Adult Deformity

Yetişkin Deformite

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ABSTRACT

Adult deformity, which occurs with degeneration of the spine, is a pathology that has been seen usually in the older population. The patients with adult deformity have a pain and disability that develops within time. Adult deformity is different from adolescence idiopathic scoliosis because of its features. Primary degenerative scoliosis is the most common situation in adult deformities. Posterior dynamic stabilization systems can be used at the beginning period of progressive adult deformity. The treatment of adult deformity and scoliosis in advanced cases includes fusion along with osteotomies and instrumentations. Adult deformity has also high rates of both morbidity and complication.

KEYWORDS: Spinal deformity, Adult degenerative scoliosis, Fusion, Osteotomies

ÖZ

Yetişkin deformite omurganın dejenerasyonu sonucunda oluşan ve genellikle ileri yaşlarda karşımıza çıkan bir patolojidir. Yetişkin deformitede ağrı ve zamanla gelişen fonksiyon kaybı ön plandadır. Yetişkin deformite bu özellikleri ile idiopatik adelosan skolyozdan ayrılr. Primer dejeneratif skolyoz yetişkin deformiteler içinde en çok karşılaştığımız bir durumdur. İlerleyen yetişkin deformitenin başlangıc döneminde posterior dynamik stabilizasyon sistemleri kullanılabilir. İlerlemiş yetişkin skolyoz ve deformite tedavisi osteotomileri içeren füzyon ve enstrümantasyonu içerir. Erişkin deformite cerrahileri yüksek morbidite ve komplikasyon oranlarına sahiptir.

ANAHTAR SÖZÇÜKLER: Omurga deformitesi, Yetişkin dejeneratif skolyoz, Füzyon, Osteotomiler

INTRODUCTION

Adult deformity is a kind of deformity that progresses slowly and occurs in the elder population, and differs from idiopathic deformity with its radiological and clinical features, forming mechanism and treatment. Surgery indications, surgery strategies and medical treatments differ for idiopathic scoliosis.

Spinal canal stenosis, spondylolisthesis, rotational subluxation, lumbar hyperlordosis and rigid deformities occur with adult deformities. As a result, we cannot use adolescent idiopathic deformity criteria for the treatment of adult deformities.

CLASSIFICATION

Classification of most common pathologies is important. The classification maintains a unique language to understand the problem and creates a protocol for treatment. The surgeon can understand the problem without seeing the radiologic imaging and can decide on the treatment promptly if he/she knows the classification.

King and Moe (19) have managed to classify deformity in 1983 after attempts from the beginning of last century. This classification is important for thoracic deformity treatment (Table I). The authors have shown appropriate fusion levels and places of distraction instrumentation. This system has caused a decrease in the rates of late decompensation and revision surgery. There are two important deficits at this classification; It is not appropriate for newer segmental instrumentation systems (28) and does not include lumbar deformities (11). There was also no information about sagittal plan deformities in this classification (7,8,14).

The Lenke Classification that came afterwards includes all curve types, and detailed information about curves and sagittal plan deformities that are of the highest importance for this classification (22). This classification is commonly used (Table II). The importance of this classification is to be standard of fusion levels (23,24). We also know that there are some arguments about deformity levels (21).

We expressed that adult deformity differs from idiopathic adolescent deformity. Especially in adult cases, the deformity is at the lumbar region. Lumbar lordosis, oilioliseth and end-plate obliquity are important as radiological parameters in adult deformities (33). Degenerative parameters like lumbar stenosis, rotational subluxation and spondylolisthesis as well as sagittal imbalance play an important role at adult deformity classification (12). At first, Schwab made a classification which included these parameters (30). After that there were a lot of classifications. Nowadays we use the Schwab-SRS classification that is most popular and accepted (31). We disregard the other classifications to avoid confusion. Before making the last classification, firstly Jackson (16) then...
Roussoly (27) and Lafage (20) explained the importance of the pelvis which ensures a correlation between vertebra and lower extremities and provides sagittal balance. The last classification includes this knowledge. If an adult deformity would be classified, sagittal vertical axis (SVA), pelvic tilt (PT) and pelvic incidence (PI) and known PI-LL and lumbar lordosis (LL) must be included. These parameters that are related with pain and disability are very important at reconstruction surgery (20, 29). Schwab classification, which is the last accepted and corrected classification, includes these pelvic parameters. We have to remember this classification when trying to treat adult deformities.

In this classification basic curves are (34):

Curve type T;

If thoracic major curve is more than 30 degrees, the apical vertebra is T9 and higher.

### Table I: King and Moe Classification

<table>
<thead>
<tr>
<th>Location</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thoracic</td>
<td>I</td>
<td>Principal lumbar, secondary thoracic curve</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>Principal thoracic, secondary lumbar curve</td>
</tr>
<tr>
<td></td>
<td>III</td>
<td>Thoracic curve only (apex ≥T10)</td>
</tr>
<tr>
<td></td>
<td>IV</td>
<td>Long thoracic curve (extends to L4)</td>
</tr>
<tr>
<td></td>
<td>V</td>
<td>Double thoracic curve</td>
</tr>
<tr>
<td>Double major</td>
<td></td>
<td>Equally structural thoracic &amp; lumbar curves</td>
</tr>
<tr>
<td>Lumbar</td>
<td></td>
<td>Apex in lumbar spine</td>
</tr>
<tr>
<td>Thoracolumbar</td>
<td></td>
<td>Apex at thoracolumbar junction</td>
</tr>
</tbody>
</table>

### Table II: Lenke Classification

<table>
<thead>
<tr>
<th>Type</th>
<th>Proximal thoracic</th>
<th>Main thoracic</th>
<th>Thoracolumbar/lumbar</th>
<th>Curve type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Non-Structural</td>
<td>Structural (Major*)</td>
<td>Non-Structural</td>
<td>Main Thoracic (MT)</td>
</tr>
<tr>
<td>2</td>
<td>Structural</td>
<td>Structural (Major*)</td>
<td>Non-Structural</td>
<td>Double Thoracic (DT)</td>
</tr>
<tr>
<td>3</td>
<td>Non-Structural</td>
<td>Structural (Major*)</td>
<td>Structural</td>
<td>Double Major (DM)</td>
</tr>
<tr>
<td>4</td>
<td>Structural</td>
<td>Structural (Major*)</td>
<td>Structural</td>
<td>Triple Major (TM)</td>
</tr>
<tr>
<td>5</td>
<td>Non-Structural</td>
<td>Structural</td>
<td>Structural (Major*)</td>
<td>Thoracolumbar / Lumbar (TL/L)</td>
</tr>
<tr>
<td>6</td>
<td>Non-Structural</td>
<td>Structural</td>
<td>Structural (Major*)</td>
<td>Thoracolumbar / Lumbar-Main Thoracic (TL/L-MT)</td>
</tr>
</tbody>
</table>

**STRUCTURAL CRITERIA**

(Minor Curves)

*Major = Largest Cobb Measurement, always structural
Minor = all other curves with structural criteria applied

**LOCATION OF APEX**

(SRS definition)

<table>
<thead>
<tr>
<th>CURVE</th>
<th>APEX</th>
</tr>
</thead>
<tbody>
<tr>
<td>THORACIC</td>
<td>T2 - T11 - T12 DISC</td>
</tr>
<tr>
<td>THORACOLUMBAR</td>
<td>T12 - L1</td>
</tr>
<tr>
<td>LUMBAR</td>
<td>L1-2 DISC - L4</td>
</tr>
</tbody>
</table>

**Modifiers**

<table>
<thead>
<tr>
<th>Lumbar Spine Modifier</th>
<th>CSVL to Lumbar Apex</th>
<th>Thoracic Sagittal Profile</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>CSVL Between Pedicles</td>
<td>T5 - T12</td>
</tr>
<tr>
<td>B</td>
<td>CSVL Touches Apical Body(ies)</td>
<td>- (Hypo) &lt;10°</td>
</tr>
<tr>
<td>C</td>
<td>CSVL Completely Medial</td>
<td>N (Normal) 10° - 40°</td>
</tr>
</tbody>
</table>

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Curve type L;
If lumbar and thoracic major curves are more than 30 degrees, the apical vertebra is T10 or lower.

Curve type D;
There is a double major curve and each curve much more than 30 degrees.

Curve type N; Coroner curve or curves are not much more than 30 degrees. There is no major coronal deformity.

Sagittal’s modifiers are PI-LL, PT, SVA (Figure 1).

The first modifier is the difference between the PI and LL curve. It shows the proportional relation between PI and LL.

If the LL curve is lower than the PI curve you have to plan for performing an osteotomy or osteotomies. That is the importance of this knowledge.

PI; pelvic tilt + sacral slope
A line is drawn from the center of the S1 end-plate to the center of the femoral head and a second line is drawn perpendicular to line drawn along S1 endplate. The angle between the two lines is the pelvic incidence.

LL; It is estimated like the sagittal Cobb curve. The LL curve is intersected by the L1 upper end-plate target line and S1 lower target line.

The modifier is accepted as zero if the curve difference between PI and LL is lower than 10 degree.

If this curve is from 10 to 20 degrees, modifier is accepted as +. If it is more than 20 degrees, the modifier is accepted as ++.

PT is an important parameter in evaluation of spinal deformities. High PT is a sign of increased pelvic retroversion, and low PT curve means inadequate pelvic retroversion and compensation. Sagittal balance deteriorates more quickly (20). This parameter is related closely with pain and disability. It is also important for surgical strategy. In a recent study it is mentioned that patients who have got much more PT angle with same SVA need more osteotomies for providing stable instrumentation (32). Finally we can say that the PT curve is indicator of pelvis retroversion.

PT; a line is drawn from the center of the S1 endplate to the center of the femoral head. A second vertical line is drawn intersecting the center of the femoral head. The angle between the two lines is the pelvic tilt.

PT modifier is estimated as follows:
If the PT curve is lower than 20 degrees, it is accepted as zero.
If it is between 20–30 degrees, it is accepted as ‘+’; if the angle is much more than 30 degrees, it is accepted as ‘++’.

The last modifier is the Sagittal Vertical Axis (SVA). This is also a modifier closely related with pain and disability. SVA is the distance between plumb line and the sacrum posterior superior end.

If the distance is lower than 40 mm, the modifier is accepted as zero.
If the distance is between 40 mm and 95 mm, the modifier is accepted as ‘+’.
If the distance is much more than 95 mm, the modifier is accepted as ‘++’.

A case is used to present this classification more clearly. (Figure 2A,B).

Aebi (1) made a deformity classification for etiology. It is very important for understanding the adult deformity.

Type 1 Scoliosis; Primary degenerative scoliosis (de novo scoliosis) is usually seen at the thoracic and lower region in childhood (Figure 3A-E).

Type 2 Scoliosis; This is progression of adolescent thoracic, thoracolumbar and/or lower scoliosis.

Type 3 Scoliosis; secondary degenerative scoliosis;
   a) The idiopathic or other type of scoliosis progress and form this type. Also asymmetry of leg length, pelvic pathology or
lumbosacral transitional anomaly cause this type of scoliosis which is usually at thoracolumbar, lumbar or lumbosacral regions.

b) Metabolic bone disease (osteoporosis) with asymmetric arthritis or/and vertebra fracture (Figure 4).

Type 1 scoliosis is most common. In this group patients start their lives with a healthy spine but the spine starts to curve at older ages. Degenerative pathology begins from the intervertebral disc. The asymmetric degenerations of the disc make asymmetric loadings. As a result, the region where degeneration started curves slowly its own. Lysis of spine and foramens compress the roots and thus symptoms occur.

The other important group is type 3 b. In developed countries, osteoporosis is serious problem especially for women who live longer. Osteoporosis is also one of the main problems of older ages. Degenerations reduce vertebral resistance and thus excessive loading occurs and can cause acute vertebral fracture or progressive loss of vertebra height. The spine starts to curve.

Figure 2: SVA is always gravity line or over and over ideally. At the beginning of deterioration of sagittal balance SVA becomes in front the gravity line. A 59-year-old female had got operated for degenerative disk disease. Flat back syndrome was formed by the operation. Plumb line had slid in front of the gravity line. Sacrum had got retroversion to the back and thus PI had increased. Patient tried to flex the legs because of trying to put head line into the pelvis. Nevertheless sagittal balance could not be corrected.

CLINIC

The beginning of deformity is quite insidious. The degeneration that starts the loss of vertebral disc height progresses very slowly, especially in primer degenerative scoliosis. Most patients go to the medical center for pain. They lose time at wrong physical treatment programs and medications because vertebral ossifications are thought to be the reason of this pain.

Actually this approach is not wrong but there is missing point. You have to obtain all spine X-rays imaging that includes both femur heads every year to understand deformity progression. If deformity is caught at the beginning, it could be solved by minimal invasive surgery. However if deformity progresses, osteotomies and fusion having of high mortality and morbidity rate have to be used for these elder patients. Pain and disabilities are the main problems for progressive deformities. Degenerations causes pain. The stenosis of the vertebral canal and foramina also causes sciatica. Patients get worse and cannot move because of pain which is very hard to solve the causes of and thus other medical problems occur.
**TREATMENT**

Treatment is related with the degeneration stage. If it is at the beginning and not progressed, the combination of physical treatment, analgesics and anti-inflammatory drugs are beneficial.

You can use foraminal and spinal canal injection if there is minimal root compression. Deformity sometimes does not occur with any symptoms. You have to explain to patients that deformity could get worse and need surgical treatment.

You can manage the deformity with more minimally invasive surgery at the beginning period while sagittal modifier (PI-LL, PT, SVA) and sagittal balance are normal. Therefore you can prevent the progression. We suggest dynamic stabilization at the beginning period of deformity similar to other authors (10,35,36). We can see this suggestion in various articles. Thus you can manage the problem without progression and you do not need to make massive osteotomies and fusion. In advanced cases you have to make fusion. We recommend a hybrid system for these (36) (Figure 5). The vertebra is a mobile system. If you make rigid stabilization at one region, you could face some problems at the other levels. The most important problem is proximal junctional kyphosis which is anterior angulation of the vertebra at the end of the stabilization system (18) (Figure 6). The other problem is to connect this rigid system to pelvis. Two sacral screws are

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**Figure 3:** Primitive degenerative scoliosis makes up the bigger part of the adult deformities. Most of the patients have not got any problem at young ages. At elder ages the water ratio of the vertebral disc decreases and thus the height of the disc is decreased. Asymmetry of disc height, degeneration of facet joints, sliding of the spine in the front and back, and formation of osteophytes follow the degeneration mechanism. We see the 75-year-old female patient’s X-ray imaging. **A)** we can see the major pathology on X ray imaging from at 67-years-old patient. **B,C,D)** we see prominent degeneration and scoliotic deformity on a 75-year-old patient’s X ray imaging. **E)** we see the spine corrected by fusion and instrumentation.
usually not enough for this. Anterior or posterior fusion must be done at the L5-S1 level. You can also use iliac screw or iliac instrumentation for providing a rigid system (2,9,13,39). It is a massive surgery and causes much blood loss. In advanced deformity surgeries you have to think of the pelvic parameters, coronal and sagittal balance for inhibiting to lose instrumentation and pseudoarthrosis. High mortality, morbidity, risks, massive blood loss are serious problem for these patients (3). Bono and Lee (5) found good result in 82%, fusion rate of 87%, complication rate of 55% in their review. This means that there is a lot of trouble at operation like bleeding and infection. The amount of blood loss changes from 360 ml to 7000 ml, and the average is 1500ml. This causes a serious cardiovascular problem and 70% of the these patients suffer complications (4,15,25). Serious blood loss that causes pulmonary, cardiac, renal problems could result in DIC and increased infection (6,26,38). Long hospitalization time also triggers psychological problems and increases the mortality risk (17,37). Knowing BMI is important because obese patients are much more under risk for complications (40).

We have to check the comorbidities of these patients to avoid complications. The real problem is to manage the deformity surgery. We are trying to establish a standard for how to do the deformity surgery. How can a person who suffered from deformity deal with deformity surgery? We do not know whether or not a patient get away pain and his/her problem related deformity. This decision of surgery belongs to the surgeon.

Figure 4: Osteoporosis and deformities related with osteoporosis form the major part of adult deformities. We see thoracic kyphotic deformity because of thoracic osteoporotic fracture and lumbar sciotic deformity because of lumbar osteoporotic fracture in a 79-year-old male.
Figure 5: 56 years old female had suffered from back pain while walking and standing and need sitting. At neurological examination there is no pathology. 40 degree lumbar deformity had occurred. Laminar, vertebral fusion was made by instrumentation at L2-L3 vertebra segment. Dynamic screws were put in L1 and L4 vertebrae for not forming fusion.
REFERENCES


Figure 6: A) 63 years old male patient with thoracal adult deformity (kyphosis and scoliosis) applied with some complaints which are dyspnea, fallen head to front and difficulty of walking. B) Kyphotic and scoliotic deformities were improved with fusion and instrumentation. C) Loosened screws due to proximal junctional kyphosis in thoracal area were removed.


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