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Review Article

Five major controversial issues about fusion level selection in corrective surgery for adolescent idiopathic scoliosis: a narrative review

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Abstract

BACKGROUND CONTEXT: Shoulder imbalance, coronal decompensation, and adding-on phenomenon following corrective surgery in patients with adolescent idiopathic scoliosis are known to be related to the fusion level selected. Although many studies have assessed the appropriate selection of the proximal and distal fusion level, no definite conclusions have been drawn thus far.

PURPOSE: We aimed to assess the problems with fusion level selection for corrective surgery in patients with adolescent idiopathic scoliosis, and to enhance understanding about these problems.

STUDY DESIGN: This study is a narrative review.

METHODS: We conducted a literature search of fusion level selection in corrective surgery for adolescent idiopathic scoliosis. Accordingly, we selected and reviewed five debatable topics related to fusion level selection: (1) selective thoracic fusion; (2) selective thoracolumbar-lumbar (TL-L) fusion; (3) adding-on phenomenon; (4) distal fusion level selection for major TL-L curves; and (5) proximal fusion level selection and shoulder imbalance.

RESULTS: Selective fusion can be chosen in specific curve types, although there is a risk of coronal decompensation or adding-on phenomenon. Generally, wider indications for selective fusions are usually associated with more frequent complications. Despite the determination of several indications for selective fusion to avoid such complications, no clear guidelines have been established. Although authors have suggested various criteria to prevent the adding-on phenomenon, no consensus has been reached on the appropriate selection of lower instrumented vertebra. The fusion level selection for major TL-L curves primarily focuses on whether distal fusion can terminate at L3, a topic that remains unclear. Furthermore, because of the presence of several related factors and complications, proximal level selection and shoulder imbalance has been constantly debated and remains controversial from its etiology to its prevention.

CONCLUSIONS: Although several difficult problems in the diagnosis and treatment of adolescent idiopathic scoliosis have been resolved by understanding its mechanism and via technical advancement, no definite guideline for fusion level selection has been established. A review of five major controversial issues about fusion level selection could provide better understanding of adolescent idiopathic scoliosis. We believe that a thorough validation study of the abovementioned controversial issues can help address them. © 2017 Elsevier Inc. All rights reserved.

Keywords: Adding-on; Adolescent idiopathic scoliosis; Coronal decompensation; Fusion level; Shoulder imbalance; Surgical treatment

Introduction

Two major advances in the management of idiopathic scoliosis over the past 30 years include the development of modern instrumentation techniques and the enhanced understanding of the nature of curvature. After several trials and errors, strong and secure instrumentation systems have been developed, which have led to marked improvements in postoperative

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patient care and in the amount of correction. However, adverse effects of modern instrumentation, such as coronal decompensation [1,2] or adding-on phenomenon [3], have also been observed. These unexpected complications primarily result from the incorrect determination of the fusion level.

To standardize the fusion level, several curve classification systems have been proposed by previous reports. The two most widely used classifications are those by King et al. and Lenke et al. [4,5]. Although the King classification is easy to use, it considers only the thoracic curve and coronal plane deformity. In contrast, the Lenke classification includes the lumbar curve and sagittal plane profile, and exhibits good interobserver and intraobserver reliability; however, the limitations include its complexity and the lack of consideration of rotational deformity [6].

With the advent of modern instrumentation systems involving segmental pedicle screw insertion, the fusion level to be selected now differs from that used in the traditional Harrington era. Nevertheless, the principles of fusion established by Moe remain valid [7]. A maximal amount of curve correction should be achieved to obtain a stable and balanced spine. Similarly, efforts should be made to save mobile segments, particularly in the lumbar spine. The prevention of postoperative shoulder imbalance is another controversial issue. In fact, there are many debatable issues related to fusion level selection. Among these, we selected five major issues and have reviewed the problems with appropriate examples and literature.

Selective thoracic fusion

Selective thoracic fusion (STF) remains the most debatable issue during the selection of fusion level. The STF concept was introduced for the correction of main thoracic (MT) curves and minor lumbar curves, including King type 2 or Lenke type 1B, 1C, or 3B (Fig. 1) [8,9].

In thoracic and lumbar double curves, the level of correction and fusion could involve either both the curves or only the thoracic curve. If both curves are included for fusion, a larger amount of correction is achieved, without any risk of persistence or progression of the lumbar curve. However, the inclusion of both curves also diminishes the number of mobile segments, which can become a large burden for patients in the long term. Selective thoracic fusion ensures the correction and fusion of only the thoracic curve, and hence, a greater number of mobile lumbar segments can be saved with a shorter incision. However, there is also a risk of decompensation, which can lead to persistence of the lumbar curve and consequently to deviation of the trunk. The fusion of both curves (or nonselective fusion) and STF can be divided by the distal level of the fusion for convenience: STF for L1 or above, and nonselective fusion for L2 or below.

Selective thoracic fusion is defined as the fusion of the major thoracic curve, where the minor lumbar curve is left unfused. By definition, a minor curve must have completely deviated from the midline (central sacral vertical line [CSVL]),

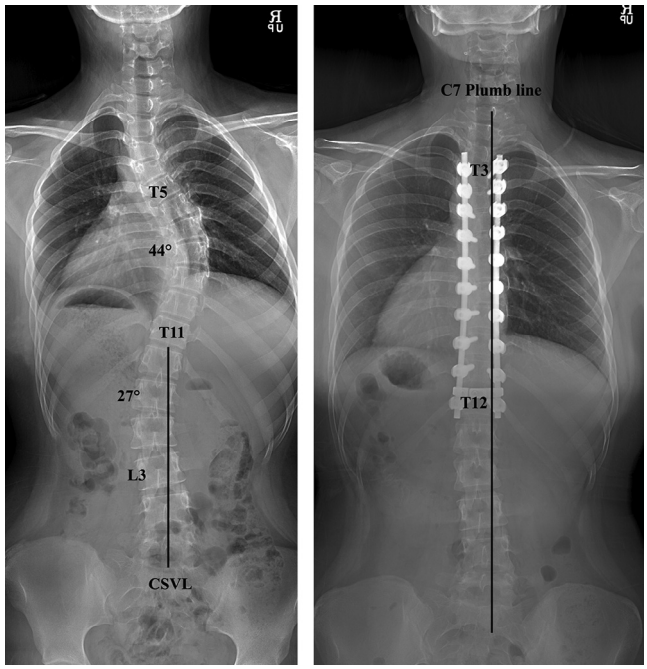

Fig. 1. Selective thoracic fusion (STF) in a 15-year-old female patient with AIS. (Left) A whole-spine anterioposterior radiograph showed a Lenke type 1B curve. (Right) Coronal balance was well maintained following STF at 4 years postoperatively.

which suggests that STF is indicated only for King type 2 or Lenke type 1B or 1C [8]. In certain articles, STF was more broadly applied for most curve types; however, it should be confined to King type 2 [10]. It was reported that spontaneous lumbar curve correction can be achieved via STF in carefully selected cases [11]. Moreover, spinal balance and correction of the lumbar curve remained stable for 20 years following STF in Lenke 1B, 1C, or 3C curves [12]. A retrospective review showed that a 36% thoracic correction was closely matched by a 34% lumbar correction at the latest follow-up, whereas preoperative coronal imbalance was a risk factor for postoperative coronal imbalance (p=.04) in lumbar "C" modifier curves [13]. Thus, the outcomes of STF have been described in many studies (Table 1) [9,12,14–19].

However, the use of STF in double curves with thoracic and lumbar curves could lead to postoperative coronal decompensation, which is a frequently observed complication. The two most plausible causes of decompensation, excluding technical problems, are overcorrection of the thoracic curve and incorrect identification of the lumbar curve.

Overcorrection of the thoracic curve in STF

With the advent of modern strong instrumentation devices, it has become easy to correct spinal deformity, particularly in adolescent cases with flexible spines. However, if the degree of correction in the thoracic curve is excessive, it cannot be matched by the lumbar spine, which then results in decompensation [20,21]. Therefore, it is strongly recommended to not overcorrect the thoracic curve, and ensure that the lumbar

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