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ADULT SCOLIOSIS

YETİŞKİN SKOLYOZU

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SUMMARY:

Adult scoliosis deformity afflicts a significant portion of the elderly and is increasing in prevalence. Back pain and deformity are major indications for surgery in adult scoliosis. Understanding the pathoanatomy and behavior of this disease would change the patient outcome. When selecting a treatment method, major symptoms and underlying medical disease should be carefully evaluated, not only to relieve symptoms but also to minimize complications. True decision of the surgical option and fusion levels that varies to patient needs evidence based approach. And this will decrease the unexpected results.

Key words: Adult scoliosis, diagnosis, surgical treatment

Level of evidence: Review article, Level V

ÖZET:

Yetişkin skolyozu; yaşlı populasyonun önemli kısmını etkilemekte ve prevelansı artmaktadır. Bel ağrısı ve deformite yetişkin skolyozunda cerrahi için major endikasyonlardır. Hastalığın patoanatomisini ve davranışını anlamak tedavi sonuçlarını değiştirebilir. Tedavi yöntemi kararını verirken asıl şikayetin ve altta yatan hastalığın dikkatli olarak değerlendirilmesi sadece sikayetleri ortadan kaldırmayı değil komplikasyonlarıda azaltır. Hastadan hastaya farklılık gösteren, cerrahi seçeneğin ve füzyon seviyelerinin doğru seçilmesi kanıta dayalı yaklaşım gerektirir ve bu istenmeyen sonuçları azaltacaktır.

Anahtar Kelimeler: Erişkin skolyozu, tanı, cerrahi tedavi

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INTRODUCTION:

Adult scoliosis defines a broad spectrum of deformity that can result from scoliosis in childhood or arise de novo from degenerative changes. Adult scoliosis has different epidemiologic, etiologic and symptomatic patterns then childhood scoliosis. Because of this, approach to adult scoliosis differs significantly from childhood scoliosis. In the child with scoliosis, the primary goal of care is to avoid the consequences of deformity progression. But in adult scoliosis patients characteristically present with pain, functional limitations, neural symptoms and symptomatic deformity resulting quality of life impairment. Improvement of present pain and disability is an important and measurable goal of treatment for adults with scoliosis.

The purpose of this review is to discuss the adult scoliosis that affect the spine and to define specific consideration that are useful in guiding and developing an evidence based approach to care.

EPIDEMIOLOGY:

Presently, a scoliotic curve of more than 10 degrees exists in 1.4 to 12 % of the population[47]. Adult scoliosis afflicts a significant portion of the elderly and is increasing in prevalence and ranges widely from 8.3 % to 68 % of population, with a higher prevalence occurring among older patients[2,8,34,21]. The source of variability is related to differences in definition of scoliosis, methods of defining cohorts, sample size and screening tools. Healey et al. identified curves over 10 degrees in more than 50 % of elderly females with back pain and osteoporosis[20]. Robin et al. identified some degree of scoliosis in 70 % of adults, between ages 50 and 83 with 30% of those having curves greater than 30 degrees[30]. The incidence of symptomatic adult scoliosis reportedly is 6 %, and the average age of those first seeking medical care is 60 to 69 years. Cosmesis tends to be the primary concern among adolescents with scoliosis.

PATHOPHYSIOLOGY AND NATURAL HISTORY:

Unlike adult idiopathic scoliosis, with its array of curve patterns, the degenerative scoliosis curve typically occurs in the lumbar spine. Degenerative scoliosis is usually seen in elderly adults over the age of 60. The scoliotic curve is caused by degeneration of the intervertebral disks and facet joints. The degeneration of these spinal column segments can cause instability leading to rotation, lateral listesis, spondylolistesis, kyphosis or osteoporosis with vertebral body compression fractures[48]. As patients age and develop further degeneration of the vertebrae and surrounding structures, their curves may progress at a faster rate. Adult degenerative curves are typically of smaller magnitude than those seen in adult idiopathic scoliosis[19].

The risk factors of curve progression may be a curve size over 30 degrees, an asymmetric disc above and below the apical vertebra, lateral subluxation of the apical vertebra over 6 mm and L5 vertebra being located above rather than below the intercrestal line[29].

DIAGNOSTIC EVALUATION AND IMAGING:

As in all scoliosis evaluation; during the physical examination of the patient, a three-dimensional assessment of the spine is appropriate to evaluate patient posture, neurological assessment, hip flexion contractures, leg length inequality, the presence of pelvic obliquity, evaluation of body habitus, and nutritional status.

Careful physical examination is important in the assessment of the deformity. Addressing the main complain is paramount. A big curve may be the main cause of symptoms or a big curve without symptoms may be with single root entrapment symptoms. Neural deficit and radicular symptoms are an important clinical presentation of adult scoliosis. Spinal canal stenosis and foraminal narrowing are common findings that may need to be addressed if they correlate with findings on history and physical examination. Surgeon should define if there is a correlation of nerve root's myotome and dermatomes with the pain distribution area.

Radiographic assessment of the adult with scoliosis requires occiput to femoral heads standing posterior anterior and lateral views. The cobb angles should be measured on the PA and side-bending radiographs. The stable, neutral and apical vertebrae should also be identified on the PA and side-bending films to aid with preoperative planning. Inadequate plain film evaluation may lead to an incomplete assessment of the cause and extent of deformity[22].

Advanced imaging with magnetic resonance imaging (MRI) or computer tomography (CT) scan is important to assess the role of decompression of the neural elements. **(Figure-1)** Intrinsic intervertebral disc degeneration is best measured with MRI and facet arthropaty is most apparent with CT scan. In the osteoporotic patient with compression fracture, MRI is also helpful in detecting recent fractures that may be amenable to non-operative or less invasive surgical options (vertebral augmentation). In patients with previous fusions or attempted fusions, CT and bone scans are useful to assess bony union or the presence of a pseudoarthrosis[14,4].

CLASSIFICATION:

The mostly used and simple classification of adult scoliosis is based on the onset of the scoliosis age. Adult idiopathic scoliosis, which begins during the adolescent period and continues throughout adulthood; and adult degenerative scoliosis, which develops post-adulthood[19,1,13].

It is difficult to make a clear differentiation between the two types of scoliosis. If a patient's scoliosis begins in adolescence, it is categorized as adult idiopathic scoliosis. However if the patient does not know exactly when the deformity began, the type may not be definitively determined (Table-1).

Aebi classification divides types based on causes, and helps in planning overall treatment and predicting the natural progress of scoliosis. Type I is primary degenerative scoliosis caused by degenerative changes in the vertebral disc asymmetry and the posterior articulation. Type II is progressive idiopathic scoliosis, which is caused by further development of idiopathic scoliosis that started before adulthood. Type III is secondary adult scoliosis. Type IIIa is caused by extra vertebral causes such as static scoliosis or pelvic inclination. Type IIIb is a type of bone metabolic disease similar to osteoporotic fracture and scoliotic deformity that is caused by weakness of vertebral bone[1].

The Scoliosis Research Society's (SRS) classification system categorizes the form of curvature into six different types and three modifiers, referencing the model of King's classification and Lenke classification for adolescent idiopathic scoliosis. The system focuses on radiographic features of spinal deformity and enables comprehensive categorization with inclusion of not only scoliosis, but also kyphosis[24].

Schwab classification focuses on the relationship between radiological findings and clinical evaluation, which categorizes the apex of the curve, lumbar lordosis and vertebral body subluxation based on radiological findings. Surgical management is more commonly performed in patients with decreasing lumbar lordosis and higher vertebral subluxation[35].

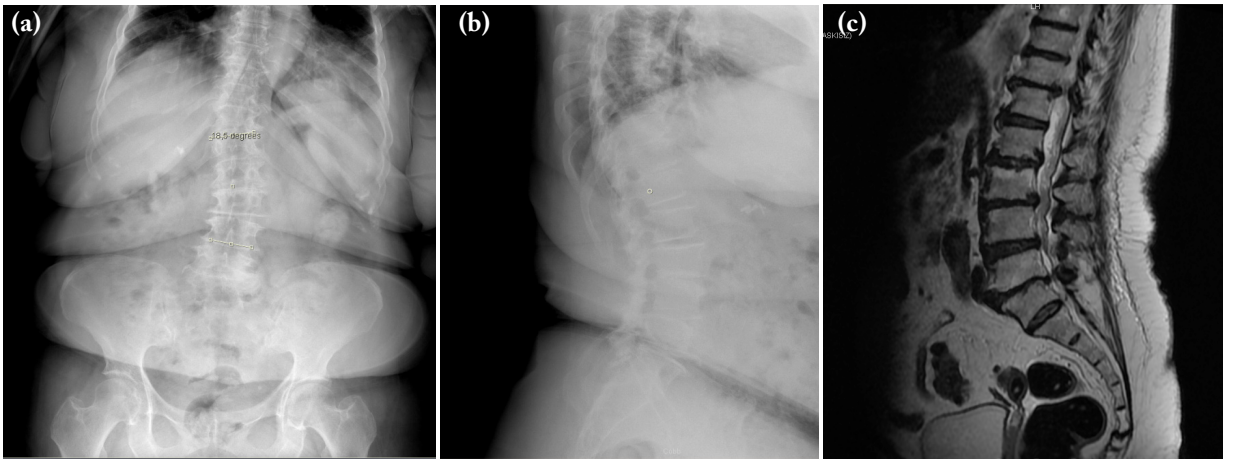

Figure-1. 74 year old female with radicular symptoms and back pain. **a.** PA roentgenogram of the patient with degenerative scoliosis. T12-L3 cobb angle was 18 degree. **b.** Lateral roentgenogram of the patient showing osteophyte formation and disk height reduction. **c:** Sagittal MRI of the patient showing disk degeneration , modic changes and spinal stenosis.

Table-1. Comparison of Type I and Type II Adult Scoliosis

Characteristic	**Type I**	**Type II**
Description	Primary degenerative (De novo) scoliosis	Progressive idiopathic scoliosis
Location	Thoracolumbar and lumbar spine	Thoracic, thoracolumbar or lumbar spine
Type of curve	Short, sharp	Long segment
Flexibility	Rigid	Semi- flexible
Predominant pathoanatomy	Asymmetric disk collapse, lateral listesis, wedging of vertebrae	Rotation, tilting of vertebrae
Symptoms	Back pain, radicular pain, claudication pain, fatigue, los of global balance	Back pain, loss of global balance, fatigue

SRS-Schwab classification considers the relationship between spino-pelvic parameters and sagittal balance. This system consists of four components: curve type, pelvic incidence minus lumbar lordosis modifier, global alignment modifier, and pelvic tilt modifier. Curve type is divided into T: thoracic only, L: TL/lumbar only, D: double curve with T and TL/L curves >30°, N: No major coronal deformity. This classification reflects the severity of disease and suggests guideline for treatment. But still there is no suggestion of specific treatment like fusion level of the deformity, so surgical methods should be individualized[36].

NONSURGICAL TREATMENT:

Nonsurgical management is offered as the first line of conservative care but its efficacy is not well supported in the literature. In the absence of neurological deficit or significant instability, non-operative care should be initiated with all patients. In the absence of cardiovascular contraindications, physical therapy, stretching, and aerobic conditioning are encouraged in such patients[37]. Other treatments for deformity include core strengthening, specifically aqua therapy, walking, cycling, plates, and yoga[31].

Only a few patients can benefit from temporary relief with bracing in combination with exercise as it has been shown to be ineffective in significantly preventing curve progression in adult spinal deformity[37,39,26]. Despite the possibility for pain relief, brace discomfort and trunk muscle balancing should be weighed in the decision making to use as a form of non-operative treatment. It is quite reasonable to consider the use of alternative treatments including acupuncture, chiropractic care.

Non-steroidal anti-inflammatory drugs (NSAIDs) can often alleviate the arthritic type of symptoms. However, it is critical to counsel the patients about the specific side effects such as gastrointestinal irritation, elevation of blood pressure, thrombocytopenia, and renal toxicity. Vestergaard et al. reviewed the risk of fractures associated with the use of NSAIDs. The study reported an increase in fracture risk associated with low doses of common pain relievers such as ibuprofen, diclofenac, and acetaminophen; they attributed this increase to falls as opposed to weakened bone structure[45].

Other non-narcotic medicines such as antidepressants and anticonvulsants could also be considered. If patients suffer from night pain and difficulty sleeping, tricyclic antidepressants can offer assistance with these problems. Gabapentin and pregabalin may decrease neurogenic pain and assist with sleep. However, the major side effect of such medications is sedation, and it is not well tolerated by some patients. If a patient cannot tolerate the side effects during the day, they often take it only at night for sleep and nerve pain relief[48].

In an acute exacerbation of back pain and radiculopathy, there may be some role for narcotic pain medicine. However, the chronic use of these medicines is not recommended. The long-term side effects and addiction potential should be strongly considered when prescribing these medicines. Vestergaard et al reviewed the risk of fractures associated with the treatment of morphine and opiate therapy. The study reported an increased fracture risk associated with morphine, fentanyl, methadone, oxycodone, nicomorphine, ketobemidone, tramadol, and codeine[46].

Injection therapy is another alternative non-operative option. Although the evidence for injection therapy as a tool to decrease or eliminate pain is not clearly defined in the literature, patients often experience extended pain relief with injection therapy, thus reducing the need for medication in such patients[15]. Injection therapy can include epidural steroids, facet blocks, nerve root blocks, and trigger-point injections. Non-operative treatments may be used alone or in any combination.

Glassman and colleagues reviewed the non-operative resource used by 123 adult with scoliosis. Patients treated non-operatively reported no improvement in pain or disability over a 2 year follow-up. This study brings into question the value of non-operative treatment commonly used for adult scoliosis patients[18]. Smith et al reported on a total of 317 patients who experienced back pain in adults with scoliosis. From the 317 patients involved in the retrospective review, 147 patients underwent surgery for adult deformity and 170 were treated non-operatively. At the 2-year follow-up evaluation, patients receiving operative treatment demonstrated significant improvement in patient outcomes reporting lower Numerical Rating Scale and Oswestry Disability Index (ODI) scores as compared with patients receiving non-operative treatment. The study concluded that surgical treatment can result in significantly improved back pain in those patients who are symptomatic[40]. Li et al reported on 83 patients, 34 of whom were treated operatively and 49 who were treated non-operatively. Compared with the non-operative group at 2-year follow-up, patients in the operative group demonstrated significant improvement in pain, self-image, mental health, health-related quality of life, and overall satisfaction with their treatment[23]. As reflected in literature, a lack of evidence exists to support the effectiveness of non-operative treatment[31,37].

SURGICAL TREATMENT:

The goal of surgery is to relieve back pain, improve radiating pain and claudication and correct deformity[5,25]. A combination of surgical options may be carried out to achieve these goals, including decompression, fusion and/or correction of deformity. Long level fusion including deformity correction may induce excessive blood loss and prolonged surgery time, both of which lead to more postoperative complications. If

such complications are anticipated, limited surgery can be selected considering the patient's age and general medical condition. However pain usually recurs when limited surgery is selected, and degenerative change may progress in the non-fused area, eventually causing adjacent segment disease.

Surgical options include: decompression alone; decompression and limited short fusion; and decompression and long fusion with correction of deformity. Surgery should be selected with a full understanding of the cause of symptoms while considering the advantages, disadvantages, indications and complications of each surgical option[3].

1. Decompression alone:

Although most patients require decompression surgery for radiating pain, decompression alone is not usually recommended in adult degenerative scoliosis. After wide laminectomy and facet joint resection, deformity and instability may worsen, causing recurrence of spinal stenosis[44]. However this method can be applied in elderly patients with poor medical conditions who have a high likelihood of per-operative complications. Nevertheless decompression alone at the apex of curvature is not indicated at which the lateral subluxation is severe. This procedure can be considered in small scoliosis curve without lateral subluxation.

2. Decompression and limited short fusion:

Limited short fusion in which decompression is performed is another option to prevent the spinal instability that arises from decompression alone. Limited short fusion does not involve fusion of the whole curve, but only a decompressed area. This technique is a good choice in moderate scoliosis curve and mild subluxation of the apical vertebra. Adjacent segment disease is a common complication with this method[9]. Degenerative changes may be accelerated outside of fusion when fusion stops within the deformity. Thus fusion should not be stopped at the apex of curvature, but should continue above the apex or stop below the apex.

3. Decompression and long fusion with correction of deformity:

When the lumbar scoliosis curve is large and subluxation of the apical vertebra is severe, correction of deformity is required. Improvement of back pain and successful fusion are attributed to the correction of scoliosis as well as restoration of lumbar lordosis and sagittal imbalance. Posterior instrumentation can achieve a correction of scoliosis. However it is difficult to restore lumbar lordosis[13,9]. And this lumbar lordosis usually requires anterior interbody release combined with anterior column support. Restoration of sagittal imbalance is achieved by anterior column support or additional techniques such as vertebral osteotomy[6].

For adult scoliosis surgical treatment, there are a lot of techniques and approaches that has been defined. These techniques include; osteotomy, colon resection, minimal invasive surgery, mini open surgery and etc. Surgical techniques and approaches, are beyond the scope of this review.

GENERAL PRINCIPLES OF SURGICAL TREATMENT:

These points mentioned below should be considered for surgical treatment of adult scoliosis.

1) General condition including medical co-morbidities: Selection of the surgical procedure is highly depends on the general condition of the patient. Patient's cardiopulmonary status, diabetes mellitus presence, increased tromboembolic event risk and etc. affects the procedure selection.

2) Osteoporosis: Osteoporosis can weaken fixation strength, causing loss of correction and pseudarthrosis. Segmental fixation and anterior column support may strengthen the fixation, and use of cement around the pedicle screw can enhance screw purchase.

3) Stiffness of curve: In stiff curve it is difficult to achieve optimal correction with surgery. In adolescent scoliosis, the compensatory curve is spontaneously corrected when the major curve is surgically corrected. However spontaneous correction is not as promising in adult scoliosis due to the decreased flexibility of the curve associated with degenerative change.

4) Coronal and sagittal imbalance: Accompanied coronal and sagittal imbalance is common in degenerative scoliosis. Sagittal imbalance leads to poor results in surgery, so that the restoration of imbalance is more critical than correction of scoliosis itself[17].

The fusion level for correction of deformity in degenerative scoliosis has a crucial consideration on the results of surgery. Generally the recognizable criteria to determine fusion level are as follows[19,1]:

1) Fusion should not be stopped at the apex of the curve.
2) The junctional kyphosis is included in the fusion.
3) The severe lateral subluxation is included in the fusion.
4) The spondylolisthesis and retrolisthesis are included in the fusion.
5) The upper instrumented vertebra is better to be horizontal than tilted.

There is debate about the proximal fusion level that it should be extended to T10 or stop at the lumbar spine. Fusion stopped at L1 is likely to cause adjacent segment disease at the thoracolumbar region. To prevent this, fusion up to T10 is recommended since T10 is more stable than T11 and T12 due to true rib attachment on T10. However some surgeons suggest that this cannot prevent adjacent segment disease

fundamentally, because it develops as a degenerative process[38]. Conversely fusion up to T10 is likely to cause more per-operative complications. Cho et al. reported that fusion to T11 or T12 was acceptable when the upper instrumented vertebra was above the upper end vertebra[10].

It is important to determine whether distal fusion level should be stopped at L5 or extend to the sacrum. The distal fusion usually goes to L5, since the apex of scoliosis is located at L2-4 and the L4-5 disc has degenerative changes. There is no doubt that fusion to the sacrum is performed in patients who have existing pathology at the L5-S1. However there is controversy regarding whether fusion stops at L5 or extends to the sacrum when the L5-S1 segment looks healthy[30,23]. Surgery in which the fusion stops at L5 compared to S1 is considered to be relatively small; however this may cause subsequent degeneration at L5-S1. Edwards et al. reported that 61% of patients under fixation at L5 showed degenerative changes, leading to sagittal imbalance and increasing risk of reoperation[16]. Accordingly it is preferable to fuse to the S1 in patients with sagittal imbalance, as it is highly likely to cause subsequent degeneration at the L5-S1 segment, even without degenerative change before surgery. Fusion to the sacrum achieve a better correction of sagittal imbalance than fusion to L5. However the complication rate is higher in the fusion to the sacrum. Pseudarthrosis, which is the most common complication at the L5-S1 segment, developed in 42% of cases of fusion to the sacrum, but 4% of cases of fusion to L5. To prevent pseudarthrosis, interbody fusion and additional iliac fixation are strongly recommended[11]. Sagittal decompensation after fusion to the sacrum is not uncommon, and therefore restoration of lumbar lordosis is critical to achieve sagittal balance[12].

COMPLICATIONS:

Complications are associated with all procedures. Surgical treatment for adult deformity, regardless of corrective procedure, is associated with high complication rates[19]. Literature-reported complications include pseudarthrosis, infection, neurological deficits, cerebrospinal fluid leaks, failure of implants, catastrophic injury, adjacent segment disease, systemic complications, and pulmonary embolism[27]. Sansur et al reported an overall complication rate of 13.4 % for treatment of adult scoliosis. The study concluded that osteotomies, revisions, and combined approaches resulted in significantly higher complication rates[32]. Smith et al retrospectively reviewed the rate of complications associated with surgery for scoliosis in relation to patient age[41]. The study concluded that older patients in comparison with younger patients had a significantly greater complication rate at 2-year follow-up. However, despite the greater risk of complications, elderly patients, in comparison to younger patients, demonstrated a greater extent of improvement in standardized measures of disability, pain, and health-related quality of life[43]. Smith et al reported a total infection (superficial and deep) rate of 3.7 % from 5801 adult scoliosis patients following surgery. The rate of infection also increased when surgery included a fusion[42]. Mok et al reported a reoperation rate of 26% at 2-year follow-up among 89 patients who underwent surgery to treat adult deformity as compared with 65% of patients who did not require a revision procedure[27]. Scheufler et al retrospectively reviewed the clinical outcomes and complications of 30 adult scoliotic patients. The study reported a major complication rate of 59.9 % and a minor complication rate of 23.4 %. Despite the high major complication rate, 83 % of patients were satisfied with the treatment at the 1-year follow-up[33].

CONCLUSION:

Adult scoliosis deformity can have a significant and measurable impact on an adult's health-related quality of life. The patient often has an associated comorbidity or osteoporosis. The goals of surgery are to treat pain, relive neurologic symptoms and maintain or restore global balance. The absolute degree of coronal curve correction and cosmesis is less important than the restoration of sagittal balance.

The surgery is technically demanding and associated with significant risk and morbidity. The key questions in surgical planning are the choice of fixation levels, extension of fusion across the thoracolumbar junction, choice of an L5 or sacral end point. The surgical approaches to adult deformity continue to evolve. New techniques and technologies are welcome, but caution is required to determine the indications and safety.

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