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Proposal of a New Treatment-Oriented Classification System for Spinal Deformity in Ankylosing Spondylitis

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Abstract

Objective: To describe and apply an optimal classification system for the management of ankylosing spondylitis (AS) that may be appropriate to make a preoperative surgical plan.

Background: The treatment choices of ankylosing spondylitis kyphosis remain controversial. The lack of a widely accepted classification system contributes to the variation in surgical decision making.

Methods: The classification is mainly based on radiographic findings. The sagittal deformity of spine in ankylosing spondylitis is classified according to three criteria: the location of the apex, the lumbar modifier (A, lumbar lordosis $<0^{\circ}$, and B, lumbar kyphosis $>0^{\circ}$) and the thoracic/thoracolumbar kyphosis severity modifier (− or +).

Results: The ankylosing spondylitis kyphosis can be divided into 4 types according to the location of the apex: Type I (lumbar), Type II (thoracolumbar), Type III (thoracic), Type IV (cervical or cervicothoracic junction). Either Type II or Type III is further divided into four subtypes based on the lumbar modifier and the thoracic/thoracolumbar kyphosis severity modifier: Type IIA−, Type IIA+, Type IIB−, Type IIB+, Type IIIA−, Type IIIA+, Type IIIB−, and Type IIIB+. Surgical decision making for AS kyphosis can be made according to the new classification.

Conclusion: This new classification system can be used effectively to classify AS kyphosis, which can be used to guide surgical decision making, including determining the site and the levels of osteotomies. Further research may be needed to validate the classification.

Keywords: Ankylosing spondylitis; Kyphosis; Spinal deformity; Classification

Introduction

Ankylosing spondylitis (AS), a chronic inflammatory disease, usually results in spinal deformity. The characteristic change of this deformity is a combination of a thoracic hyperkyphosis and a flattening of the lumbar lordosis, with the head and neck thrust forward and, then, causing a downward and forward shift of the patient's truncal center of mass. The patient's lower extremities are used to maintain the sagittal balance by extension of the hips, flexion of the knees, and plantarflexion of the ankles, because the other spinal segments of AS patients can not move to compensate. Patients with a sagittal imbalance cannot walk or stand erect without overwork of the musculature because of a compromised biomechanical advantage, which leads to muscle fatigue and activity-related pain, restricted activities of daily living, and causes intra-abdominal complications [1-3]. The goal of surgical correction of these patients is to restore an optimal sagittal balance, spinal alignment, and horizontal vision for obtaining satisfactory clinical results besides appearance [4-6].

Various types of corrective osteotomies were used for the management of AS kyphosis. Smith-Petersen described the first spinal osteotomy type, an opening wedge osteotomy, in 1945, by removing the posterior elements and

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extending the anterior column at the level of the disc space [7]. Pedicle subtraction osteotomy, a closing wedge osteotomy, is another osteotomy type for AS patients, in which the posterior elements, the pedicle, and body are carefully wedged and removed and the hinge is located at the anterior cortex of the vertebral body [8,9].

For AS kyphosis, decision on the appropriate surgery should be the focus on the following: (1) the ideal location of the osteotomy(ies); (2) the levels of the osteotomy(ies); and (3) the anchor points of instrumentation. However, there is no widely accepted classification system for spinal deformity of ankylosing spondylitis, which can contribute to variation in surgical decision making. An ideal system should be easy to learn and apply in clinical practice. The purpose of this investigation was to describe a new treatment-oriented classification system for the AS spinal deformity, and to detail the preoperative surgical plan according to this system.

Materials and Methods

Study design

Classification of AS deformity is mainly based on standing full-spine frontal and lateral radiographs. For patients whose whole spine cannot been included in the radiographs, three-dimensional reconstruction computed tomography (CT) of the spine is used. Total consecutive 258 patients who met the inclusion criterion of an AS with a kyphosis deformity and having undergone spinal osteotomy at our hospital were reviewed. The diagnosis of AS was made by radiographic features, laboratory tests, and clinical features according to the New York Criteria [10]. This classification has been conceived to provide a rationale for surgical planning in AS with spinal deformity, and only the sagittal deformity of the spine is taken into account, whereas other conditions, such as a coronal deformity, dislocation of the sacroiliac joints and the hip joints, etc, are not included.

Classification principles

Sagittal deformity of the spine, AS kyphosis, is classified according to the following three criteria: the location of the apex, the lumbar modifier, and the thoracic/thoracolumbar kyphosis severity modifier.

The main criterion of the classification is the location of the kyphosis' apex, because surgical decision making for AS kyphosis should focus on the location of the osteotomy(ies), and the levels of osteotomy(ies) and the osteotomy sites are usually chosen at the apex of the deformity that contributed most to the deformity. On the basis of the anatomy of the spine, four kinds of kyphoses can be identified, and four types of location of the apex can also be confirmed.

Lumbar kyphosis: The apex is located between the second and third lumbar disc and the caudad border of the fifth lumbar vertebra.

Thoracolumbar kyphosis: The apex is located between the cephalad border of the tenth thoracic vertebra and the caudad border of the second lumbar vertebra.

Thoracic kyphosis: The apex is located between the fourth and fifth thoracic intervertebral disc and the 9th and 10th thoracic intervertebral disc.

Cervical or cervicothoracic junction kyphosis: The apex is located between the caudad border of the second cervical vertebra and the caudad border of the fourth thoracic vertebra.

The second criterion is the lumbar modifier: A, lumbar lordosis $<0^\circ$, and B, lumbar kyphosis $>0^\circ$. The loss of the lumbar lordosis is often coexistent with the hyperkyphosis of the thoracolumbar and the thoracic spine. Theoretically, the loss of lumbar lordosis may contribute more to the sagittal imbalance than the same degree of hyperkyphosis of the thoracic spine owing to the former shorter arm [11,12]. Therefore, the condition of the lumbar alignment may partly affect the plan of the surgery. Usually, for lumbar kyphosis, lumbar osteotomy needs be performed to reconstruct the lumbar lordosis in order to correct the sagittal imbalance of the spine. The normal lumbar lordosis is between 20° and 40°. However, it is difficult to confirm the ideal lumbar lordosis because of significant normal variation of the lumbar lordosis and the pelvic incidence (PI). To describe the deformity more conveniently and learn the classification more easily, the cutoff of lumbar alignment is chosen as "0°," and two types of lumbar modifiers are defined: A, lumbar lordosis $<0^\circ$, and B, lumbar kyphosis $>0^\circ$.

The third criterion is the thoracic/thoracolumbar kyphosis severity modifier (−, or +). The Cobb angle degree of the thoracic and thoracolumbar kyphosis also should be considered. Though these conditions were not the main factors for a surgical plan, they may help to confirm whether a lumbar osteotomy can compensate these hyperkyphoses, and then help to make sure the levels of the osteotomy. We classify them into a minor group (−) and a larger group (+). In the thoracolumbar spine, the cutoff between − and + is 35 degrees, and in the thoracic spine the cutoff between + and − is 65 degrees.

Result

Four categories of deformity have been identified and described (Fig. 1, Table). In this classification, the kyphosis can be divided into four types according to location of the apex: Type I (lumbar), Type II (thoracolumbar), Type III (thoracic), and Type IV (cervical or cervicothoracic junction). There are no patients who were divided into Type IV in our hospital and we designed Type IV in our classification merely according to the literature [13-18] and the anatomy. Thus, subtypes of Type IV are not included in this classification. And then either Type II or Type III is further divided into four subtypes based on the lumbar modifier combined with the thoracic/thoracolumbar kyphosis severity modifier: Type IIA−, Type IIA+, Type IIB−, Type IIB+, Type IIIA−, Type IIIA+, Type IIIB−, Type IIIB+ (Fig. 1, Table).