	27	
Structural allograft (Group 2)	3 (75.0)	1 (25.0)	4	
Nonstructural, any (Group 3)	15 (93.8)	1 (6.3)	16	
None documented (Group 4)	9 (81.8)	2 (18.2)	11	
Total	47 (81.0)	11 (18.9)	58	.40

TABLE 6. Atlantoaxial Arthrodesis Failure Rates by Graft Group.

Graft group	No Fail (%)	Fail (%)	Total	P-value
Age = Adult (>18 yr)				
Structural autograft (Group 1)	75 (87.2)	11 (12.8)	86	
Structural allograft (Group 2)	29 (82.9)	6 (17.1)	35	
Nonstructural, any (Group 3)	76 (93.8)	5 (6.2)	81	
None documented (Group 4)	41 (93.2)	3 (6.8)	44	
Total	221 (89.8)	25 (10.2)	246	.21
Age = Child (0-18 yr)				
Structural autograft (Group 1)	15 (88.2)	2 (11.8)	17	
Structural allograft (Group 2)	5 (100.0)	0 (0.0)	5	
Nonstructural, any (Group 3)	14 (87.5)	2 (12.5)	16	
None documented (Group 4)	6 (85.7)	1 (14.3)	7	
Total	40 (88.9)	5 (11.1)	45	1.0

upper cervical spinal fusion. We also identified a higher fusion failure rate than has been reported in most previous studies, although recent pediatric series have reported rates consistent with our findings. The primary goal of the study was not to define fusion failure rates, but to identify a difference between failure rates based on the graft material. While the overall failure rate was higher than previous reports, this was the case for all subgroups and we do not believe there was a methodological reason that predisposed our data to reflect differential failure rates in 1 graft group versus another. This supports the assertion that fusion failure (as measured by reoperation after 90 d) does not correlate with the use of autograft versus allograft.

While this work represents a novel application of these databases, both MarketScan® (Truven Health Analytics) and PHARMetrics/Lifelink (IMS Health) are well established resources for clinical outcomes research.¹²⁻²⁵ Lad et al¹⁹ and Mukherjee et al²³ utilized MarketScan® (Truven Health

Analytics) to correlate demographic factors with neurosurgical outcomes. Mehra et al²² used the PHARMetrics/Lifelink (IMS Health) database to compare the distribution of medical care and costs for patients with chronic low back pain. The data that compose each of these resources are based on reimbursed claims and commercially reviewed, supporting their accuracy.

Secondary data analyses offer the advantage of access to large study populations and the efficiency of bypassing aspects of the data collection process. The source data are generally not collected for the purpose of the study in question that highlights the importance of inclusion/exclusion criteria. We chose broad inclusion criteria for entrance into the study and regarding fusion failure. We analyzed subjects who had a code of 22590 or 22595 and 12 mo of follow-up data. Twelve months of follow-up provided sufficient time for fusion failure to manifest while minimizing the loss of study. Fusion failure was defined by the presence of any member of a list of 21 codes >90 d after the most recent surgical

TABLE 7. CPT-4 Codes Indicating Fusion Failure

Code	n	% failed cases	Code	n	% failed cases
Adult occipitocervical (n = 16)			Adult atlantoaxial (n = 25)		
20661	2	12.5	20664	1	4.0
20670	3	18.8	20670	1	4.0
20680	3	18.8	20680	11	44.0
20930	1	6.3	20930	3	12.0
20931	2	12.5	20931	2	8.0
20936	2	12.5	20936	3	12.0
20937	2	12.5	20937	3	12.0
20938	1	6.3	20938	3	12.0
22315	1	6.3	22590	2	8.0
22590	3	18.8	22595	3	12.0
22595	1	6.3	22600	6	24.0
22600	2	12.5	22840	6	24.0
22840	2	12.5			
Pediatric occipitocervical (n = 11)			Pediatric atlantoaxial (n = 5)		
20661	1	9.1	20661	1	20.0
20664	2	18.2	20930	1	20.0
20670	1	9.1	20936	1	20.0
20680	2	18.2	20937	2	40.0
20930	2	18.2	20938	1	20.0
20936	1	9.1	22595	4	80.0
20937	1	9.1	22840	2	40.0
20938	1	9.1			
22590	1	9.1			
22600	2	18.2			

20661—Application of halo, including removal; cranial

20670—Removal of implant; superficial (eg, buried wire, pin, or rod) (separate procedure)

20680—Removal of implant; deep (eg, buried wire, pin, screw, metal band, nail, rod, or plate)

20930—Allograft, morselized, or placement of osteopromotive material, for spine surgery only

20931—Allograft, structural, for spine surgery only

20936—Autograft for spine surgery only (includes harvesting the graft); local (eg, ribs, spinous process, or laminar fragments) obtained from same incision

20937—Autograft for spine surgery only (includes harvesting the graft); morselized (through separate skin or fascial incision)

20938—Autograft for spine surgery only (includes harvesting the graft); structural, bicortical, or tricortical (through separate skin or fascial incision)

22315—Closed treatment of vertebral fracture(s) and/or dislocation(s) requiring casting or bracing, with and including casting and/or bracing by manipulation or traction

22590—Arthrodesis, posterior technique, craniocervical (occiput-C2)

22595—Arthrodesis, posterior technique, atlas-axis (C1-C2)

22600—Arthrodesis, posterior or posterolateral technique, single level; cervical below C2 segment

22840—Posterior non-segmental instrumentation (eg, Harrington rod technique, pedicle fixation across 1 interspace, atlantoaxial transarticular screw fixation, sublaminar wiring at C1, facet screw fixation)

20664—Application of halo, including removal, cranial, 6 or more pins placed, for thin skull osteology

procedure that might be associated with surgical intervention. The 90-d time window was selected to exclude potential instrumentation malpositioning, which would likely merit rapid return to the operating room for repair. We cannot exclude the possibility of patients with asymptomatic pseudoarthrosis being included in our fusion group as we are unable to assess fusion radiographically with the available data set. However, there is no evidence that this would have occurred at different rates between our study groups. As such, the assertion that fusion rates may not differ between those receiving autograft versus allograft is not significantly weakened. This methodological limitation does, however, need to be considered when interpreting the absolute fusion rate in our study. Also, while using broad criteria for study entry and

outcome definition increases the generalizability of our findings, it limits the comparison of our results to existing literature, which is almost exclusively primarily collected data. We believe that our methods predispose our analysis to err on the side of identifying high rates of fusion failure. For example, using primary data from the Pediatric Craniocervical Society, we previously conducted a retrospective analysis of 77 children who underwent occiput-C2 posterior instrumented fusion¹¹ with no documented failures of fusion. The subjects, however, were all children who had undergone O-C2 instrumentation with rigid internal fixation. In the present work, the study population was neither limited to those whose constructs ended at C2 nor to those who had rigid internal fixation, although the timeframe of our study (2000-

2010) is within a period when rigid fixation was well established for craniovertebral junction fixation. Winegar et al²⁶ reviewed the published literature regarding adult occipitocervical fusion from 1969 to 2010 and documented an overall 93.3% successful fusion rate (515/554). Arthrodesis rates with specific graft materials were not documented, but 303/311 (97.4%) patients with documented graft material were fused with autograft. In a series of 69 adult patients who underwent rigid internal occipitocervical instrumented fusion, Nockels et al²⁷ reported a 96.9% (62/64) fusion rate with no difference in rates of fusion between the groups fused with iliac crest autograft vs local autologous bone plus allograft. In 191 adults who underwent transarticular screw fixation for either occipitocervical or atlantoaxial instability, Gluf et al³ reported a 98% fusion rate using almost exclusively iliac crest autograft. Singh et al⁵ reported fusion in 96.6% (29/30) of adults who underwent occipitocervical fusion using the Ohio Medical Instruments Loop and autograft in most cases. These studies all demonstrated a fusion failure rate lower than the 9.2% rate we report from the adult occipitocervical population, and considerably lower than the 18.9% rate from the pediatric group. With the exception of the review by Winegar et al,²⁶ however, each was also based on a narrowly selected patient population. These studies report that fusion was assessed by some combination of CT and radiographs, or the method was not discussed. Using radiographs alone to assess fusion has been shown to have a low intraobserver reliability with overestimation of solid fusion. Normative data to establish the degree of allowable motion over a fused segment for definitive determination of fusion is lacking.²⁸ A study by Sayama et al⁷ includes 34 pediatric cases of occipitocervical or atlantoaxial fusion augmented with rhBMP-2. Fusion was determined by postoperative CT > 12 mo after surgery as interpreted by a neuroradiologist. They reported a fusion rate of 89.2% with 3 patients requiring revision surgery.

Reported fusion rates following atlantoaxial instrumented fusion are also very high. Elliott et al¹ completed a review describing atlantoaxial fusion in adults since 1994. They showed no difference in fusion rates between subjects who had undergone fusion using iliac crest autograft (99.7%) versus those using allograft (100%). They only reviewed studies published after 1994 to maximize the proportion of patients treated with rigid internal fixation. In this regard, our analysis is similar, as our patients were treated beginning in 2000. However, we did not formally exclude subjects who may have been treated with nonrigid fixation, which may have affected fusion rates. In a series describing results following pediatric upper cervical arthrodesis, Gluf et al³ reported a 100% fusion rate using autograft in 67 patients (23 Occipitocervical; 44 atlantoaxial). This confirmed the results of Wang et al,⁶ who reported a 100% fusion at 3 mo in 13 children undergoing posterior atlantoaxial instrumented fusion. Again, these fusion failure rates are lower than the 10.3% fusion failure rate in our atlantoaxial arthrodesis subjects. As with the data regarding occipitocervical fusion, however, recent data regarding atlantoaxial fusion also correlate more closely with our findings. In 2015, Sivakumar et al⁸ presented an 89.3%

fusion rate from a multicenter pediatric population undergoing atlantoaxial instrumented fusion. These more recent studies were not specifically limited to rigid internal fixation, which is similar to the population included in our data set.

Despite reported high rates of fusion, our results, combined with those of Sayama and Sivakumar suggest that, in a generalized population, the rate may be lower than expected.^{7,8} Sayama et al⁷ reported a fusion rate of 89.2% for pediatric patients (10-17 yr) undergoing occipitocervical or atlantoaxial fusion with rhBMP-2 with >12 mo follow-up using CT imaging. Mazur et al²⁹ reported a 15.7% failure rate requiring revision surgery in 107 patients (1.2-17.9 yr) undergoing occipitocervical fusion. Fusion was defined as a solid bony bridge from the occiput to the posterior elements of C2 on a CT scan. Autograft was used in 96.9% of cases (59.8% rib; 36.2 iliac crest). Age, sex, method of fixation, use of biologicals or BMP, or postop bracing did not affect failure rates. Their subgroup analysis of failures showed a significant association between failure and patients with skeletal dysplasia or spinal anomalies. Deutsch et al³⁰ found a fusion rate of 94% (48/51) undergoing occipital fixation with iliac crest graft. The follow-up was >12 mo (average of 36 mo) and fusion was assessed with radiographs.³⁰

Limitations

While the strengths of this work include the large number of subjects and the generalizability of the data, it is critical to recognize the limitations. Despite the large number of cases in the datasets, our analysis ultimately included small subgroups, which limited our ability to detect differences. Due to distinctions in the anatomy and indications for surgery, we felt it was necessary to analyze the pediatric and adult groups separately. We also felt that occipitocervical and atlantoaxial fusion patients merited independent analyses. This resulted in 4 separate analyses. Further subdivision of each of these groups, based on the graft material, resulted in small subgroups. Additionally, 98 (18.8%) records lacked graft material data; however, it was similar in all 4 subgroups (range 15.6-20.8%). Furthermore, there was no statistically significant difference in fusion failure rates between these subjects and those with documented graft. While this could represent practice variation, the absence of documented graft material is more likely explained by a failure of appropriate coding of the graft material utilized at the treating institution.

It is also important to consider reasons for reoperation other than fusion failure, most notably adjacent segment disease (ASD). We believe that very few reoperations were due to ASD as the mean time to reoperation was 0.52 yr. This is supported by the literature describing the usual time course to the development of ASD. In an adult population, Deutsch et al³⁰ reported a 94% fusion rate for occipitocervical fusion with 7% (4/175) developing ASD on imaging and 3.5% (2/175) proceeding to revision within 3 yr. The patients with ASD were more likely to be fused from occiput to C5 rather than to C4. Hildebrand et al³¹ reported an 8.7% incidence of ASD over 3 yr (average 2.9%/yr) following

anterior cervical fusion in adults. This is consistent with the 3.5% found by Deutsch et al,³⁰ with only a subset requiring reoperation. Therefore, we would expect a low rate of reoperation due to ASD in our population, with a mean time to reoperation of 0.52 yr.

It is important to consider why the pediatric occipitocervical fusion group demonstrated a higher failure rate (18.9%) than the other groups. Given the consistent failure rates of the other 3 groups, it is unlikely that this deviation reflects methodological variation. We previously reported that 61% of pediatric occipital fusions were done for congenital anomalies⁴ versus 10.5% in adults.²⁶ Due to their highly atypical anatomy and complications associated with their underlying condition, this pediatric population is more likely to be surgically challenging^{11,32} and may be more prone to failure. This assertion is supported by the findings of Mazur et al,²⁹ who demonstrated an association between fusion failure and skeletal dysplasia or spinal abnormalities. We attempted to examine this in our study by assessing the prevalence of a code indicating subaxial arthrodesis (22600). In the adult occipitocervical arthrodesis group, this code was present in 69% (120/173) of cases, while in the pediatric group it was present in only 34% (20/53), opposing the idea that the pediatric population was treated with longer constructs as a proxy for greater anatomic complexity. However, the frequency of the 22600 code in the adult population may be elevated by the more routine use of O-C3 fusion in adults. This may mask that the pediatric group was, in fact, at higher risk of failure.

CONCLUSION

Through the analysis of 522 subjects from 2 insurance claims datasets, no difference was identified in upper cervical fusion failure rates based on the graft material employed. The overall fusion failure rate was 10.9%, which is higher than reported rates. Notably, the 58 pediatric patients who underwent occipitocervical fusion demonstrated a failure rate of 18.9%. The most likely explanation is the broad inclusion criteria we selected both for inclusion in the study population and consideration for fusion failure. Our findings indicate that upper cervical fusion failure is not dependent on the graft material selected and also demonstrate the challenges of direct comparison between studies based on primary and secondary data.

Claims-based data sources allow access to large populations over time permitting examination across sites thereby creating observational cohorts of large samples of surgical patients. This approach has promise for future comparative effectiveness studies, and with consensus definitions of coding from groups such as the Pediatric Craniocervical Society, will promote research that can be both hypothesis testing and hypothesis generating, and can enhance existing primary data collection efforts.

Disclosures

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COMMENTS

The authors describe a study population obtained from insurance claims databases, analyzed to determine if there is a difference in fusion rates using different types of graft material in craniocervical and atlantoaxial arthrodesis. The authors have been careful to point out problems inherent with this type of data. The biggest issue is that the indications for surgery are unknown. Furthermore, while the primary outcome measure was “failure of fusion”, what was really measured was the performance of subsequent surgery. By setting the definition for failed fusion at >90 days after the index procedure, they hoped to weed out

instrumentation complications and other indications for surgery that had nothing to do with “failed fusion”. The indications for the subsequent surgery are unknown, as they were for the index procedure. Although these authors have done a good job explaining why the findings of this study are perhaps relevant (there was no difference between outcomes with respect to graft material), I am left wondering what was actually measured because the number of “failure of fusion” cases seems high. Not enough detailed outcome studies have been done for occipitocervical and atlantoaxial fusion. This study should generate interest in developing multicenter prospective studies to analyze outcomes in for these procedures in more detail.

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Availability of rigid internal fixation have resulted in excellent fusion rates for occipitocervical and atlantoaxial fusions. Majority of studies reporting rates of arthrodesis following occipitocervical and atlantoaxial arthrodesis have been based on use of autografts. Considering the increasing use of allograft for obtaining fusions following occipitocervical and atlantoaxial fusions, the study performed by the authors comparing fusion rates based on graft material following occipitocervical and atlantoaxial arthrodesis in adults and children seems very clinically relevant and hence the authors are to be applauded for their attempt.

Apart from the various shortcomings such as definition of failed fusions as defined by reoperation for extension of the previous fusion and/or re-do of the previous fusions, absence of data on rigid versus semi-rigid fixations techniques and lack of description on the type of autograft (iliac crest vs rib autograft) used that have been acknowledged by the authors and well discussed in the manuscript; the non-differential nature of limitations uniform to all the groups analyzed in the study still supports the conclusion that the fusion rates may not differ between those receiving autograft versus allograft. While use of iliac crest or rib autograft still remains common in patients undergoing occipitocervical and atlantoaxial fusions based on personal experience among a number of spine surgeons; the findings from this comparative study does provides some objective data supporting the similar efficacy of allograft without the associated morbidity of harvesting autograft and increased operative time and may help spine surgeons in choosing the best graft options for occipitocervical and atlantoaxial fusions notwithstanding the limitations of the study.

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