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Anterior instrumentation for adolescent idiopathic scoliosis

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Abstract Thirty-two patients with adolescent idiopathic scoliosis underwent anterior fusion with rigid single rod (third generation instrumentation) and titanium mesh cages. The mean follow-up was 31 (24–45) months and the mean age was 14.9 years. There were 8 patients with King type I, 10 with type II, 6 with type III, 4 with type IV and 4 with lumbar curves. Titanium mesh cages were used in all the lumbar procedures and at the cranial and caudal ends of the instrumented area in thoracic cases. All the patients were immobilized in an orthosis for 3–6 months postoperatively. Mean preoperative primary coronal Cobb angle of 56° was improved to 8.6°. Average correction rate was 84%. Sagittal balance was restored with a mean thoracic kyphosis of 28° and a mean lumbar lordosis of 38°. Spontaneous secondary curve decompensation did not occur and postoperative thoracolumbar junctional kyphosis was not seen. One case had to be revised due to proximal screw pull out and loss of correction.

Résumé 32 patients atteints de scoliose idiopathique de l'adolescence ont subi une fusion vertébrale antérieure avec une seule tige seule rigide (instrumentation de la troisième génération) et cages en maille du titane. Le suivi moyen était de 31 (24–45) mois, l'âge moyen de 14.9 années. Il y avait 8 patients de type King I, 10 de type II, 6 de type III, 4 de type IV et 4 avec courbure lombaire. Les cages en titane ont été utilisées dans toute les procédures lombaires et aux extrémités crânienne et caudale de la région instrumentée dans les localisations thoraciques. Tous les patients ont été immobilisées dans un corset pour 3 à 6 mois postopératoires. L'angle coronal primaire de Cobb étaient de 56° avant l'opération et a été amélioré de 8.6°. Le taux moyen de correction était 84%. La balance sagittale a été restaurée avec une cyphose thoracique moyenne de 28° et un lordose lombaire moyenne de 38°. Il n'y a pas eu de décompensation de la courbure secondaire ni de cyphose postopératoire à la jonction thoraco-lombaire. Une reprise a été nécessaire à cause de l'arrachement d'une vis proximale avec perte de la correction.

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Introduction

The aim of surgical treatment for adolescent idiopathic scoliosis (AIS) is to obtain a balanced spine over the pelvis while fusing as few motion segments as possible. Third generation posterior instrumentation systems (i.e. CD, TSRH, Isola), which provided three-dimensional and powerful correction of the deformity has also resulted in complications such as shoulder asymmetry, lumbar curve decompensation, trunk-shift, late recurrence of rib-hump deformity and less than optimal sagittal balance due to inadequate correction of the apical vertebra rotation [13, 18, 19].

These complications have led to the development of anterior instrumentation systems using either single or double rods [9, 10, 16, 20, 21]. During this period implants such as mesh cages were developed and either these implants or structural allografts were used to preserve disc height, to increase primary stability and to avoid kyphosis induced by the instrumentation [16, 20].

The purpose of this study was to evaluate the efficacy of third generation anterior instrumentation systems and

Harms titanium mesh cages in a series of 32 patients with AIS after a minimum 2-year follow up.

Materials and methods

We started using third generation anterior instrumentation for the treatment of AIS in January 1997. One hundred and eighty-two AIS patients were surgically treated between January 1997 and December 2000, using either anterior, posterior or combined surgery. Patients were selected for anterior instrumentation mostly due to reasons such as saving one or more distal motion segments, thoracic hypokyphosis, occasionally inadequate posterior soft tissue mass and surgeon's preference. During this period 51 AIS patients underwent only anterior instrumentation and fusion and 32 of these were included in the study with a minimum 2-year follow-up. Twenty-six patients were female and 6 were male and their average age was 14.9 (11–20) years. The curve was classified as type I in 8, type II in 10, type III in 6, type IV in 4 and lumbar curves in 4 patients.

Standing postero-anterior and lateral, supine traction and bilateral bending radiographs were used for preoperative evaluation and determination of the fusion levels. Standing postero-anterior and lateral radiographs of the spine were also obtained after surgery and at the most recent follow-up. Standard radiographic measurements were performed for pre- and postoperative frontal and sagittal plane analysis. Preoperative X-rays were retrospectively evaluated by the senior author (A.H.) and proper levels of fusion were determined according to King-Moe criteria [11] as if posterior instrumentation had been used.

The surgical procedure consisted of steps and details that need to be mentioned in addition to the current standard anterior technique [1, 2, 9, 10] utilized for correction, instrumentation and fusion of all vertebral levels within the Cobb angle of the primary curve. A second thoracotomy through the same skin incision was used to facilitate surgical manipulation for long thoracic curves. Costovertebral joint resection was performed at all instrumented thoracic levels and internal anterior thoracoplasty when needed. Apart from two patients with thoracic curves, Harms titanium mesh cages were used in all patients as structural grafts. Mesh cage with autogenous grafts was inserted into each disc space to prevent instrument-related kyphosis in the thoracolumbar and lumbar curves and into one or two proximal and distal disc spaces (at T5-T6 and T6-T7 and below T10) to prevent junctional kyphosis in the thoracic curves. After giving the proper sagittal contour, the rod was first fixed to the most distal segment and then correction was achieved by performing translation with a cantilever maneuver. The rod was first fixed distally in order to prevent pull-out of the most proximal screw. No spinal cord monitoring was used but the Stagnara wake-up test following final correction was a routine part of the surgical procedure.

Each patient was mobilized on the second postoperative day and discharged after 7–10 days. Thoraco-lumbosacral orthosis (TLSO) was given for 3–6 months.

Results

The most upper and lower segments instrumented were T4 and L4, respectively. The average number of fused vertebrae was 5.6 (3–8). On average 0.9 (0–2) levels were saved from fusion when posterior instrumentation was used. The preoperative frontal curve measured an average of 56° (40°–84°) and the average curve after operation measured 8.6° (0°–20°). Curve correction in the instrumented area reached 84% (70–100%) on average. Sixteen patients with King type II and III curves had an average preoperative thoracic kyphosis of 13° (-10°–27°), which became 28° (14°–44°) on average postoperatively. This represented an average correction of 115% (0–250%) in the thoracic kyphosis angle. Sixteen patients with King type I, IV and lumbar curves had an average preoperative lumbar lordosis of 44° (26°–64°), which became 38° (20°–58°) on average postoperatively.

No patient developed decompensation of the secondary curve. Spontaneous correction of the secondary thoracic curve in 8 patients with King type I curve was 10° (43%) on average with a minimum of 7° (28%) and a maximum of 15° (55%). Spontaneous correction of the secondary lumbar curve in 10 patients with King type II curve was 22°(57%) on average with a minimum of 15° (31%) and a maximum of 26°(77%). None of the 16 patients with thoracic curve instrumentation developed a thoracolumbar junctional kyphosis. Preoperative spinal decompensation was more than 2 cm in 10 patients. Only 4 patients had more than 2 cm spinal decompensation postoperatively. No neurological complications or deep infection were seen. As a complication 1 patient with a rigid 79° King type II curve had the most proximal screw pull-out in the early postoperative period. A secondary procedure of posterior instrumentation between T2 and T12 levels was therefore needed.

We did not see any pulmonary problems. Compared to patients with posterior instrumentation, the average hospitalization stay was slightly longer due to the need for respiratory training and rehabilitation, which did not cause any specific problem even for patients who had undergone double thoracotomy.

The average duration of follow-up was 31 (24–45) months. Radiographic fusion was achieved in all patients. None of the patients developed implant failure or correction loss of more than 10° in frontal and sagittal plane alignment. Retrolisthesis caudal to the instrumented and fused segments was not noted in any patient (Fig. 1).

Discussion

There are few reports on anterior scoliosis surgery and instrumentation with the third generation instrumentation systems [9, 10, 16, 20, 21]. Anterior scoliosis surgery and instrumentation provides an equal or higher frontal plane correction compared to posterior instrumentation [2, 14]. The average frontal plane correction achieved with anterior instrumentation varies between 71% and 82% [9, 10, 16, 21]. Frontal plane correction in our series averaged 84%, which is comparable to these reports. It is important to perform a complete discectomy and resection of intervening rib heads and costovertebral joints for increasing segmental mobility and correction. This also helps decreasing abnormal forces and thus, prevents the proximal screw pull-out and distal segment retrolisthesis [16].

Instrumentational kyphosis has been a common problem following anterior scoliosis surgery with Dwyer,

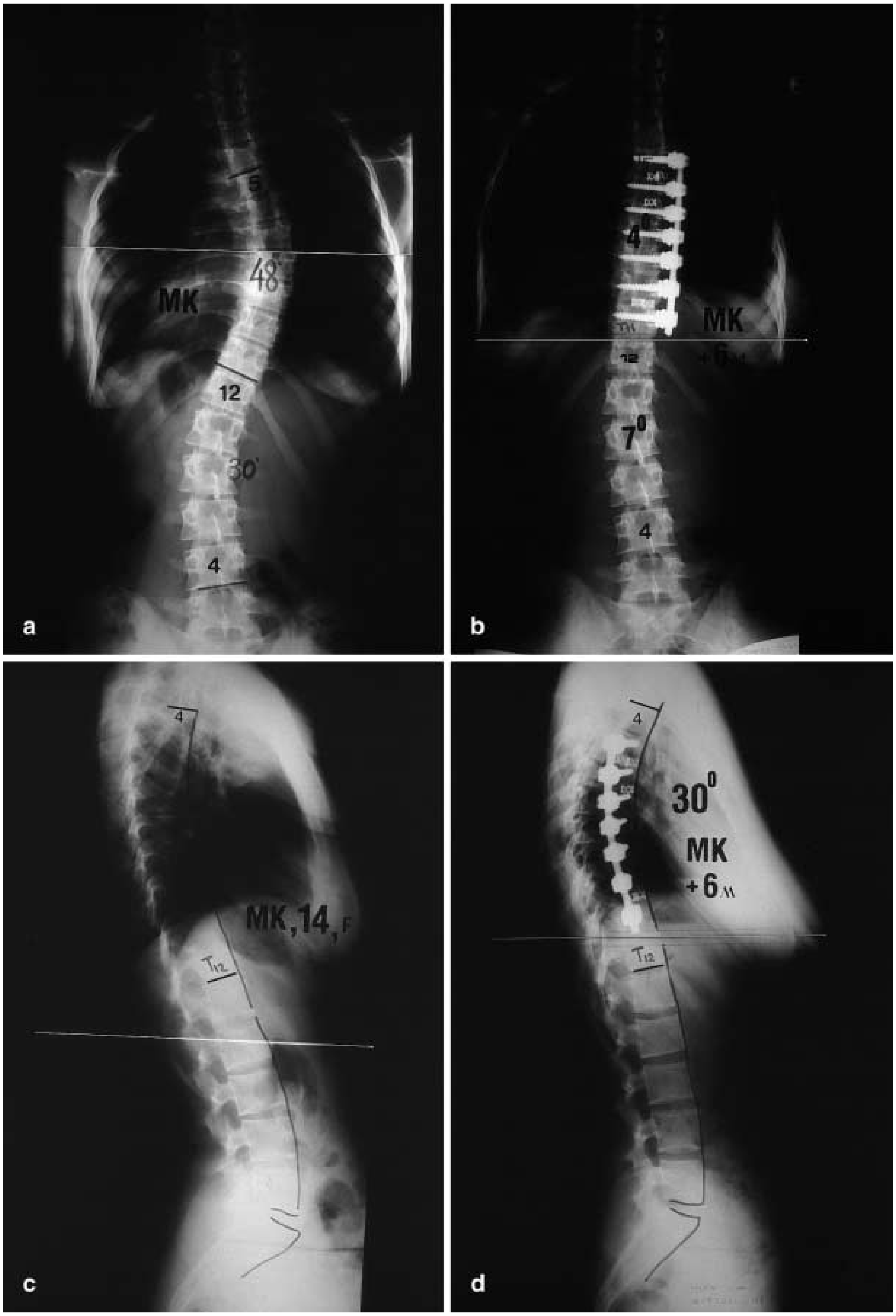

Fig. 1 a,b Selective anterior fusion and instrumentation in King type II curve resulted in 91% thoracic, 76% spontaneous lumbar curve correction. Fusion was achieved in 6 months. **c** Preoperative 16° thoracic hypokyphosis seen on the lateral radiograph. **d** Mesh cages were used for proximal and distal transitional segments and a more physiologic 30° thoracic kyphosis was achieved

Zielke and Harms-Moss instrumentation systems. This complication has been attributed to using non-rigid first and second generation instruments but nothing like structural allografts and mesh cages to preserve disc space [2, 6, 7, 8, 15, 17]. Single rod third generation anterior instrumentation systems also resulted in 40% increased kyphosis at follow-up in the absence of structural allografts or cages [2, 21]. Kaneda, on the other hand, used only rib grafts for disc spaces in patients with lumbar and thoracolumbar curves and did not report any early or late increase in kyphosis [9, 10]. This might be explained by the stability of the Kaneda system, which involves two semi-rigid rods.

Third generation rigid anterior instrumentation-related implant failure, loss of correction and pseudoarthrosis rates vary between 0% [3, 5] and 5% [10, 16] in the literature. To our knowledge, there is no study comparing single and Kaneda's double-rod constructs for anterior scoliosis surgery. In all of our cases we have used a single rigid-rod construct.

We did not observe any significant loss of sagittal plane correction. We attribute that to using titanium mesh cages below T10 for the thoracolumbar junction and all lumbar levels. Rib-grafts were used in the thoracic levels to provide normal thoracic kyphosis. As we take intraoperative lateral X-rays, we have noted a different but quite important aspect, which is acute kyphotic angulation at the cranial end of the instrumentation. This develops in response to compression of upper segments proximal to the apical thoracic segment. Keeping this in mind we recommend no compressive forces but mesh cages for the disc spaces at the proximal one or two thoracic segments.

There is no consensus on using postoperative orthoses [9, 10, 16, 20, 21]. We have routinely used a TLSO for 3–6 months. In our opinion although it causes a slight increase in the cost, TLSO is effective postoperatively for providing additional stability until fusion is achieved, correcting secondary curves and for avoiding postoperative pain-related postural changes or trunk deviation after lumbotomy or thoracotomy.

Fusing the shortest possible area and saving of distal lumbar motion segments are significant gains after anterior surgery. Cochran et al. [4] have reported a direct correlation between the length of fusion extending to the lumbar region and the incidence of degenerative low back pain. The number of distal motion segments saved by using anterior instrumentation is reported to be between 1 and 2.4 [2, 16]. We have used King and Moe [11] criteria for comparison with posterior instrumentation and fusion and found that 0.9 levels on average and two levels at most were saved with anterior instrumentation and fusion. We also think that saving lumbar motion segments distally is important for spinal motion and for avoiding degenerative low-back pain.

Selective anterior fusion and spontaneous correction of the lumbar curve in King type II curves form another controversial issue. Harms et al. believe that the lumbar curve in the King type II curve pattern should be 70% or more flexible for anterior fusion of the thoracic curve [14, 16]. Although the standard treatment is posterior instrumentation for King type II curve, we advocate anterior correction, fusion and instrumentation of the thoracic curve in cases with significant thoracic hypokyphosis and in cases that a distal motion segment can be saved. However, as for posterior surgery the secondary lumbar curve should be flexible and correction of the thoracic curve should not exceed the amount of lumbar curve correction at preoperative bending X-rays [3, 10, 12, 14]. None of our patients developed postoperative decompensation of the secondary lumbar curve. The average spontaneous lumbar curve correction in our series was 57% (31–77%). It is 43% and 51%, respectively in Turi et al's. [21] and Betz et al's. [2] series. According to Lenke et al's. study [14] on King type II AIS curves, thoracic curve correction after selective anterior instrumentation and posterior instrumentation is 58% and 38% (P<0.5), respectively. Spontaneous lumbar curve correction in the same study is 56% and 37% on average (P<0.5) after anterior instrumentation and posterior instrumentation, respectively.

In conclusion, as compared with posterior instrumentation, anterior instrumentation for AIS achieves improved correction of the rotational, frontal and especially sagittal plane deformities while fusing shorter segments. Using mesh cages at proper disc spaces helps decreasing instrument related complications and also provides better control of the sagittal alignment.

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