CASE REPORT

Spontaneous improvement of lateral spondylolisthesis on scoliosis after correction of scoliosis deformity

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ABSTRACT

Introduction: Scoliosis is a three-dimensional deformity of the spine. Scoliosis can be divided into three types: congenital, neuromuscular, and idiopathic. Sometimes lateral spondylolisthesis is also present in patients with scoliosis deformity. Understanding the pathophysiology of these two abnormalities is very important to achieve optimal treatment. Then, only correcting one deformity will improve both.

Case presentation: We found five patients with idiopathic scoliosis accompanied by lateral spondylolisthesis. All five patients complained of a curved back without back pain. The x-ray found that all lateral spondylolisthesis were located in the lower curve. The surgeon decided to correct the scoliosis deformity. The fusion is performed by determining Lower Instrumented Vertebra (LIV) scoliosis. Only two patients had the level of lateral spondylolisthesis within the instrumented vertebra. There is no specific corrective surgery for the patients' spondylolisthesis. The authors found that all patients improved lateral spondylolisthesis after correcting and fusing their scoliosis.

Discussion and Conclusion: Scoliosis has its challenges for orthopaedic spine surgeons. Spondylolisthesis associated with scoliosis generally occurs in the lower lumbar segment. The pathoanatomic of spondylolisthesis concomitant with scoliosis can be grouped into three theories: patients with spondylolisthesis whose scoliosis occurs later and have a history of family members with scoliosis, patients with spondylolisthesis concomitant with scoliosis who complain of sciatic pain, and patients who have olisthetic vertebrae. Each of these theories will lead to appropriate treatment actions. Deformity correction is aimed at one pathoanatomic but improves both abnormalities if the appropriate treatment is taken.

Keywords: Scoliosis, Spondylolisthesis, Spine, Surgeons, X-Rays

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INTRODUCTION

Scoliosis is a three-dimensional deformity of the spine: In the coronal plane, it is characterized by the presence of an abnormal lateral curve; in the sagittal plane, it can be characterized by an abnormal kyphotic deformity, and in the axial plane, scoliosis is characterized by a rotational deformity (Choudhry et al., 2016).

From the etiology, scoliosis can be divided into three kinds. First, congenital scoliosis begins in fetal growth during pregnancy and is characterized by hemivertebrae or bar body at the lateral aspect of corpus vertebrae. Second, neuromuscular scoliosis accompanies comorbid neuromuscular system disorders such as Duchenne muscular dystrophy, Marfan’s syndrome, and Ehlers-Danlos syndrome. Third, idiopathic scoliosis is a type of scoliosis whose cause has not been determined, and many factors can be the etiology of this type of scoliosis (Hoashi et al., 2013; Choudhry et al., 2016).

Based on the three types of scoliosis above, the most common is idiopathic scoliosis. This type is further divided into three sections based on the age range. Infantile idiopathic scoliosis occurs from birth to less than three years of age. Juvenile idiopathic scoliosis occurs at the age of three years to less than ten years. Adolescent idiopathic scoliosis (AIS) occurs at the age of 10 years to less than 18 years (Hoashi et al., 2013; Slattery and Verma, 2018).

Several studies have been conducted to determine the incidence of idiopathic scoliosis in a community group. De Sauza et al., who conducted a study in Goiania, Brazil, found a scoliosis prevalence rate of 4.3%. In Indonesia, especially in Surabaya, a study on the prevalence of scoliosis was conducted by Komang et al., which got a figure of 2.93%. This prevalence rate will be more varied compared to other regions or community groups (DeSouza et al., 2013; Komang-Agung et al., 2017).

Any person is said to have scoliosis if they have a spine with an abnormal curve of 10 degrees or more. The Cobb angle method is used to measure the curve of the spine. Spine surgeons generally use the Lenke classification. The classification divided scoliosis into six groups based on the nature of the patient’s curve. This classification combines a lumbar spine modifier and a thoracic sagittal profile to assess the overall scoliosis curve in both sagittal and axial planes (Hoashi et al., 2013; Choudhry et al., 2016; Slattery and Verma, 2018).

In Lenke classification, the curve will be divided into three: proximal thoracic (PT), main thoracic (MT), and lumbar/thoracolumbar (L/TL). Each curve has an apical vertebra and an upper and lower-end vertebra. The apical vertebrae are vertebrae on one curve that undergo maximal rotation and minimal inclination, while the upper and lower-end vertebrae are those that undergo minimal rotation but maximal inclination. (see table 1) (Hoashi et al., 2013; Slattery and Verma, 2018).

On one occasion, scoliosis was associated with spondylolisthesis. Both scoliosis and spondylolisthesis are idiopathic. Research conducted by Lehman et al. found that 4.38% of 1266 patients had scoliosis with concomitant spondylolisthesis (Lehman et al., 2011). Likewise, a study by Hershman et al. of 349 scoliosis patients found that 4.58% had spondylolisthesis (Hershman et al., 2013).

Spondylolisthesis generally performs surgery if the patient complains of pain for six months with no improvement by medical intervention or vertebral slippage that continues or reaches 50% (Hershman et al., 2013). Whereas in scoliosis with posterior stabilization fusion, the terms upper instrumented vertebra (UIV) and lower instrumented vertebra (LIV) are known. It is considered to preserve the mobile unit of the intervertebral disc as much as possible (Kim et al., 2021). At the same time, spondylolisthesis is usually located in
the lower lumbar, which is sometimes below the LIV. This condition becomes polemic when
the patient undergoes fusion. Understanding the pathophysiology of these two problems is
very important to achieve optimal treatment. In this recent study, the authors described a
case series of spondylolisthesis on scoliosis deformity.

**Table 1. Lenke Classification**

<table>
<thead>
<tr>
<th>Type</th>
<th>Curve</th>
<th>Proximal thoracic</th>
<th>Main thoracic</th>
<th>Thoracolumbar/lumbar</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Main thoracic</td>
<td>Nonstructural</td>
<td>Structural</td>
<td>Nonstructural</td>
</tr>
<tr>
<td>2</td>
<td>Double thoracic</td>
<td>Structural</td>
<td>Structural</td>
<td>Nonstructural</td>
</tr>
<tr>
<td>3</td>
<td>Double major</td>
<td>Nonstructural</td>
<td>Structural</td>
<td>Structural</td>
</tr>
<tr>
<td>4</td>
<td>Triple major</td>
<td>Structural</td>
<td>Structural</td>
<td>Structural</td>
</tr>
<tr>
<td>5</td>
<td>Thoracolumbar/lumbar</td>
<td>Nonstructural</td>
<td>Nonstructural</td>
<td>Structural</td>
</tr>
<tr>
<td>6</td>
<td>Thoracolumbar/lumbar main thoracic</td>
<td>Nonstructural</td>
<td>Structural</td>
<td>Structural</td>
</tr>
</tbody>
</table>

**Lumbar spine modifier**

<table>
<thead>
<tr>
<th>Modifier</th>
<th>CSVL to the lumbar apex</th>
<th>Thoracic sagittal profile</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>CSVL between pedicle</td>
<td>-(below normal) &lt;10°</td>
</tr>
<tr>
<td></td>
<td>CSVL touches apical bodies</td>
<td>N(normal) 10°-40°</td>
</tr>
<tr>
<td>B</td>
<td>CSVL completely medial</td>
<td>+(above normal) 40°</td>
</tr>
<tr>
<td>C</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(Slattery and Verma, 2018)

**CASE PRESENTATION**

The authors describe five patients with idiopathic scoliosis who also had spondylolisthesis.
All patients were women. The authors used the Lenke classification to categorize these
patients. The distribution of patient data can be seen in Table 2. The patient came to our
hospital complaining of a crooked back without back pain. The patients can carry out their
daily activities usually. Based on the patient's complaints, the authors conducted an
examination in the form of a whole anteroposterior (AP) and lateral spine x-ray in a
standing position. Then, the patient’s abnormal curve using the Cobb angle method (see
Figure 1). The patients were diagnosed with idiopathic scoliosis from the physical and
radiological examination. The size of the abnormal curve of all patients is described in Table
3.

**Table 2. Distribution of patient**

<table>
<thead>
<tr>
<th>No</th>
<th>Gender/ Age</th>
<th>Diagnosis</th>
<th>spondylolisthesis level</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>F/ 21 y.o</td>
<td>AIS Lenke 2A (N)</td>
<td>L5-S1</td>
<td>PSF T2-L3</td>
</tr>
<tr>
<td>2</td>
<td>F/ 15 y.o</td>
<td>AIS Lenke 4B (N)</td>
<td>L4-L5</td>
<td>PSF T3-L4</td>
</tr>
<tr>
<td>3</td>
<td>F/ 23 y.o</td>
<td>AIS Lenke 5B (N)</td>
<td>L2-L3</td>
<td>PSF T7-L4</td>
</tr>
<tr>
<td>4</td>
<td>F/ 13 y.o</td>
<td>AIS Lenke 6C (-)</td>
<td>L3-L4</td>
<td>PSF T5-L4</td>
</tr>
<tr>
<td>5</td>
<td>F/ 20 y.o</td>
<td>AIS Lenke 3A (+)</td>
<td>L4-L5</td>
<td>PSF T4-L4</td>
</tr>
</tbody>
</table>
In addition, concomitant lateral spondylolisthesis was found in all five patients in the lower lumbar curve. According to grade Meyerding, the lateral spondylolisthesis is less than 25% (Koslosky and Gendelberg, 2020). The surgeon decided to perform scoliosis deformity correction surgery followed by posterior fusion. Selective upper instrumented vertebra (UIV) and lower instrumented vertebra (LIV) were determined. Shoulder imbalance is considered to determine UIV, while LIV is determined from the central sacral vertebral line (CSVL) (Kim et al., 2021). Two of five patients in this study, posterior stabilization fusion covered the level of lateral spondylolisthesis.

![Figure 1. X-ray AP whole spine and inset image with the yellow line showing the level of lateral spondylolisthesis](image)

A pre-bending rod was used to correct the deformity after the pedicle screw was placed, and a half-to-full facet osteotomy was performed. The surgeon uses rod de-rotation to obtain correction of vertebral rotation. There is no specific corrective surgery at the patient's lateral spondylolisthesis. However, the postoperative AP and lateral whole spine x-ray evaluation results showed improvement in lateral spondylolisthesis (see Figure 2).

**Table 3. The size of the abnormal scoliosis curve**

<table>
<thead>
<tr>
<th>No</th>
<th>Proximal Thoracic</th>
<th>Degree</th>
<th>Lumbar/Thoracolumbar</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>30</td>
<td>70</td>
<td>30</td>
</tr>
<tr>
<td>2</td>
<td>42</td>
<td>87</td>
<td>43</td>
</tr>
<tr>
<td>3</td>
<td>20</td>
<td>68</td>
<td>30</td>
</tr>
<tr>
<td>4</td>
<td>10</td>
<td>65</td>
<td>96</td>
</tr>
<tr>
<td>5</td>
<td>24</td>
<td>108</td>
<td>40</td>
</tr>
</tbody>
</table>
DISCUSSION

Scoliosis has its challenges for orthopedic spine surgeons. Experience and tricks are needed in the treatment of this deformity. Osteotomy alone is not enough to return the abnormal scoliosis curve to its proper shape. Maneuvers are required in deformity correction surgery, not infrequently a combination of the two maneuvers (Basobas et al., 2003; Chang, 2003; Theruvath et al., 2012).

It is crucial to classify according to Lenke. UIV and LIV are determined to achieve selective vertebral instrumentation. This step aims to preserve the mobility of the vertebrae but obtains maximum deformity correction (Kim et al., 2021). Because concomitant spondylolisthesis scoliosis is expected in the lower lumbar region, determination of LIV is critical to successful deformity correction. It is necessary to understand in advance the stable vertebra (SV) in the form of the most distal vertebra of the lowest abnormal curve bisected by the central sacral vertebra line (CSVL) (Trobisch et al., 2013). Generally, LIV is SV apart from other considerations.

The past literature has described six maneuvers in correcting scoliosis deformity: distraction-compression, segmental and global rod de-rotation, rod translation, direct vertebral rotation (DVR), cantilever bending technique, and vertebral coplanar alignment (Theruvath et al., 2012). In this study, the authors used global and segmental rod de-rotation to correct the scoliosis deformity. Despite its limitations in correcting abnormal curves, it is a safe maneuver to avoid fracture and even post-correction neurological deficits.

There is literature that divides the condition of lateral spondylolisthesis in scoliosis into two clinical types. Patients in the first group will complain of low back pain, which can radiate to both legs. Radiologically, this group had a slightly abnormal coronal curve, no more than 15 degrees. In the second group, patients rarely complained of low back pain and had a complete spine X-ray interpretation with an abnormally more significant curve in the coronal plane (Crostelli et al., 2012).
An understanding of the olisthetic vertebrae has been gained since Tojner (1963) published his observations of 237 patients with spondylolisthesis, 30% of whom were associated with scoliosis. The literature also states that the severity of the scoliosis curve is not affected by the spondylolisthesis grade. In comparison, the olisthetic vertebra is a vertebral segment that is rotated so that it slips from both the sagittal and coronal planes resulting in compensatory scoliosis of the overlying vertebra. A vertebral body is said to undergo olisthesis if the disc height to the underlying body is asymmetrical. One of the disc margins is narrowed and even collapsed (Tojner, 1963).

The pathoanatomic of association lateral spondylolisthesis with scoliosis is divided into three: 1. patients with spondylolisthesis whose history reveals a family member with scoliosis. This theory indicates that the pathoanatomic of the two are unrelated where scoliosis and spondylolisthesis occur idiopathically, 2. patients with spondylolisthesis who complain of sciatic pain so that the patient presents with a scoliosis deformity due to muscle spasm, 3. patients who have olisthetic vertebrae (Crostelli et al., 2012). The third theory aligns with the research conducted by Tojner et al. (Tojner, 1963).

Another piece of literature by Khashab et al. found lateral spondylolisthesis associated with scoliosis characterized by sciatic pain. The patient's scoliosis curve is around 15 degrees. While the degree of spondylolisthesis, they found 75% listhesis, according to Meyerding 4. After performing instrumentation and interbody fusion for the spondylolisthesis, the patient's complaints of pain were reduced. Postoperative x-ray evaluation revealed an improved scoliosis curve. This condition follows the second theory in the previous explanation (Khashab et al., 2020).

In this study, we found five patients with no family history of scoliosis. The patient also did not complain of back pain. Meanwhile, the x-ray evaluation revealed a sizeable abnormal curve more than 15 degree. We decided to treat scoliosis deformity. Postoperative x-ray showed improved lateral spondylolisthesis as the scoliosis curve improved. Based on the three theories described, it can be directed to the appropriate treatment. Surgery for lateral spondylolisthesis concomitant scoliosis is performed on only one pathoanatomic (Tojner, 1963; Crostelli et al., 2012; Khashab et al., 2020).

In the previous study, each indication for deformity correction surgery was mentioned. For scoliosis according to the size of the existing abnormal curve. Meanwhile, spondylolisthesis is determined by the patient's instability complaints, namely, pain that interferes with daily activities and does not improve after non-operative treatment, such as physiotherapy strengthening back muscles, and pain medication (Schlenzka et al., 2019).

CONCLUSION
Correction of scoliosis deformity accompanied by lateral spondylolisthesis is challenging for orthopedists, especially spine surgeons. Knowledge of the pathophysiology of lateral spondylolisthesis in the patient will determine which pathologist will be fused. In the discussion section, the three pathophysiological theories have been explained. Based on the literature, deformity correction is aimed at one pathoanatomic but improves both abnormalities if the appropriate treatment is taken. The authors suggest that deformity correction in scoliosis be taken in patients who do not complain of back pain. Meanwhile, correction of spondylolisthesis was performed on patients who complained of back pain, and the abnormal lateral curve did not exceed 15 degrees. If the deformity correction is scoliosis, the next thing that needs to be considered is LIV.
REFERENCES


