Do benefits overcome the risks related to surgery for adult scoliosis? A detailed analysis of a consecutive case series

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Abstract

Purpose The surgical approach to adult spine deformities is complex and presents a high incidence of complications.

Methods We report here a prospective consecutive case series analysis of 20 patients submitted to posterior correction and instrumented fusion for adult degenerative scoliosis. Clinical outcomes were assessed by self-reported measures. Pre-operative and post-operative complications were analysed during a mean 30-month follow-up period.

Results Eleven patients (55 %) presented pre-operative or post-operative complications. Fifteen different complications occurred, six in the early pre-operative period and nine during follow-up period: ten of these complications occurred in patients who underwent a previous surgery for spine disease.

Conclusions The clinical improvement at the final follow-up resulted as statistically significant only for the group of patients exposed to posterior fusion without interbody fusion. The observations reported here have to be considered for a shared decision-making in the management of adult scoliosis.

Keywords Adult degenerative scoliosis · Posterior instrumented arthrodesis · Posterior lumbar interbody fusion (PLIF) · Transforaminal lumbar interbody

fusion (TLIF) · Pre-operative and post-operative complications

Introduction

Adult deformity is a significant health issue within the ageing population in the world communities. According to Aebi, adult scoliosis can be separated into four major groups, type 3 being subdivided into two subtypes [1]:

- Type 1: primary degenerative scoliosis (“de novo” form), mostly located in the thoracolumbar or lumbar spine.
- Type 2: progressive idiopathic scoliosis in adult life of the thoracic, thoracolumbar, and/or lumbar spine.
- Type 3: secondary degenerative scoliosis, consequent to:
 - Subtype 3a: idiopathic scoliosis or other forms of scoliosis.
 - Subtype 3b: metabolic bone disease (mostly osteoporosis) combined with asymmetric arthritic disease and/or vertebral fractures.

The common complaints in patients affected by adult deformity are back pain, complications associated with neural compression (radicular pain and claudication symptoms), neurological deficit, progression of the curve, and cosmesis [1]. Surgeons are generally conservative in the treatment of adult scoliosis because of the complication rates associated with the surgical procedures and poor bone quality endemic in this population. A prerequisite for surgical intervention is usually failure of all appropriate conservative care. The surgical approach to adult degenerative scoliosis is complex in terms of decision-making to choose the patient and the procedure appropriately.

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Although it is typically for the relief of pain and disability that patients seek and surgeons propose the surgical treatment for adult scoliosis, there is little literature to support the premise that surgery offers these benefits [2–4]. Studies highlighted that complications remain a common occurrence and a significant concern in adult scoliosis surgery, with rates ranging from 10 to 40 % on middle-age adults and higher in the elderly patients. Despite the high complication rates, recent evidence demonstrates the potential benefits of surgical treatment for adult scoliosis, reporting a significant improvement of the outcome measures as compared with baseline measures [5–7].

In order to evaluate if the decision-making process concerning the treatment of adult deformity may be considered correct or if it requires some adjustments, we analysed a consecutive series of patients who underwent surgical treatment for adult degenerative scoliosis in a single institution during a 30-month period. We evaluated and reported the benefits, in terms of clinical outcomes, pain relief, quality of life, radiographic correction, and the risks associated with pre-operative and post-operative complications.

Patients and methods

In this case series analysis, 20 patients (average age 55.3, ranging from 40 to 74 years; 14 females and 6 males) underwent surgical treatment for adult degenerative scoliosis during a 24-month period. Pre-operative, demographic data and data concerning the type of scoliosis are collected in Table 1. Eleven patients had previous spine surgery.

Table 1 Demographic data and types of scoliosis

Number of patients	20
Gender	
Female	14
Male	6
Average age	55.3 years (40–74)
Classification of scoliosis	
Type 1	
Primary degenerative scoliosis, “de novo” form	11
Type 2	
Progressive idiopathic scoliosis in adult life	4
Type 3	
Secondary degenerative scoliosis	5
Type 3a	1
Type 3b	4

Surgical technique

All patients underwent posterior laminectomies, instrumented reduction and fusion at an average 10 vertebrae, ranging from 5 to 18 instrumented vertebrae with pedicle screw constructs. Twelve patients underwent fusion at thoracolumbar-sacral level, four at thoracolumbar level and four at lumbar-sacral level. The proximal extent of the fusion was T4 = 4, T8 = 4, T10 = 8, T12 = 3, L2 = 1. The distal extent of the fusion was L1 = 1, L4 = 1, L5 = 2, S1 = 16. Four patients had fixation to the sacrum and twelve patients had fixation to the sacrum and iliac wings. The length of the fusions is reported in Table 2. In addition to posterior fusion, some of the patients had interbody fusion at one or more levels. Five patients had a PLIF at 1 or 2 levels with a PEEK cage filled with autologous and allogenic bone graft. PLIF levels included L3–L4 in one patient, L4–L5 in three patients and L5–S1 in one patient. One patient, who presented an additional lumbar vertebra, had a PLIF at L5–L6 level and at L6–S1 level. Nine patients had TLIF at one, two or three levels with a PEEK cage filled with autologous and allogenic bone graft. TLIF levels included L1–L2 in one patient, L2–L3 in four, L3–L4 in three, L4–L5 in four, and L5–S1 in five patients.

Pre-operative and post-operative clinical analysis

Clinical data were collected pre-operatively and post-operatively at different periods of follow-up (3, 6, 12, 18, 24 and 36 months after surgery). Previously to the surgery and during the follow-up, all patients underwent surveys concerning Visual Analog Pain score (VAS), Oswestry Disability Index (ODI) and Quality of life (EuroQoL 5D) to evaluate clinical outcomes of the surgery by self-administered questionnaires. Overall complications were recorded. Major complications were those that required a second surgery or those that resulted in permanent neurological deficit.

Table 2 Length of the fusions

Type of fusion	Number of cases
T4-ileum	2
T4-L1	1
T4-L4	1
T8-ileum	4
T10-ileum	5
T10-L5	2
T10-S1	1
T12-ileum	2
T12-S1	1
L2-S1	1

Pre-operative and post-operative radiographic analysis

Anteroposterior, lateral bending, and sagittal full spine standing radiographs were performed pre-operatively and post-operatively at different follow-up periods to measure deformity curvature and flexibility. Successful fusion and proper positioning of the hardware were examined by radiographs and CT scan at 1 year follow-up.

Statistical analysis

Statistical analysis of the data was performed by calculating means, standard deviations, standard errors of the mean and *p* values by *t* Student's test. *p* < 0.01 was considered statistically significant.

Results

All the patients who received indications for surgical treatment had a long history of failed conservative care, constant back pain of high intensity (average VAS score 8.5, range 5–10) and high degree of disability (average ODI score 57 %, range 40–94 %) (Table 6). On the basis of Aebi classification [1], eleven patients presented primary degenerative scoliosis (“de novo” form, type 1), four patients were affected by progressive idiopathic scoliosis in adult life (type 2); and five patients presented secondary degenerative scoliosis, one with type 3a (as a consequence of previously treated idiopathic scoliosis) and four with type 3b, as a consequence of previous fractures or lesions (Table 1). Most of patients presented a scoliotic curve at lumbar level, four patients had additional kyphosis at thoracic level or at the thoracolumbar transition and seven patients presented loss of sagittal curves (“flat back”).

Surgical treatment and complications

All patients underwent posterior laminectomies, instrumented reduction of the deformity and fusion. Most of them had additional interbody fusion with cage (PLIF or TLIF) (Table 3).

Nine patients (45 %) had a favourable post-operative course without significant complications at the early post-operative period or during follow-up period (Fig. 1). In these cases the length of hospital stay averaged 14 days.

As shown in Table 3, we observed 15 complications occurring in 11 patients (55 %). One patient, submitted to posterior fusion only, presented one early complication and two different complications during follow-up; another patient, where a TLIF was used, presented one early post-operative complication and one late complication after 15 months of follow-up; finally, a third patient, where a

Table 3 Pre-operative and post-operative complications

	Posterior fusion only	Posterior fusion and PLIF	Posterior fusion and TLIF	Total number of cases
Surgery cases of scoliosis	6	5	9	20
Patients having complications	2 (33 %)	4 (80 %)	5 (55 %)	11 (55 %)
Pre-operative complications	1	2	3	6 (40 %)
Neurological damage	0	1	2	3
Wound infection	1	0	1	2
Liquoral fistula	0	1	0	1
Early revision surgery	0	0	2	2
Post-operative complications	3	3	3	9 (60 %)
Wound infection	2	0	0	2
Hardware failure	1	2	3	6
Pseudoarthrosis	0	1	0	1
Late revision surgery	2	2	2	6
Total number of complications	4 (26.7 %)	5 (33.3 %)	6 (40 %)	15

PLIF was used, presented two related complications at 9 months of follow-up.

Six cases of complications (40 %) occurred in the early post-operative period, while nine cases (60 %) occurred during the follow-up period. Four cases (26.7 %) occurred in patients submitted to posterior fusion only, five cases (33.3 %) in patients who received PLIF in association with posterior fusion and six cases (40 %) occurred in patients who underwent TLIF in association with posterior fusion. In the group operated by posterior fusion only, two out of six (33 %) presented complications; the incidence was higher in the TLIF group (55 %) and significantly higher in the PLIF group (80 %). We observed 11 cases of major complications: eight cases of complications requiring re-intervention and three cases of permanent neurological damage (Table 3).

Major complications included hardware failure (40 %), wound infections (27 %), neurological damages (20 %), spinal fluid leakage (7 %) and pseudoarthrosis (7 %). A second surgery was necessary in 40 % of the patients (Table 4).

Eleven patients (55 %) had previous spine surgery (non-intact group) and nine patients (45 %) underwent their first spine procedure (intact group) (Table 5). We observed that

Fig. 1 Pre-operative and post-operative full spine radiographs of a patient who underwent posterior instrumented correction of adult scoliosis without any pre-operative or post-operative complication. **A1** Pre-operative anteroposterior full spine radiograph. **A2** Post-

operative anteroposterior full spine radiograph (1 year follow-up). **B1** Pre-operative lateral full spine radiograph. **B2** Post-operative lateral full spine radiograph (1 year follow-up)

Table 4 Percentage of patients who sustained major complications

Need for revision surgery	40 %
Hardware failure	40 %
Wound infection	27 %
Neurological damage	20 %
Liquoral fistula	7 %
Pseudoarthrosis	7 %

six patients from the non-intact group (54 %) had complications in the revision surgery, while complications occurred in five patients in the intact group (55 %). Considering the total number of complications, five (33.3 %) occurred in the intact group, while ten (66.7 %) occurred in the non-intact group. The incidence of pre-operative complications was significantly higher in the non-intact patients (83 %) as compared to the intact group (17 %). Also the incidence of late post-operative complications was higher in non-intact patients (55 %) with respect to the intact ones (45 %).

Among six cases of pre-operative complications, there were three cases of permanent neurological damages (one cauda equina syndrome, one external popliteal sciatic paralysis, and one neurological damage consequent to junctional syndrome and vertebral fracture), two cases of wound infection and one case of spinal fluid leakage (liquoral fistula).

Table 5 Complications in primary spine surgery cases or in revision spine surgery cases

	Primary spine surgery	Revision spine surgery	Total number of cases
Surgery cases	9	11	20
Patients having complications	5 (55 %)	6 (54 %)	11
Pre-operative complications	1 (17 %)	5 (83 %)	6
Neurological damage	1	2	3
Wound infection	0	1	1
Liquoral fistula	0	2	2
Early revision surgery	0	2	2
Post-operative complications	4 (45 %)	5 (55 %)	9
Wound infection	1	1	2
Hardware failure	3	3	6
Pseudoarthrosis	0	1	1
Late revision surgery	4	2	6
Total number of complications	5 (33.3 %)	10 (66.7 %)	15

During the follow-up period, five cases of hardware failure were detected after 2, 3, 9, 15 and 18 months, respectively. Post-operative hardware failures concerned

Fig. 2 Pre-operative and post-operative full spine radiographs of a patient who underwent posterior instrumented correction of adult scoliosis and PLIF. The patient presented a bar breakage 9 months after surgery, requiring re-intervention. Pre-operative anteroposterior

(**A1**) and lateral (**B1**) radiographs. Post-operative anteroposterior (**A2**) and lateral (**B2**) radiographs (9 months F.U.). Arrow shows the bar breakage. Anteroposterior (**A3**) and lateral (**B3**) radiographs performed 6 months after the revision

four cases of screws mobilisation, one case of rod mobilisation and one case of longitudinal rods breakage consequent to pseudoarthrosis. In five cases, a second surgery was necessary to remove and substitute the hardware. One of these cases is documented in Fig. 2. At follow-up, all the patients had good clinical and radiographic outcomes. In one case the failure of a sacral screw appeared as minor complication not requiring a second surgery.

Clinical outcomes

Patients undergoing surgical correction of adult degenerative scoliosis in this case series experienced a significant improvement in their overall pain (VAS score), functional ability (ODI score) and quality of life (Euro QoL-5D score) as compared to their pre-operative status (Table 6). After a mean of 30-month follow-up period (range 39–20 months), the pre-operative VAS scores averaged 8.5 (range 5–10) and improved to 4.5 (range 1–8), the pre-operative ODI scores averaged 57 % (range 40–94 %) improving to 35 % (range 0–66 %) and Euro QoL scores averaged 28 (range 10–70) improving to 59 (range 10–100). However, when we analysed separately the three different groups of surgical treatment (posterior-only, PLIF or TLIF) we observed that improvement of VAS, ODI and quality of life scores during the follow-up period was statistically significant only for the group of patients submitted to posterior fusion without interbody fusion. The TLIF group had a significant improvement only in the VAS score (Fig. 3).

Table 6 Assessment of overall clinical outcomes

	Pre-operative	Follow-up	Improvement (%)	<i>p</i> value
VAS score	8.5 (5–10)	4.5 (1–8)	47	0.0001 ^a
ODI score	57 % (40–94 %)	35 % (0–66 %)	39	0.0005 ^a
Euro QoL-5D score	28 (10–70)	59 (10–100)	54	0.0002 ^a

^a Extremely statistically significant

Radiographic outcomes

Curve correction in this series of patients improved to 64.3 % from 31.1°, pre-operative (range 11.8°–64.7°) to 10.5° post-operative (range 0.9°–31.9°) at latest follow-up (Table 7). When we analysed the three groups separately, the correction was 63 % in the posterior-only group, 70 % in the TLIF group and 60 % in the PLIF group. Sagittal balance at latest follow-up could be correctly evaluated for 14 patients and it was restored in 8 of them (57 %).

Discussion

The surgical complexity for adult scoliosis depends on many factors and it is increasingly understood today that spine fusion should be avoided whenever possible.

Fig. 3 Clinical outcomes in the surgical correction of adult scoliosis. **a** Pre- and post-operative VAS scores in patients with posterior-only fusion, posterior fusion with PLIF or posterior fusion with TLIF. **b** Pre- and post-operative ODI scores in patients with posterior-only fusion, posterior fusion with PLIF or posterior fusion with TLIF. **c** Pre- and post-operative EuroQoL scores in patients with posterior-only fusion, posterior fusion with PLIF or posterior fusion with TLIF. ** $p < 0.001$; * $p < 0.01$

Table 7 Radiographic measurements of scoliosis curves

Type of surgery	Pre-operative (°)	Follow-up (°)	Correction (%)
Total cases	31.1 (range 64.7–11.8)	10.5 (range 31.9–0.9)	64.3
Posterior fusion only	35.6 (range 45.6–15)	13.1 (range 25.4–1.3)	63.2
Posterior fusion and PLIF	28.9 (range 45–11.8)	11.6 (range 31.9–0.9)	59.9
Posterior fusion and TLIF	30 (range 64.7–15.7)	9 (range 18.8–1.5)	70

treatment in these patients and make them easily exposed to multiple and serious complications.

Thus, an accurate evaluation of benefits and risks for this kind of surgery is compelling for a patient and physician shared decision-making, which is very important for adult scoliosis treatment. However, there is a paucity of current peer-reviewed literature addressing the premise that adult spinal deformity patients benefit from surgical treatment [2–4]. Yadla et al. [8] in a recent systematic review analysed 49 articles reporting data in 3,299 patients, and found only four articles reporting on all specified outcome measures (change in ODI scores before and after surgery, change in SRS scores, curve reduction, complications, and pseudoarthrosis) [9–12]. The articles analysed reported a huge number of complications, with a pooled incidence of 41.2 % [8]. Mermer et al. [13] reported an overall complication rate of 69 %, with a propensity to sustain more complications for patients undergoing revision surgery with respect to patient undergoing primary surgery [13].

More recently, a retrospective review of data collected from six centres in France (analysing 306 patients) indicated a 39 % overall complication rate for primary adult scoliosis surgery; 26 % of patients were re-operated for mechanical or neurological complications and the risk of re-intervention resulted to be 44 % in the 6-year period after the primary procedure [14].

In the present study we report a detailed analysis of the clinical and radiographic outcomes and of complications occurring in a consecutive series of patients who underwent surgery for adult degenerative scoliosis, during the last 3 years. Collectively, an improvement has been obtained after the surgical treatment, both in terms of clinical and radiographic point of view. The clinical conditions and the outcome scores appear to be stabilised for

Unfortunately, up to now, there is not a better treatment available in severely degenerated and deformed spines. Several factors contribute to the complexity of the surgical

most patients after one-year post-operative period, as previously demonstrated [15]. However, it is relevant to underline that a huge number of complications have been detected during the pre-operative and post-operative period; 55 % of the patients presented complications during the early or late post-operative period and some patients had more than one complication at different follow-up periods. Our data also showed a higher incidence of complications associated with revision surgery with respect to primary spine surgery, confirming recent data reported in the literature [13, 16]. In particular, pre-operative complications incidence was significantly higher in case of second surgeries (83 %) as compared to primary surgeries (17 %). Also late post-operative complications were significantly more frequent in patients who underwent a previous surgery (66.7 versus 33.3 % for intact patients). A 40 % rate of re-intervention due to complications has been registered. The most common complications were problems related to instrumentation (40 %). In three cases a permanent neurological deficit occurred due to the damage of nerve roots consequent to the surgery.

Other evidence resulting from our study is the higher incidence of complications in patients who underwent interbody fusion (PLIF or TLIF) in addition to conventional posterior fusion. Posterior lumbar interbody fusion (PLIF) or transforaminal lumbar interbody fusion (TLIF) techniques have been introduced in the last years to achieve a better lumbar fusion and stabilisation, using specifically designed cages packed with bone graft [17–19]. However, none of these instrumentations has solved the problem of non-union in the complex pathology of degenerative scoliosis. As shown by recent reports [16], the results from our study indicate that the introduction of a new element of complexity, such as PLIF and TLIF, in the surgery for adult scoliosis can increase the risk of complications and it should be carefully evaluated in the surgical planning. When it is possible, the use of posterior fusion associated with decompression seems to be related to more satisfactory clinical outcomes and lower rate of complications as compared to the use of interbody fusion.

In the present study we reported a detailed analysis of clinical outcomes and complications, as a consequence of surgical treatment of adult scoliosis, and highlight the need for shared decision-making, along with a careful evaluation of the patient's pre-operative clinical conditions and extensive counselling to evaluate risks and benefits of the surgery.

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Conflict of interest None.

References

1. Aebi M (2005) The adult scoliosis. *Eur Spine J* 14:925–948
2. Smith JS, Shaffrey CI, Berven S et al (2009) Operative versus non operative treatment of leg pain in adults with scoliosis: a retrospective review of a prospective multicenter database with two-years follow up. *Spine* 34:1693–1698
3. Smith JS, Shaffrey CI, Berven S et al (2009) Improvement of back pain with operative and nonoperative treatment in adults with scoliosis. *Neurosurgery* 65:86–93
4. Bridwell KH, Berven S, Edwards C II et al (2007) The problems and limitations of applying evidence-based medicine to primary surgical treatment of adult spinal deformity. *Spine* 32:S135–S139
5. Cho KJ, Suk SI, Park SR, Kim JH, Kim SS, Choi WK, Lee KY, Lee SR (2007) Complications in posterior fusion and instrumentation for degenerative lumbar scoliosis. *Spine (Phila Pa 1976)* 32:2232–2237
6. Zimmerman RM, Mohamed AS, Skolasky RL, Robinson MD, Kebaish KM (2010) Functional outcomes and complications after primary spinal surgery for scoliosis in adults aged forty years or older. *Spine* 35:1861–1866
7. Smith JS, Shaffrey CI, Glassman SD, Berven SH, Schwab FJ, Hamill CL, Horton WC, Ondra SL, Sansur CA, Bridwell KH (2011) The spinal deformity study group. Risk-benefit assessment of surgery for adult scoliosis. *Spine* 36:817–824
8. Yadla S, Maltenfort MG, Ratliff JK, Harrop JS (2010) Adult scoliosis surgery outcomes: a systematic review. *Neurosurg Focus* 28:E3
9. Bridwell KH, Lewis SJ, Edwards C, Lenke LG, Iffrig TM, Berra A et al (2003) Complications and outcomes of pedicle subtraction osteotomies for fixed sagittal imbalance. *Spine (Phila Pa 1976)* 28:2093–2101
10. Shapiro GS, Taira G, Boachie-Adjei O (2003) Results of surgical treatment of adult idiopathic scoliosis with low back pain and spinal stenosis: a study of long-term clinical radiographic outcomes. *Spine (Phila Pa 1976)* 28:358–363
11. Buchowski JM, Bridwell KH, Lenke LG, Kuhns CA, Lehman RA Jr, Kim YJ et al (2007) Neurologic complications of lumbar pedicle subtraction osteotomy: a 10-year assessment. *Spine (Phila Pa 1976)* 32:2245–2252
12. Kim YJ, Bridwell KH, Lenke LG, Cheh G, Baldus C (2007) Results of lumbar pedicle subtraction osteotomies for fixed sagittal imbalance: a minimum 5-year follow-up study. *Spine (Phila Pa 1976)* 32:2189–2197
13. Mermer MJ, Boachie-Adjei O, Rawlins BA, Peskin M, Bhatnagar R (2006) Comprehensive analysis of cantilever, translational, and modular correction techniques in adults with scoliosis treated with surgery to the sacropelvis. *J Spinal Disord Tech* 19:513–522
14. Charosky S, Guigui P, Blamoutier A, Roussouly P, Chopin D (2012) Complication and risk factors of primary adult scoliosis surgery. *Spine* 37:693–700
15. Glassman SD, Schwab F, Bridwell KH, Shaffrey C, Horton W, Hu S (2009) Do 1-year outcomes predict 2-year outcomes for adult deformity surgery? *Spine J* 9:317–322
16. Sansur CA, Smith JS, Coe JD, Glassman SD, Berven SH, Polly DW Jr, Perra JH, Boachie-Adjei O, Shaffrey CI (2011) Scoliosis Research Society—Morbidity and mortality of adult scoliosis surgery. *Spine (Phila Pa 1976)* 36:E593–E597

17. Wu CH, Wong CB, Chen LH, Niu CC, Tsai TT, Chen WJ (2008) Instrumented posterior lumbar interbody fusion for patients with degenerative lumbar scoliosis. *J Spinal Disord Tech* 21:310–315
18. Crandall DG, Revella J (2009) Transforaminal lumbar interbody fusion versus anterior lumbar interbody fusion as an adjunct to posterior instrumented correction of degenerative lumbar scoliosis: three year clinical and radiographic outcomes. *Spine (Phila Pa 1976)* 34:2126–2133
19. Li F, Chen Q, Chen W, Xu K, Wu Q (2011) Posterior-only approach with selective segmental TLIF for degenerative lumbar scoliosis. *J Spinal Disord Tech* 24:308–312