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Case series

Functional outcomes following surgical treatment in patient with primary degenerative adult scoliosis

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ABSTRACT

Introduction: Primary adult degenerative scoliosis is one of the adult scoliosis group that presents in adult patient without history of scoliosis during childhood or adolescence. This condition may be asymptomatic, mild low back pain, radiculopathy symptoms, or may be causing severe low back pain and major neurological symptoms including weakness and numbness of the lower extremities which can affect the patient quality of life.

Case presentation: In this study, we presented seven cases of primary degenerative adult scoliosis that was treated either with decompression alone, decompression with short segment fusion and deformity correction, and decompression with long segment fusion and deformity correction. The parameters measured in this study were lumbar regional angle, Cobb angle, and pelvic parameters. The functional status of the patient was measured using Oswestry Disability Index (ODI).

Discussion: The main purpose for surgical treatment in primary degenerative adult scoliosis depends on the clinical presentation and also the patient's expectations .From the study, we found that all patient underwent surgery had improvement of functional status that measured with ODI score. The mean of pre operative ODI score was 49.70 (± 13.61 SD) (severe disability) and for post operative was 21.8 (± 13.40 SD) (moderate disability). Surgery decompressed the neural element and stabilize the spine.

Conclusion: Surgery treatment in patients with degenerative adult scoliosis was shown to have better functional outcomes regardless of the technique used. Further study with bigger sample with corresponding statistical analytic is mandatory.

1. Introduction

Adult scoliosis can be very broadly divided into three groups: adult idiopathic scoliosis; resulting from the natural progression of preexisting adolescent idiopathic scoliosis, primary adult degenerative scoliosis, and secondary adult degenerative scoliosis (usually due to other forms of scoliosis, problem in lower extremity such as leg length discrepancy, vertebral fracture, or any systemic condition that also affect the bone). Degenerative adult scoliosis can be defined as a scoliosis in adult patients who have no history of scoliosis during childhood or adolescence (no primary scoliosis) but then develop a coronal plane deformity in response with degenerative changes in the spinal column. Degenerative curves usually tend to be of a lower magnitude than idiopathic ones, in which lumbar curves is more common [1–3].

Similar to the other type scoliosis, this condition is defined as a 3-dimensional deformity when the Cobb angle measurement is more than 10°. There are many factors that contribute to the development of this type of scoliosis such as bone metabolic disease (osteoporosis), vertebral fracture, facet disorder, spondylosis, and degenerative disc disease. But none of these factors are known to be the direct cause of degenerative adult scoliosis. McAviney et al. reported that degenerative adult scoliosis is a condition that affects approximately 38% of the

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population, and is more dominant in females with age > 60 years old. They also estimated that by 2050, the world's population will be predominantly older people especially with age of >60 years and this condition will increase the prevalence of degenerative adult scoliosis and further will be a significant burden to health care systems throughout the world [2,3].

It is generally understood that the deformity associated with scoliosis will eventually result in spinal canal compression-related symptoms. These symptoms usually begin after the deformity is clinically seen and may mimic the symptoms of lumbar canal stenosis. Patients with degenerative adult scoliosis typically complain about low back pain, radiculopathy, or both of the symptoms; that worsens after higher than usual daily activity. In some cases, the symptoms from spinal stenosis in degenerative adult scoliosis are worse in the extension posture, and also noted in those patients with other forms of degenerative canal stenosis that can cause neurogenic claudication. But, it is important to differentiate these symptoms from the degenerative lumbar canal stenosis because the prognosis and the management would be different. Degenerative adult scoliosis will also progress similar to other types of scoliosis with the rate about 1-6^{o} per year (average 3^{o} per year) [4,5].

The symptoms in degenerative adult scoliosis are generally moderate, but it may lead to severe symptoms such as severe low back pain and major neurological symptoms including weakness and numbness of the lower extremities, which can alter the quality of life of the patient due to functional impairments. Although based on statisctics only 15% of the degenerative adult scoliosis patients have been reported to have symptoms, while another 68% are asymptomatic. Based on the estimation that has been mentioned above, the prevalence of degenerative adult scoliosis will continue to increase in the future, and that is why the understanding of degenerative adult scoliosis management has gained in urgency to increase the quality of life of the patients [4,5].

There are many measurable parameters that associated with degenerative lumbar disorders including degenerative adult scoliosis, namely lumbar regional angle, Cobb angle as mentioned above, and pelvic parameters. Pelvic parameters are also important since the sacral vertebrae form the bond and load transfer between trunk and lower extremities. The pelvic parameters include pelvic incidence (PI), pelvic tilt (PT), and sacral slope (SS). PI describes the position of the sacral plate in relation to the femoral heads, so, the lower the PI value, the more vertical the pelvic position is. PT is the angle between the line of sacral segment to the center of femoral head and vertical line. It represents the orientation of the pelvis which varies depending on the position. In normal standing position, the PT is approximately 13^{o} ± 6^{o}. The SS is an angle that represents the sacral plateau in relation to the horizontal line. Geometrically, PI is the sum of the PT and SS angle. Due to its attachment to the pelvic bone, the pelvic parameters will affect the entire sagittal balance of the spine, so, the greater the incidence, the greater sacral slope would mean the greater the lordosis or curvature of the lumbar spine. In relation with the sagittal balance, ideally the vertical axis from the center of the 7th cervical spine would drop slightly behind the axis of rotation of the femoral head [6].

The indications for surgery in degenerative adult scoliosis typically are persistent radiating pain despite the conservative therapy given or presence of neurologic deficit. There are several options in treating the degenerative adult scoliosis operatively, including: decompression, decompression with short segment fusion, or decompression with long segment fusion and deformity correction. The choice of the surgery method is individualized considering the cause of the symptoms, indications, advantages, disadvantages, and complications [7].

The patient's functional outcome is the one of the main goal in spinal surgery, in this study we will evaluate the patient's functional outcome with Oswestry Disability Index (ODI). But, there are many pre-operative variable that can affect the functional outcome in patients with degenerative adult scoliosis who undergo spinal surgery, including the severity and duration of the canal stenotic symptoms, the presents of neurologic deficit or spondylolisthesis. We also add the pelvic parameter as a variable in this study.

For this reason, the study aimed to measure the functional outcome following surgery in patient with primary degenerative adult scoliosis in Dr. Sardjito General Hospital. We also describe the variables that mgiht correlate with the patient's functional outcome.

This case report is presented and written in line with the SCARE 2018 criteria [13].

2. Methods

This is a descriptive study with seven cases included that were diagnosed with primary degenerative adult scoliosis and treated operatively in Dr. Sardjito General Hospital. The patients were admitted at Dr. Sardjito General Hospital in Yogyakarta from January 2018 until November 2020.

2.1. Inclusion criteria

The inclusion criteria in this study are:

1. Age above 60 years old
2. Coronal Cobb angle more than 10^{o}
3. Diagnosed with primary degenerative adult scoliosis

2.2. Exclusion criteria

The exclusion criteria in this study are:

1. History of adolescent scoliosis
2. History of major vertebral trauma
3. History of vertebral infection
4. Vertebral malignancy
5. Severe hip and knee joint pain
6. Leg length discrepancy
7. History of metabolic disorder

The surgery methods used in this study included decompression alone, decompression with short segment fusion and deformity correction, and decompression with long segment fusion and deformity correction.

Among these patients, one patient was treated with decompression alone, two patients was treated with decompression with short segment fusion and deformity correction while the other four patients were treated with decompression, long segment fusion, and deformity correction.

The parameters measured in this study were lumbar regional angle, Cobb angle, and pelvic parameters. The functional status of the patient was measured using Oswestry Disability Index (ODI). The ODI score before and after the surgery was recorded on all of the patients. We did the follow-up for ODI score evaluation at three months.

3. Case series

3.1. Case 1

A female, 66 years old had low back pain since 11 months ago and walk with aid. She was diagnosed with degenerative canal stenosis of the 3rd lumbar - 1st sacral spine Schizas and Lee severe Modic 3 without neurologic deficit, degenerative spondylolisthesis of the 3rd - 4th lumbar spine Meyerding grade I Frankel E with Scoliosis de novo and was no respons to conservative treatment and planned for operative procedure (Fig. 1).

In this patient we performed decompression at the level of 3rd – 4th and 4th – 5th lumbar spine. The patient was then stabilized with short segment fusion with pedicle screw at the level of 3rd – 5th lumbar spine and interbody fusion at the level of 3rd – 4th and 4th – 5th lumbar spine

Preoperative radiologic parameter	
Regional lumbar	: 19 ° lordotic
Cobb angle coronal	: 24°
Pelvic tilt	: 22 °
Sacral Slope	: 24 °
Pelvic incidence	: 46 °

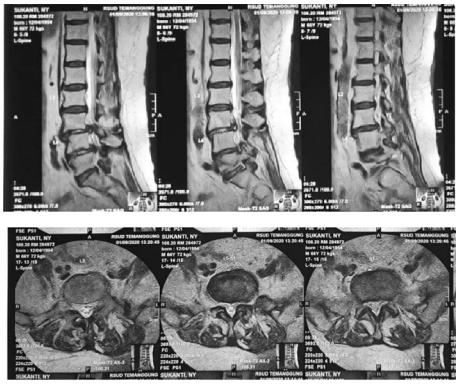
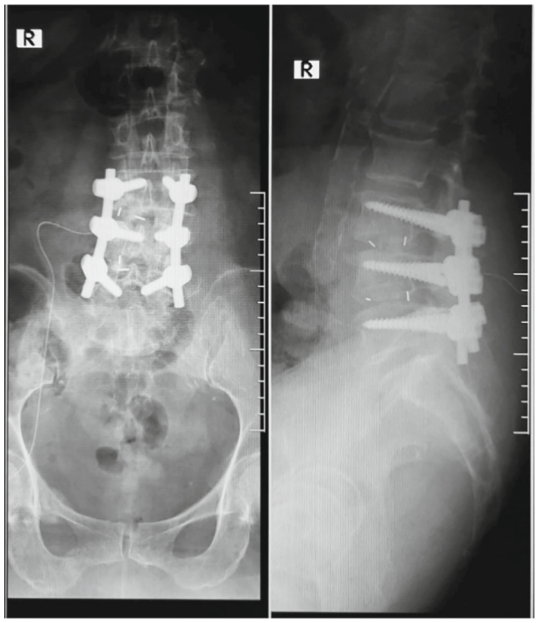


Fig. 1. Case 1 initial radiograph presentation.



Postoperative radiologic parameter :	
Regional lumbar	: 37° lordotic
Cobb angle coronal	: 8°
Pelvic tilt	: 29 °
Sacral slope	: 20 °
Pelvic Incidence	: 49 °

Fig. 2. Case 1 postoperative radiograph.

Preoperative Radiologic parameter:	
Regional lumbar	: 38° lordotic
Cobb angle coronal	: 21°
Pelvic tilt	: 22 °
Sacral Slope	: 24 °
Pelvic incidence	: 46 °

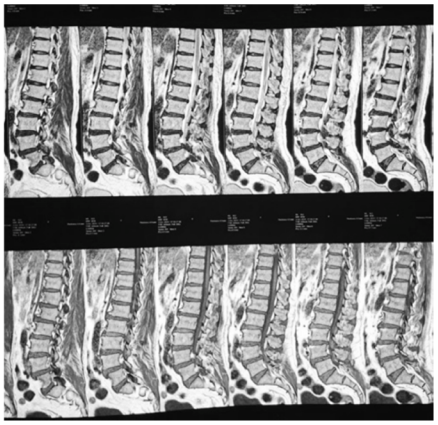


Fig. 3. Case 2 initial radiograph presentation.

(Fig. 2).

After the surgery there was correction of the Cobb angle from 24 degree to 8 degree with preoperative ODI score of 53.3% (severe disability) and postoperative of 17.3% (minimal disability).

3.2. Case 2

A male, 67 years old with pain in the lower back and radiate to the left leg since 6 months ago especially when doing activity. He also had reduce sensory in the left lower leg and was diagnosed with degenerative canal stenosis of the 3rd - 5th lumbar spine Schizas and Lee severe Modic 3 with neurologic deficit, Spondylolisthesis of the 4th and 5th lumbar spine Meyerding I Frankel D with scoliosis de Novo. The patient had no respons to conservative treatment and planned for operative procedure (Fig. 3).

In this patient we performed decompression at the level of 3rd – 4th and 4th – 5th lumbar spine. The patient was then stabilized with short segment fusion with pedicle screw at the level of 3rd – 5th lumbar spine and interbody fusion at the level of 4th – 5th lumbar spine (Fig. 4).

After the surgery there was correction of the Cobb angle from 21 degree to 10 degree with preoperative ODI score of 55.55% (severe disability) and postoperative of 20% (moderate disability).

3.3. Case 3

A male, 67 years old had complaint of pain in the lower back since 1 year ago and getting worse when he walk more than 100 m and relieve when he rest. Sensory neurologic deficit was documented. He was diagnosed with degenerative canal stenosis of the 12th thoracic spine – 4th lumbar spine Schizas and Lee severe Modic 3 with neurologic deficit, with Scoliosis de novo (Fig. 5).

In this patient we performed decompression at the level of 1st – 5th lumbar spine. The patient was then stabilized with long segment fusion with pedicle screw at the level of 12th thoracic - 5th lumbar spine with deformity correction (Fig. 6).

After the surgery there was correction of the Cobb angle from 25 degree to 11 degree with preoperative ODI score of 73.3% (crippled) and postoperative of 53.33% (severe disability).

3.4. Case 4

A male, 62 years old was complained about pain in the lower back and got worse when he had to walk in long distance. He diagnosed with degenerative canal stenosis of the 2nd lumbar-1st sacral spine Schizaz and Lee moderate Modic 2 without neurologic deficit with scoliosis de Novo and failed conservative treatment (Fig. 7).

In this patient we performed decompression only at the level of 4th lumbar – 1st sacral spine (Fig. 8).

After the surgery there was no correction of the Cobb angle with preoperative ODI score of 24 (moderate disability) and postoperative of 10 (minimal disability).

3.5. Case 5

A female, 63 years old complained about pain in the lower back region that radiate to the right leg since 2 years ago. She was diagnosed with degenerative canal stenosis of the 3rd – 5th lumbar spine Schizas and Lee moderate Modic 1 without neurologic deficit, Spondylolisthesis of the 3rd – 4th lumbar spine Meyerding grade I Frankel E and Scoliosis de novo. She was planned for operative procedure after there is evidence of instability (subluxation) (Fig. 9).

In this patient we performed decompression at the level of 3rd – 4th lumbar spine. The patient was then stabilized with long segment fusion with pedicle screw at the level of 1st - 5th lumbar spine and interbody fusion at the level of 3rd – 4th lumbar spine with deformity correction (Fig. 10).

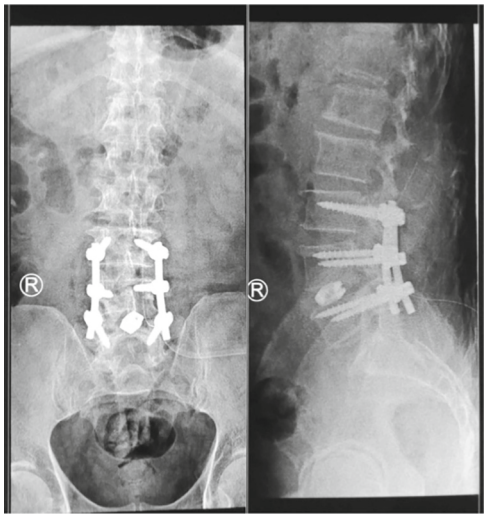
After the surgery there was correction of the Cobb angle from 20 degree to 7 degree with preoperative ODI score of 48.88% (severe disability) and postoperative of 20% (moderate disability).

3.6. Case 6

A male, 64 years old with complaint of low back pain with sensory deficit in the left leg since 9 months ago. He was diagnosed with degenerative canal stenosis of the 4th lumbar – 1st sacral spine Schizas and Lee moderate Modic 2 with neurologic deficit and Scoliosis de novo. The patient was planned for operative procedure due to progressive neurologic deficit (Fig. 11).

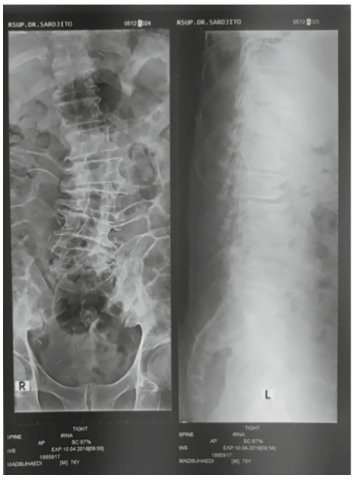
In this patient we performed decompression at the level of 4th lumbar – 1st sacral spine. The patient was then stabilized with long segment fusion with pedicle screw at the level of 3rd lumbar – 1st sacral spine with deformity correction (Fig. 12).

After the surgery there was correction of the Cobb angle from 12 degree to 3 degree with preoperative ODI score of 48.8% (severe disability) and postoperative of 20% (moderate disability).



Postoperative Radiologic parameter:
Regional lumbar : 28 ° lordotic
Cobb angle coronal : 10°
Pelvic tilt : 18 °
Sacral Slope : 35 °
Pelvic incidence : 53 °

Fig. 4. Case 2 postoperative radiograph.



Preoperative Radiologic parameter:

Regional lumbar	: 14° lordotic
Cobb angle coronal	: 25°
Pelvic tilt	: 20 °
Sacral Slope	: 12 °
Pelvic incidence	: 32 °

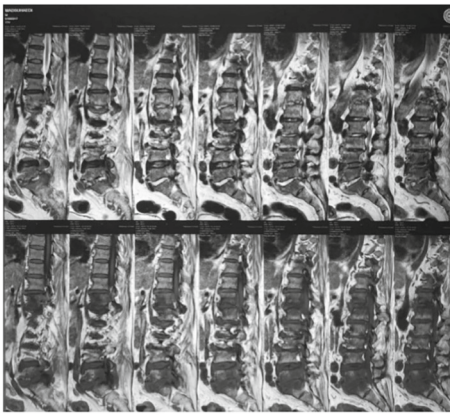
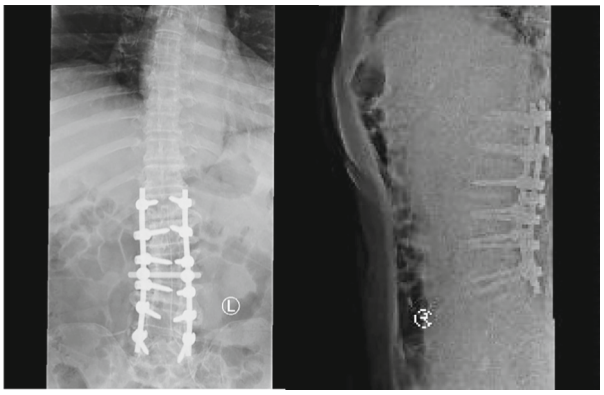


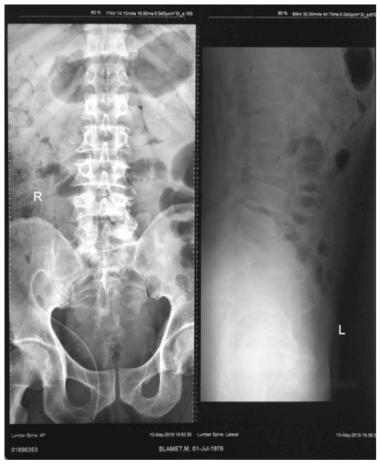
Fig. 5. Case 3 Initial radiograph presentation.



Postoperative Radiologic parameter:

Regional lumbar	: 19° lordotic
Cobb angle coronal	: 11°
Pelvic tilt	: 35 °
Sacral Slope	: 15 °
Pelvic incidence	: 20 °

Fig. 6. Case 3 postoperative radiograph.



Preoperative Radiologic parameter:

Regional lumbar	: 25° lordotic
Cobb angle	: 11°
Pelvic tilt	: 11 °
Sacral Slope	: 30 °
Pelvic incidence	: 41 °

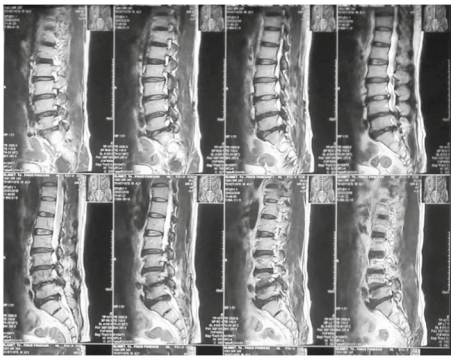


Fig. 7. Case 4 initial radiograph presentation.

3.7. Case 7

A male, 65 years old had complained about pain in the left lower back since 3 years ago. He was diagnosed with degenerative canal stenosis of the 2nd lumbar – 1st sacral spine Schizaz and Lee moderate Modic 3 without neurologic deficit, and de novo scoliosis and failed conservative treatment (Fig. 13).

In this patient we performed decompression at the level of 2nd lumbar – 4th sacral spine. The patient was then stabilized with long segment fusion with pedicle screw at the level of 12th thoracic – 5th lumbar spine with deformity correction (Fig. 14).

After the surgery there was correction of the Cobb angle from 25 degree to 17 degree with preoperative ODI score of 44% (severe disability) and postoperative of 22% (moderate disability).

Postoperative Radiologic parameter:
Regional lumbar : 25° lordotic
Cobb angle coronal : 11°
Pelvic tilt : 11 °
Sacral Slope : 30 °
Pelvic incidence : 41 °

Fig. 8. Case 4 postoperative radiograph.

Preoperative Radiologic parameter:
Regional lumbar : 34° lordotic
Cobb angle coronal : 20°
Pelvic tilt : 9°
Sacral slope : 20°
Pelvic incidence : 29°

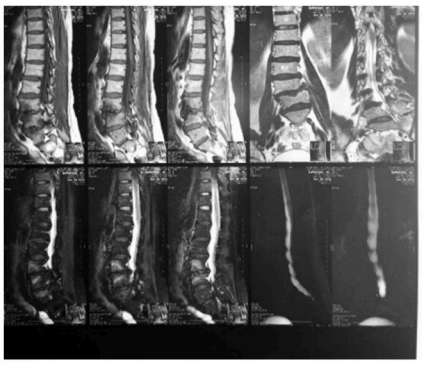
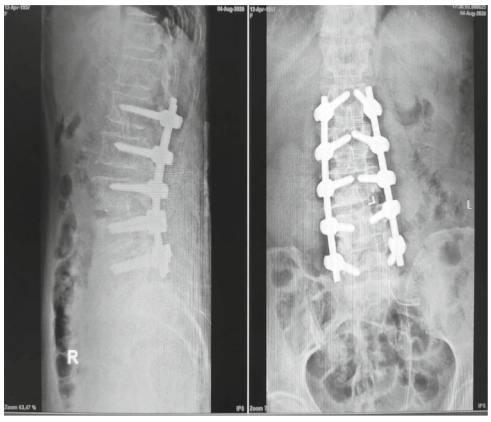


Fig. 9. Case 6 initial radiograph presentation.



Postoperative Radiologic parameters :
Regional lumbar : 48° lordotic
Cobb angle coronal : 7°
Pelvic tilt : 15°
Sacral slope : 16°
Pelvic incidence : 31°

Fig. 10. Case 5 Postoperative radiograph.

4. Result

From the study, we found that all patient underwent surgery had improvement of functional status that measured with ODI score. The mean of pre operative ODI score was 49.70 (± 13.61 SD) (severe disability) and for post operative was 21.8 (± 13.40 SD) (moderate disability). Complete result of the study is served in the table below (Table 1).

5. Discussion

The main purpose for surgical treatment in primary degenerative adult scoliosis depends on the clinical presentation and also the patient's expectations. As mentioned before, there are several options in treating the degenerative adult scoliosis operatively, including: decompression, decompression with short segment fusion, or decompression with long segment fusion and deformity correction. The decompression procedure will relieve the compression on the neural structure and hopefully will relieve the radicular and neurogenic symptoms. Decompression with

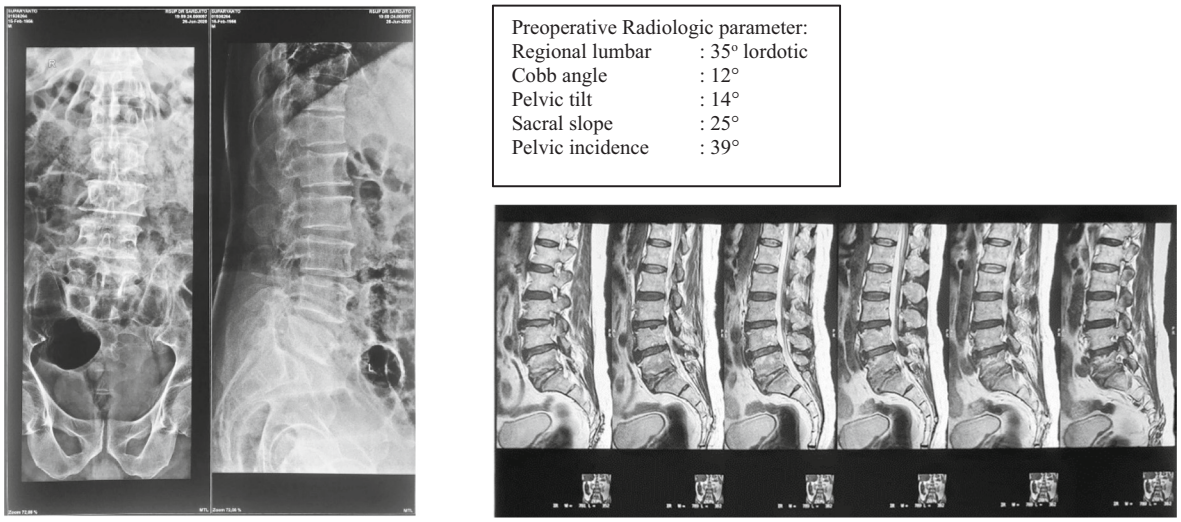


Fig. 11. Case 6 Initial radiograph presentation.

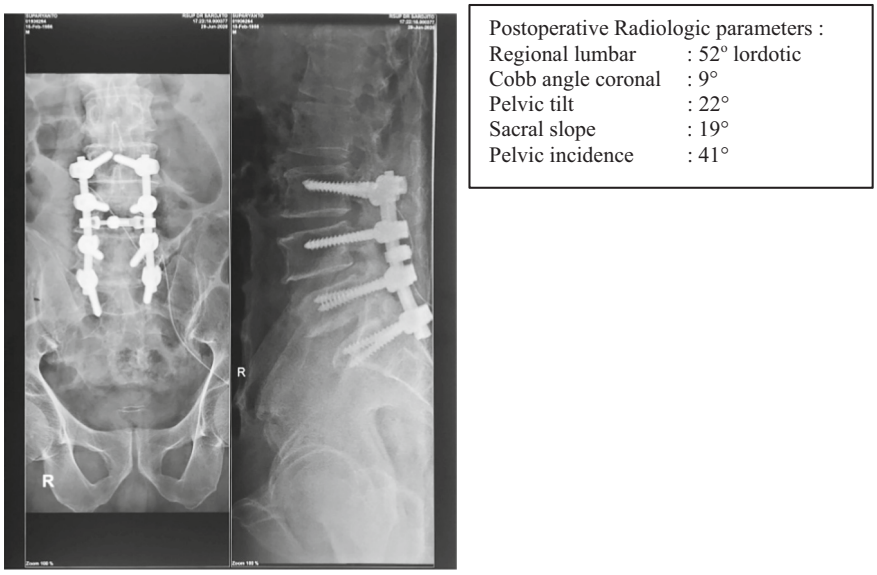


Fig. 12. Case 6 Postoperative radiograph.

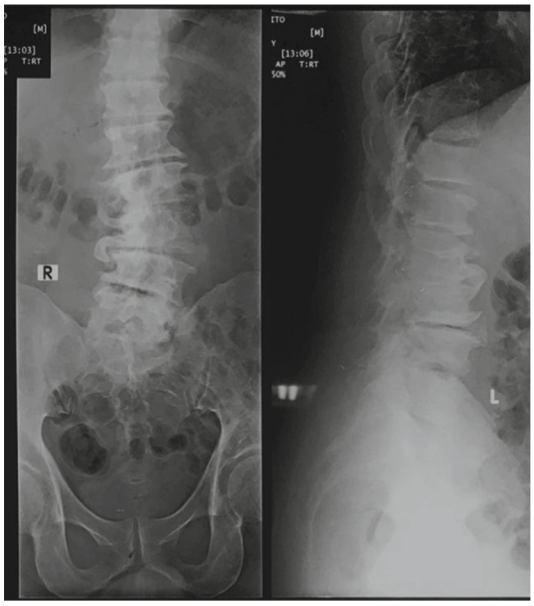
short segment fusion can prevent the spinal instability that arises from the decompression procedure. This procedure does not involve fusion to the whole curve, but only at the decompression level. This technique is usually used in patients with moderate scoliosis, and mild vertebral subluxation. The other option is decompression and long segment fusion with deformity correction. This technique is used when there is a large scoliosis curve and severe subluxation [7].

In this study, we presented seven cases of primary degenerative adult scoliosis that was treated with all of the procedures mentioned above. In patient with proven instability that was observed in plain X-ray, dynamic X-ray or MRI, we added the interbody fusion between the unstable vertebrae. The interbody fusion itself was first introduced by Cloward in 1953, and this method offers the advantage of achieving direct and indirect decompression of spinal canal, restoration of spinal column alignment and disc height, and an all-around arthrodesis. Interbody fusion procedure complications might happen depending on which approach is used including dural tear, nerve root injury in posterior lumbar interbody fusion (PLIF)/transforaminal lumbar interbody fusion (TLIF) or injury to abdominal viscera, peritoneal penetration, injury to great vessel in anterior lumbar interbody fusion (ALIF), and also psoas muscle injury, hip flexor weakness, nerve injury in extreme lateral lumbar interbody fusion (XLIF) [8].

We presented one patient with small scoliosis curve for about 11° without lateral subluxation. For this patient we performed decompression alone without any segmental fusion. We decided to do decompression alone considering the radiological and clinical symptoms were only radiating pain without any neurologic deficit and also without any prove of segmental instability. The ODI score preoperatively in this patient was 24% (moderate disability) and 10% (minimal disability) after 3 months follow up.

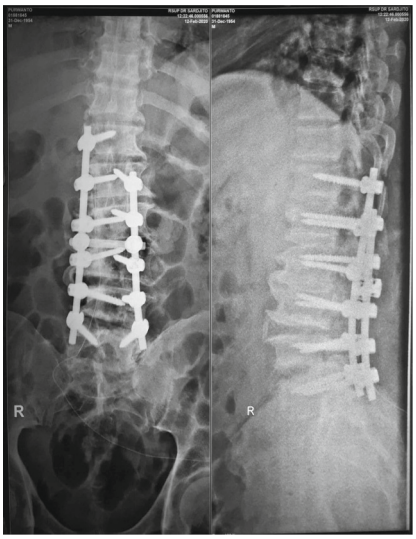
We presented two patients with scoliosis curve for 24° and 21°. In these patients we performed decompression, short segment fusion with pedicle screw and interbody fusion (PLIF), and deformity correction. The mean ODI score preoperatively was 54% (severe disability) and postoperatively 19% (minimal disability) after 3 months follow up.

Lastly, we presented four patients with mean scoliosis curve was 19°. In this group of patients we performed decompression, long segment fusion (pedicle screw ± interbody fusion), and deformity correction. The mean ODI score preoperatively was 54.6% (severe disability) and postoperatively it was 27.72% (moderate disability).



Preoperative Radiologic parameter:
Regional lumbar : 5° lordotic
Cobb angle coronal : 25°
Pelvic tilt : 17°
Sacral slope : 14°
Pelvic incidence : 31°

Fig. 13. Case 7 initial radiograph presentation.



Postoperative Radiologic parameters :
Regional lumbar : 21 °
Cobb angle coronal : 17 °
Pelvic tilt : 10 °
Sacral slope : 30 °
Pelvic incidence : 40 °

Fig. 14. Case 7 postoperative X ray radiograph.

In this study, surgical decompression and spinal correction have been shown to improve functional outcomes in patients with degenerative adult scoliosis. This is consistent with Faraaj et al. study that also showed that surgical management is superior to non-surgical management regarding of pain relief and improved function [5].

Compared to the deformity correction in adolescent scoliosis, there are increased risks of complications of surgical procedure in this population due to the possibility of body function impairment. Despite the high risk of complications in patients undergoing deformity correction surgery for degenerative adult scoliosis, most studies report a significant improvement in quality of life and a high rate of patient satisfaction [9].

We also observed some variables that might correlate with the functional outcome in patients. These variables include duration of symptoms before the surgery, presents of neurologic deficit, radiologic parameter (coronal Cobb angle and pelvic parameter), present of spondylolisthesis and the technique of the surgery. From the result of the study, we found that patient with shortest duration of pain prior the surgery (6 months) had an ODI score of 55.55% pre-operatively and 20% post-operatively. While the patient with the longest duration of pain prior surgery (3 years) had an ODI score of 44% pre-operatively and 22% post-operatively. This result consistent with the study conducted by Sigmundsoson et at. that showed patients with pain lasts <2 years prior surgery will have satisfaction almost 3 times over the patients who had pain lasts >2 years [10].

For the neurologic deficit, we observed there are 3 patients with sensoric neurologic deficit and the other 4 without any neurologic deficit. The mean of ODI score in patient with neurologic deficit pre-operatively is 59.24% (± 12.62 SD) and post-operatively is 31.1% (± 19.22 SD). While in patient without any neurologic deficit, the mean ODI score pre-operatively is 42.54% (± 12.93 SD) and post-operatively is 14.82% (± 4.62 SD). Foulongne et al study showed that presents of neurologic deficit is an important predictive factor for the outcome in patient who undergo surgery treatment. It is suggested that in patient with pre-operative neurological deficit have more favorable outcome compared the otherwise. But in this data, we found no significant difference of the ODI score changes in both group, this finding needs to be

Table 1
Result summary.

No	Identity	Age	Gender	ODI Score PRE (%)	ODI SCORE POST (%)	Instrumentation			Pelvic parameter						Coronal curve		Neurologic deficit	Time to occur (months)	Spondylolisthesis
						With-out	Short	Long	Pelvic tilt		Sacral slope		Pelvic incidence						
									Pre	Post	Pre	Post	Pre	Post	Pre	Post			Status
1	Case 1	66	Female	53,3	17,3		✓		22	29	24	20	46	49	24	8	Absent	11	Present
2	Case 2	67	Male	55,5	20		✓		22	18	24	35	46	53	21	10	Present	6	Present
3	Case 3	67	Male	73,3	53,3			✓	20	35	12	15	32	50	25	11	Present	12	Absent
4	Case 4	62	Male	24	10	✓			11	11	30	30	41	41	11	11	Absent	14	Absent
5	Case 5	63	Female	48,8	20			✓	9	15	20	16	29	31	20	7	Absent	24	Present
6	Case 6	64	Male	48,8	20			✓	14	22	25	19	39	41	12	9	Present	9	Absent
7	Case 7	65	Male	44	12			✓	17	10	14	30	31	40	25	17	Absent	36	Absent

confirmed in the future study with larger samples [11].

The presents of spondylolisthesis is documented in 3 patients with Meyerding grade I in all of those patient. The mean ODI score in this group of patient is 52.57% (± 2.77 SD) pre-operatively and 19.1% (± 1.27 SD) post-operatively. In the group of patients without spondylolisthesis, we documented 4 patients with mean ODI score pre-operative is 47.54% (± 6.76 SD) and post operative is 23.82% (± 17.42 SD). Sigmundsson et al in their study found that there is no difference in outcome of patients with or without spondylolisthesis that having spinal surgery, however in patient with spondylolisthesis, significant reduction in leg pain is predicted [10].

The radiological parameters that we observe in this study are the coronal Cobb angle and pelvic parameter. Yeh KT et al. study showed that functional outcome in patient with spinal surgery is correlate with radiological alignment parameter. They conclude that PT more than 23.4° is significantly correlates to poor ODI. Consistent with our study that showed one patient with PT = 35°, his ODI pre-operative was 73.3% (crippled) and post-operative 53.3% (severe diability), and this patient had the poorest ODI compared to the other patient. For the coronal Cobb angle, in this study we observe that in group patients with pre-operative coronal Cobb angle more than 20° (4 patients) had mean ODI 56.54% (± 10.6 SD) pre-operatively and 25.65% (±16.22 SD) post-operatively. While the other group with pre-operative coronal Cobb angle 20° or below (3 patients) had mean ODI 40.59% (± 11.73 SD) pre-operatively and 16.67% (± 4.71 SD) post-operatively [12].

Overall, we found that the patients diagnosed with primary degenerative adult scoliosis who were treated with surgery have better functional outcomes compared to their preoperative state. This finding is also consistent with many studies that recommend treatment with surgery procedure in the patients with primary degenerative adult scoliosis.

6. Conclusions

Surgical treatment in patients with degenerative adult scoliosis was shown to have better functional outcomes regardless of the technique used, decompression alone, decompression with short segment fusion and deformity correction, or decompression with long segment fusion and deformity correction. Limitation of this study is the small sample size.. Further study with larger sample size and more comprehensive statistical analysis is required to confirm the clinical significance of the surgery treatment options in patients with degenerative adult scoliosis.

Consent

Written informed consent was obtained from the patient for publication of this case report and accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal on request.

Provenance and peer review

Not commissioned, externally peer-reviewed.

CRediT authorship contribution statement

Terms	Definition	Person in charge
Conceptualization	Ideas; formulation or evolution of overarching research goals and aims	Yudha Mathan Sakti
Methodology	Development or design of methodology; creation of models	Yudha Mathan Sakti
Software	Programming, software development; designing computer programs; implementation of the computer code and supporting algorithms; testing of existing code components	Not available
Validation	Verification, whether as a part of the activity or separate, of the overall	Rahadyan Magetsari

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(*continued*)

	replication/ reproducibility of results/ experiments and other research outputs	
Formal analysis	Application of statistical, mathematical, computational, or other formal techniques to analyze or synthesize study data	Not available
Investigation	Conducting a research and investigation process, specifically performing the experiments, or data/ evidence collection	• Rezky Winda Saraswaty • Aristida Cahyono Putra
Resources	Provision of study materials, reagents, materials, patients, laboratory samples, animals, instrumentation, computing resources, or other analysis tools	• Rezky Winda Saraswaty • Dwi Budhi Susanto
Data curation	Management activities to annotate (produce metadata), scrub data and maintain research data (including software code, where it is necessary for interpreting the data itself) for initial use and later reuse	• Akbar Mafaza • Dwi Budhi Susanto
Writing - Original Draft	Preparation, creation and/or presentation of the published work, specifically writing the initial draft (including substantive translation)	• Akbar Mafaza • Anak Agung Ngurah Nata Baskara
Writing - Review & Editing	Preparation, creation and/or presentation of the published work by those from the original research group, specifically critical review, commentary or revision – including pre-or postpublication stages	• Bagus Yudha Pratama • Anak Agung Ngurah Nata Baskara
Visualization	Preparation, creation and/or presentation of the published work, specifically visualization/ data presentation	Bagus Yudha Pratama
Supervision	Oversight and leadership responsibility for the research activity planning and execution, including mentorship external to the core team	Rahadyan Magetsari
Project administration	Management and coordination responsibility for the research activity planning and execution	Aristida Cahyono Putra
Funding acquisition	Acquisition of the financial support for the project leading to this publication	Yudha Mathan Sakti

Declaration of competing interest

No potential conflict of interest relevant to this article was reported.

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