Short-term Complications Associated With Surgery for High-Grade Spondylolisthesis in Adults and Pediatric Patients: A Report From the Scoliosis Research Society Morbidity and Mortality Database

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BACKGROUND: Although it is generally agreed upon that surgery for high-grade spondylolisthesis (HGS) is associated with more complications than low-grade spondylolisthesis, its description is primarily based on case reports and relatively small case series.
OBJECTIVE: To assess short-term complication rates associated with the surgical treatment of HGS in pediatric and adult patients and to identify factors associated with increased complication rates.
METHODS: All cases of HGS from the Scoliosis Research Society Morbidity and Mortality database for the year 2007 were reviewed. Patients were classified as pediatric (≤18 years) or adult (>18 years). Complications were tabulated, and the rates were compared between the patient groups and based on clinical and surgical factors.
RESULTS: 165 cases of HGS were reported (88 pediatric, 77 adult). There were 49 complications (29.7%) in 41 patients (24.8%), with no difference in the proportions of pediatric vs adult patients with a complication ($P = .86$). Occurrence of new neurological deficit after surgery was the most common complication, seen in 19 (11.5%) patients. Performance of an osteotomy was associated with a higher incidence of new neurological deficits in both adult and pediatric groups ($P = .02$ and $P = .012$, respectively). Although most of the new neurological deficits improved over follow-up, 10% had no improvement.
CONCLUSION: This study provides short-term complication rates associated with surgical treatment for HGS in adult and pediatric patients and may prove valuable for patient counseling, surgical planning, and in efforts to improve the safety of patient care.

KEYWORDS: Adult, Complications, Grade, Pediatric, Spondylolisthesis, Surgery

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High-grade spondylolisthesis (HGS) is defined as slippage of a spinal vertebral body relative to an adjacent vertebral body of greater than 50% according to the Meyerding classification.[1] The natural history of HGS is generally not as favorable as low-grade spondylolisthesis (LGS), and the condition often warrants surgical treatment to address pain and disability.[2-9] The choice of surgery can vary from in situ fusion, with or without postural reduction, to instrumented reduction and combined anterior-posterior fusion techniques.[4,10-12]

ABBREVIATIONS: HGS, high-grade spondylolisthesis; **LGS,** low-grade spondylolisthesis; **M&M,** Morbidity and Mortality; **SRS,** Scoliosis Research Society

However, there is a relative lack of high-quality evidence in the literature favoring the superiority of one surgical technique over another for the treatment of HGS; consequently, the ideal surgical approach remains controversial.[11]

Apart from the experience of the treating surgeon and clinical presentation, the potential for complications often significantly impacts the choice of approach for management of HGS. Although it is generally agreed upon that surgery for HGS is associated with more complications than LGS, the relevant literature primarily consists of a limited number of case reports and small cases series that are predominantly restricted to children or adolescents.[7,13-23] An improved understanding of the complications associated with various treatment approaches may not only prove valuable for patient

counseling and quality improvement, but may also prove beneficial in surgical planning that aims to achieve the best balance between complication avoidance and favorable clinical outcome.[4,11,12,19]

Our objectives in the present study were 2-fold. First, we sought to assess the short-term complication rates associated with the surgical treatment of HGS in adult and pediatric patients, based on a large series of patients from a broad range of institutions by using the Scoliosis Research Society (SRS) Morbidity and Mortality (M&M) database. Although this database is essentially a registry without an effective auditing process, the authors feel that, at a minimum, it provides useful general information about current practice and estimates of rates for acute complications. Second, we assessed for associations between the occurrence of complications and various clinical and surgical factors. Collectively, these data provide benchmarks of complications rates associated with surgery for HGS that may prove useful for patient counseling, surgical planning, and efforts to improve the safety of patient care.

MATERIAL & METHODS

Members of the SRS submit spinal surgery case data, including M&M data, by using a secure Internet-based questionnaire, which was developed by the SRS M&M Committee in the early 1990s. The questionnaire was modified in 2004 to include more detailed questions about specific aspects of the surgical indications, surgical procedure, and complications. The M&M data in the SRS database predominantly reflect short-term complications associated with the perioperative period, and the means of data collection do not permit entry of long-term complications. Data submission includes a process in which members formally attest that submitted data are true and complete. All patients and patient data in the database are deidentified. This project was submitted to the institutional review board at the Hospital for Special Surgery (New York, New York) and was determined to be exempt from institutional review board approval based on the use of deidentified data.

The SRS collected data for spondylolisthesis grade only for 1 year (2007), and, for the purpose of this study, all reported surgical cases with the diagnosis of HGS in pediatric and adult patients during that 1 year were extracted from the SRS database. The inclusion criterion for this study was the presence of HGS (Meyerding grade III, IV, or V), irrespective of the etiology. Patients were classified as either pediatric (≤18 years of age) or adult (>18 years or age). The complications reported in these cases were identified and tabulated. For each case included in the present study, the following data were extracted: patient age, diagnosis, etiology of spondylolisthesis, presence of preoperative neural compression, American Society of Anesthesiologists (ASA) grade, procedure type (reduction, osteotomy, instrumentation), whether direct decompression was performed, whether the surgery was a revision, whether fusion was performed and, if so, the type of fusion performed, type of surgical approach, electrophysiological monitoring parameters, use of implants, use of minimal-access approach, and presence or absence of complications and/or mortality. Complications were additionally subclassified (eg, pulmonary embolus or deep venous thrombosis). Occurrence of, extent of (cauda equina or nerve root), and recovery from (none, partial, or complete) new neurological deficits were also available and extracted. Not consistently included in the database were success of reduction, whether the reduction was partial or complete, long-term follow-up, and objective outcome measures. Although presence of preoperative neural element compression was not specifically collected as part of the SRS M&M database reporting process, surgeons did report whether a direct decompression of the neural elements was performed as part of the surgical procedure.

Statistical analysis was performed using SPSS software (SPSS Inc., Chicago, Illinois). Statistical comparisons between subgroups were performed using Fisher exact test. A P value $< .05$ was considered statistically significant. Association of complication occurrence based on sex, grade of spondylolisthesis (III vs IV/V), etiology of slip, and revision surgery was done. Also analyzed were the association of occurrence of new neurological deficits in relation to the grade of spondylolisthesis, whether direct decompression was performed, revision vs primary surgery, reduction vs in situ fusion, whether the procedure included an osteotomy, and whether intraoperative neuromonitoring was performed.

RESULTS

A total of 165 cases of HGS were reported to the SRS M&M database for the year 2007, consisting of 88 pediatric and 77 adult patients. Patient demographics, spondylolisthesis type and grade, and ASA grade are summarized in Table 1. Based on these parameters, the pediatric and adult groups were very similar, except that there were more patients with degenerative spondylolisthesis and ASA grade II or III in the adult group, as would be expected. Comparison of surgical parameters between the pediatric and adult patient groups demonstrated only 2 significant differences (Table 2). Compared with pediatric patients, a greater proportion of adult patients underwent a decompression (83% vs 69%, $P = .046$), and a lesser proportion had intraoperative neuromonitoring (53% vs 84%, $P < .001$).

TABLE 1. Patient Demographics and Radiological Descriptors for 165 Patients Treated Surgically for High-Grade Spondylolisthesis

Parameter, n (%)	Pediatric (≤18 Years Old)	Adult (>18 Years Old)
n	88	77
Age, mean (range)	13.9 (7-18)	44.4 (19-84)
Sex (male:female)	27 (31): 61 (69)	33 (43): 44 (57)
Meyerding grade		
III	40 (45)	53 (69)
IV	34 (39)	17 (22)
V	14 (16)	7 (9)
Spondylolisthesis type		
Isthmic	56 (64)	47 (61)
Dysplastic (pars intact)	21 (24)	7 (9)
Degenerative	4 (5)	16 (21)
Postlaminectomy	2 (2)	4 (5)
Traumatic	0 (0)	3 (4)
Pathological	1 (1)	0 (0)
Not specified	4 (5)	0 (0)
ASA grade[a]		
I	69 (78)	31 (40)
II	8 (9)	26 (34)
III	6 (7)	11 (14)
Not specified	5 (6)	9 (12)

[a]ASA, American Society of Anesthesiology.

There were 49 complications (29.7%) in 41 patients (24.8%), as detailed in Table 3. Occurrence of new neurological deficit after surgery was the most common complication, seen in 19 (11.5%) patients, followed by implant-related and deep-wound infection, seen in 7(4.2%) and 6 (3.6%) patients, respectively, from the overall cohort. The rates of durotomy in the pediatric and adult groups were 0% and 6.5%, respectively. The occurrence of dural tears was not stratified based on the operative approach because of the small number of patients. No mortalities were reported in this series.

Comparing the pediatric and adult patient groups, there was no significant difference in the percentage of patients affected by a complication (24% vs 26%, respectively, $P = .86$), and the mean number of complications per patient was the same in the 2 groups (0.30 in each group). Of the 165 patients in the database, 23 (17%) were identified as undergoing revision surgery. There was

TABLE 2. Surgical Parameters Associated With the Surgical Treatment of 165 Cases of High-Grade Spondylolisthesis Stratified Based on Patient Age Group[a]

Parameter, n (%)	Pediatric (≤18 Years Old)	Adult (>18 Years Old)
n	88	77
Direct neural decompression[b]		
No	27 (31)	13 (17)
Yes	61 (69)	64 (83)
Reduction		
No	19 (22)	27 (35)
Yes	55 (62)	34 (44)
Not specified	14 (16)	16 (21)
Revision		
No	79 (90)	63 (82)
Yes	9 (10)	14 (18)
Fusion		
No	7 (8)	1 (1)
Yes	81 (92)	76 (99)
Fusion category (based on n = 81)		
Posterior or posterolateral only	39 (48)	29 (38)
TLIF ± posterolateral	12 (15)	20 (26)
PLIF ± posterolateral	22 (27)	8 (10)
Anterior only	1 (1)	3 (4)
Anterior and posterior, same day	7 (9)	15 (19)
Anterior-posterior-anterior, same day	0 (0)	1 (1)
Not specified	7 (9)	1 (1)
Osteotomy		
No	60 (68)	58 (75)
Yes	10 (11)	6 (8)
Not specified	18 (21)	13 (17)
Osteotomy Type	(based on n = 10)	(based on n = 6)
Three-column resection	1 (10)	2 (33)
Anterior discectomy/corpectomy	4 (40)	2 (33)
Smith-Peterson	2 (20)	1 (17)
Pedicle subtraction/decancellation	2 (20)	1 (17)
Not specified	1 (10)	0 (0)
Implants		
No	6 (7)	1 (1)
Yes	82 (93)	76 (99)
Neuromontoring[c]		
No	14 (16)	36 (47)
Yes	74 (84)	41 (53)
Minimal access approach		
No	83 (94)	76 (99)
Yes	5 (6)	1 (1)

[a]TLIF, transforaminal lumbar interbody fusion; PLIF, posterior lumbar interbody fusion.
[b]$P = .046$.
[c]$P < .001$.

TABLE 3. Complications Associated With the Surgical Treatment of 165 Cases of High-Grade Spondylolisthesis Stratified Based on Patient Age Group[a]

Complication, n (%)	Pediatric (≤18 Years Old)	Adult (>18 Years Old)
Number of patients	88	77
New neurological deficit[b]		
Nerve root	9 (10.2)	8 (10.3)
Cauda equina	2 (2.3)	0 (0)
Implant related[c]	4 (4.5)	3 (3.9)
Wound infection		
Superficial	2 (2.3)	0 (0)
Deep	3 (3.4)	3 (3.9)
Peripheral nerve palsy		
Lumbar	2 (2.3)	1 (1.3)
Peroneal	2 (2.3)	0 (0)
Durotomy	0 (0)	5 (6.5)
Respiratory (not pulmonary embolism)	0 (0)	1 (1.3)
Epidural hematoma	0 (0)	1 (1.3)
Pulmonary embolism	0 (0)	0 (0)
DVT	0 (0)	0 (0)
Visual acuity deficit	0 (0)	0 (0)
Death	0 (0)	0 (0)
Other[d]	2 (2.3)	1 (1.3)
Total patients with a complication	21 (24)	20 (26)
Total number of complications (complications/patient)	26 (0.30)	23 (0.30)

[a]DVT, deep vein thrombosis.
[b]Recovery of new neurological deficits: pediatric patients: nerve root injury (1 patient had not recovery, 4 patients had partial, and 4 had complete recovery), cauda equina injury (both patients had complete recovery); adult patients: nerve root injury (1 patient had no recovery, 4 had partial recovery, 3 had complete recovery).
[c]Pediatric patients: 2 implant failures, 1 implant migration, 1 rod fracture; adult patients: 2 implant failures, 1 malpositioned implant.
[d]Pediatric patients: 1 seroma, 1 return to operating room for decompressive laminectomy following in situ fusion only; adult patients: 1 retained JP drain.

a significant difference in the complication rates between those undergoing revision surgery and those undergoing an initial procedure in the pediatric group ($P = .03$) (Table 4). There were no significant associations between the overall complication rates and sex, spondylolisthesis grade (III vs IV and V combined), or etiology of spondylolisthesis (isthmic vs dysplastic) (Table 4).

Occurrence of new neurological deficit was the most common complication seen. Of the total 19 patients (11.5%) with new-onset neurological deficit after surgery, 17 were classified as having nerve root deficit and 2 had cauda equina syndrome. Performance of an osteotomy as a part of the surgery was the only factor associated with a significantly higher incidence of new neurological deficit, both in adult and pediatric groups ($P = .02$ and $P = .012$, respectively (Table 5). There was a nonsignificant trend favoring occurrence of new neurological deficits in pediatric patients with grade IV or V spondylolisthesis vs those with grade III (Table 5). Interestingly, there was no association between the occurrence of new neurological deficit and performance of direct decompression, reduction of spondylolisthesis, revision surgery, or use of neuromonitoring in this series ($P > .05$) (Table 5).

Data on the recovery of new nerve root deficits in pediatric patients showed no recovery in 1 patient, partial recovery in 4, and complete recovery in 4. Both pediatric patients with new postoperative cauda equina deficit had complete recovery. In the adult group, new nerve root deficit was reported to have no recovery in 1 patient, partial recovery in 4 patients, and complete recovery in 3 patients.

DISCUSSION

There have been few studies on HGS, with most of them including small numbers of cases and mainly pediatric or adolescent patients.[1,7,14-18,20,21,23-34] Very few reports have been published that specifically discuss the treatment of adult patients with HGS, more specifically complications.[4,5,10,13] Recently, there have been reports from the SRS M&M database providing benchmark data for complications associated with surgery for spondylolisthesis in adult and pediatric patients with indirect reference to significantly higher chances of complications with HGS.[35,36]

In the present study, we review the short-term complication rates in the largest series of adult and pediatric patients with HGS reported to date. Even though Schoenecker et al[22] reported a 6.5% incidence of postoperative neurological deficit from a group of 189 HGS patients treated surgically with in situ fusion, the overall complication rate for the entire series was not reported. Studies in the literature often combined patients with both LGS and HGS.[4,36] Considering the fact that the complication rates for surgical treatment of HGS are not the same, data from those studies should not be extrapolated to the surgical care of patients with HGS.[36]

The occurrence of new neurological deficits after surgery was the most common complication seen, occurring in 19 (11.5%) patients. This rate is in striking contrast to the 1.1% overall incidence of new neurological deficits seen in the study by Sansur et al[36] and the overall reported rates in the literature as reviewed by Ogilvie[37] for spondylolisthesis in general. This is not unexpected considering that the majority of the patients in those studies had LGS. Sansur et al[36] did not subcategorize the occurrence of new neurological deficits between the LGS and HGS groups, and the chances that most of the cases of new neurological deficits being secondary to the surgery for HGS cannot be ignored and has significant potential clinical implication.

There are few data on surgical management of HGS in adults. Dewald et al[13] reported an overall incidence of 45% of new neurological symptoms after surgery for HGS in a series of 20 adult patients, 90% of whom improved over follow-up, a rate similar to that seen in the present study. Similarly, Goyal et al[4] reported an approximately 25% rate of postoperative radiculitis following instrumented reduction and transforaminal lumbar interbody fusion for spondylolisthesis in adults. The patient

TABLE 4. Associations With Total Complications

Parameter, n (%)	Pediatric (≤18 Years Old)			Adult (>18 Years Old)		
	Complication			Complication		
	No	Yes	P	No	Yes	P
Sex						
Male	21 (78)	6 (22)	1.0	25 (76)	8 (24)	.8
Female	46 (75)	15 (25)		32 (73)	12 (27)	
Spondylolisthesis type						
Isthmic	43 (77)	13 (23)	.8[a]	35 (74)	12 (26)	.5[b]
Dysplastic (pars intact)	15 (71)	6 (29)		6 (86)	1 (14)	
Degenerative	4 (100)	0 (0)		10 (63)	6 (37)	
Postlaminectomy	2 (100)	0 (0)		4 (100)	0 (0)	
Pathological	1 (100)	0 (0)		0 (0)	0 (0)	
Traumatic	NA	NA		2 (67)	1 (33)	
Not specified	2 (50)	2 (50)		NA	NA	
Meyerding grade						
III	32 (80)	8 (20)	.5[c]	41 (77)	12 (23)	.4[c]
IV	22 (65)	12 (35)		14 (82)	3 (18)	
V	13 (93)	1 (7)		2 (29)	5 (71)	
Revision						
No	63 (80)	16 (20)	.03	45 (71)	18 (29)	.7
Yes	4 (44)	5 (56)		12 (86)	2 (14)	

[a]Comparison of isthmic vs dysplastic only.
[b]Comparison of isthmic, dysplastic, and degenerative only, Pearson χ^2.
[c]Comparison of grade 3 vs grades 4 and 5 combined.

TABLE 5. Associations With New Neurological Deficits

Parameter, n (%)	Pediatric (≤18 Years Old)			Adult (>18 Years Old)		
	New Neurological Deficit			New Neurological Deficit		
	No	Yes	P	No	Yes	P
Meyerding grade						
III	38 (95)	2 (5)	.06[a]	49 (92)	4 (8)	.3[a]
IV	26 (76)	8 (24)		16 (94)	1 (6)	
V	13 (93)	1 (7)		4 (57)	3 (43)	
Direct neural decompression						
No	26 (96)	1 (4)	.16	13 (100)	0 (0)	.3
Yes	51 (84)	10 (16)		56 (87)	8 (13)	
Reduction						
No	18 (95)	1 (5)	.3	24 (89)	3 (11)	1.0
Yes	45 (82)	10 (18)		29 (85)	5 (15)	
Revision						
No	68 (86)	11 (14)	.6	57 (90)	6 (10)	.6
Yes	9 (100)	0 (0)		12 (86)	2 (14)	
Osteotomy						
No	56 (93)	4 (7)	.012	53 (91)	5 (9)	.02
Yes	6 (60)	4 (40)		3 (50)	3 (50)	
Neuromonitoring						
No	13 (93)	1 (7)	1.0	32 (89)	4 (11)	1.0
Yes	64 (86)	10 (14)		37 (90)	4 (10)	

[a]Comparison of grade 3 vs grades 4 and 5 combined.

population, however, also included patients with grade II spondylolisthesis. A recent study by Lamartina et al[5] reported a relatively low incidence of neurological deficit (4%) following reduction and correction of sagittal alignment in a group of 25 patients with high-grade dysplastic spondylolisthesis. Lakshmanan et al[10] reported a 0% incidence of neurological complications in a series of 12 HGS patients following circumferential fusion. The patient population involved both adolescents and adults in these studies.[5,10]

Most of the data on surgery for HGS are from reports involving children and adolescents. Table 6 summarizes the incidences of new-onset neurological deficit following surgical treatment of HGS in children and/or adolescent age groups in the literature.[2,7,14-16,18-23] The rates vary widely across studies and were specifically high in patients who underwent reduction, compared with those undergoing in situ fusion. The study by Fu et al[35] showed that reduction of spondylolisthesis was strongly associated with developing new neurological deficit after surgery in pediatric spondylolisthesis (10% vs 2%, $P < .001$). The present study revealed a 12.5% incidence of new neurological deficit in the pediatric group, which is comparable to the rates reported in the literature. Although the chances were higher after direct decompression and reduction in this study, the differences were not statistically significant; lack of this effect to be significant may be due to the small number of patients in the series. The chance of developing a new deficit after reduction likely also depends on the technique of reduction and the overall amount of reduction (complete vs partial) achieved, which may account for varied results across studies, because studies have shown that most of the total L5 nerve strain occurs during the second half of reduction.[4,5,25,32] Given the high neurological complication rate associated with treatment of HGS, consideration for a partial reduction only or in situ spinal fusion only should be given, because this approach has been reported to result in high patient satisfaction rates with a low neurological complication rate, at least in pediatric patients.[15] The same may not be true for adults with HGS, because increasing the surface area of spinal fusion by means of reduction may increase the possibility of spinal fusion, but the present study cannot provide an answer to this question, because longer-term follow-up is not available to demonstrate the risk of nonunion in adult patients.

Performance of osteotomy was significantly associated with a higher incidence of new postoperative neurological deficit in this study. This is not surprising, because osteotomy requires manipulation of the thecal sac or nerve roots in performing the procedure, and it is likely that patients requiring an osteotomy had the most severe deformities. This is in contrast to the study by Sansur et al,[36] which suggested no significant differences in rates of dural tears/nerve injuries based on the approach chosen. This difference between studies may reflect greater nerve root compromise in HGS patients that may result in greater sensitivity to manipulations such as osteotomies.

Study Limitations

Although the large number of patients treated and the broad range of experience from multiple medical centers makes the SRS database a valuable resource for spine research, it does present limitations.[35,36,38-49] These include the purely registry-based design, lack of reporting of long-term complications and follow-up, especially pseudarthrosis, lack of overall long-term outcome related to pain and function, and the potential for underreporting of events. Similarly, the lack of factors that typically influence the surgeon's choice of approach, including presence of medical comorbidities, body habitus, and available resources, are further limitations that must be acknowledged. In addition, data were not available on the slip angle, flexibility of the olisthesis, or preoperative sagittal balance, which are 3 important factors that may relate to the type of surgery being performed and the potential inherent risks involved. It is also possible that the types of osteotomies selected by surgeons when entering cases may not adequately or fully reflect the type of osteotomy actually performed. Nevertheless, because the complication rates reported in this article are based on the largest series of adult and pediatric patients treated surgically for HGS in the literature, these rates should be a useful contribution to the spine literature guiding treatment of patients with HGS.

TABLE 6. Summary of Prior Publications Reporting Incidence of New Onset Neurological Deficit Following Surgical Treatment of High-Grade Spondylolistheis in Children and/or Adolescent Age Groups

Study No.	Study	No. Patients	Mean Age, y	Procedure	Neurological Complication Rate, %
1	Boxall et al[2]	39	14.7	Reduction or in situ fusion	5.1
2	Dick and Schnebel[14]	15	20	Reduction	27
3	Schoenecker et al[22]	189	13	In situ fusion	6.30
4	Poussa et al[19]	22	14.7	Reduction or in situ fusion	4.50
5	Hu et al[16]	16	20	Reduction	25
6	Muschik et al[7]	59	14	Reduction and in situ fusion	3.40
7	Molinari et al[18]	32	13.5	Reduction or in situ fusion	11
8	Roca et al[20]	14	21	In situ fusion	14
9	Shufflebarger et al[23]	18	14	Reduction	0
10	Ruf et al[21]	27	16.7	Reduction	22
11	Helenius et al[15]	70	14.4	In situ fusion	5.70

Despite the potential limitations of the SRS M&M database, the authors feel that, at a minimum, it provides useful general information about current practice and estimates of rates for acute complications.[45] A previous report has demonstrated the general validity of the SRS M&M data set, based on comparison of the complication rates for common procedures in the SRS M&M data set with those available in the literature.[45] Future studies to investigate the treatment of HGS and its attendant complications in greater detail would likely require a large prospective, multicenter design with substantial funding, given the relative rarity of this condition.

CONCLUSION

In this series of adult and pediatric patients treated surgically for HGS, 25% of patients had 1 or more complication in a short-term follow-up. Occurrence of new neurological deficit was the most common complication, seen in approximately 10%, and was significantly associated with inclusion of an osteotomy in the surgical procedure. The overall complication rates, and specifically new neurological deficits, were not influenced by the spondylolisthesis grade and etiology or by whether decompression was performed as part of the surgery.

Disclosures

Dr Smith has been a consultant for and received an honorarium from Medtronic and Biomet; he was a consultant for and received an honorarium and research study group support from Depuy; and he received an honorarium from Globus. Dr Shaffrey was a consultant for and earned a patent at Biomet; he was a consultant for Depuy; he was a consultant for and received royalties from Medtronic; and he received grants from National Institutes of Health and the Department of Defense. Dr Lenke received a royalty from Medtronic, research support from Depuy Spine and Axial Biotech, and a royalty Quality Medical Publishing. Dr Ames was a consultant for Depuy and Medtronic and received a royalty from Stryker. Dr Perra was a consultant for and received royalties from Medtronic, he was a speaker and received an honorarium from Stryker and from K2M. Drs Kasliwal, Saulle, and Polly have no personal, financial, or institutional interest in any of the drugs, materials, or devices described in this article.

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COMMENTS

High-grade spondylolisthesis (HGS) is a rare condition that can cause pain secondary to neurological compromise or spinal instability. There are very few data regarding complications associated with the treatment of HGS. The authors describe short-term perioperative complications identified in pediatric and adult patients for treatment of HGS collected in the Scoliosis Research Society Morbidity and Mortality database. Because of the multicenter nature of the SRS database, the authors were able to review data from a high number of patients.

There are many surgical solutions to HGS, but the safest surgical approaches and goals remain unclear. The most significant management issues are reduction of slip vs in situ fusion, direct vs indirect neural decompression, and the use of osteotomies. There are many complications that can occur from this surgery, but probably the most devastating is neurological deterioration. Although this study describes many different complications, the most important finding is the relationship of surgical approach and neurologic deterioration.

I commend the authors on tackling an extremely difficult but rare surgical problem. As the authors correctly point out, this study has several limitations because of it retrospective nature and method of data collection, but it is still important information to consider to provide some estimates of the types of surgical complications and their causes. Although a multicenter nonrandomized or randomized trial is often considered the ideal, rare conditions (like HGS) often preclude the coordination of these studies. This study improves upon the literature regarding surgical treatment HGS and offers guidance for further study of this disease process.

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The authors present the results of their retrospective review of cases of high-grade spondylolisthesis entered in the Scoliosis Research Society (SRS) Morbidity and Mortality (M&M) database for 2007. This database includes deidentified data from patients entered by SRS members. Although each member must attest to the accuracy of the data he or she enters, there has never been an audit to assess the validity of the database. This is, in general, one of the main weaknesses of such databases. Although a large number of patients are entered, their representativeness of the overall population, and the accuracy of their data are open to question. Furthermore, the relatively small size of the study, 165 cases, limited set of variables, and retrospective design do not allow causal relationships to be established because of the likelihood of bias and confounding.

Bearing these significant limitations in mind, the current study offers some interesting findings. Overall, about 1 in 4 patients had a complication recorded. A new neurological deficit was the most common complication, reported in 11.5% of patients. This rate places it about in the middle of the range reported in the literature, and the authors present a reasonable discussion of the differences between the current study and prior investigations. The performance of an osteotomy was associated with a new neurological deficit in the current study, but only a small number of patients (16 overall) were reported to have had an osteotomy. Neuromonitoring was not found to have any relationship with the occurrence of a new neurological deficit, but multiple confounding variables could affect that association.

The current study offers a glimpse of the kind of information that can be obtained from registries. They are the most practical way to determine the frequency of rare outcomes and the outcomes of treatment for rare conditions. It is essential, however, that clinical, not administrative, databases be developed to answer clinical problems, and that methods are used to ensure the integrity of the data and the validity of the findings.

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