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20 Short Segment 'Bone-on-Bone' Fusion for Adolescent Idiopathic Scoliosis

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Introduction

Modern instrumentation systems have improved our ability to deal with scoliosis. Whilst the debate on the benefits of anterior over posterior approach continues, the functional benefits of shorter fusions have been un-refutable.[1 -7]

After extensive experience with all the anterior surgical procedures used to correct adolescent idiopathic scoliosis, (Dwyer, Zielke, Hall, Kaneda), and extensive experience with the KASS system of anterior spinal implants, the author modified the pre-existing techniques by removing the posterior annulus of the involved intervertebral disks to further shorten the fusion levels necessary to correct most single curves associated with AIS.

The 'short segment bone-on-bone' approach targets single curve AIS—particularly those which are flexible enough to permit surgical straightening of the apical segments to less than 30 degrees. When the major curve is straightened to less than 30 degrees, the compensatory curves straighten in response to the successful management of the major curve.

Indications (Table 20.1)

The ideal patient for this procedure is an adolescent or adult with a flexible, single major curve idiopathic scoliosis. The most common curve types to be treated by this method are structural thoracic (Lenke type 1) or thoracolumbar (Lenke type 5) curves, with a magnitude of <85°, with a compensatory curve of < 50°. The structural and compensatory curves must both be >50% flexible, or reduce to 30° or less on the 'stretch film' (Fig. 20.1). We recommend the use of this technique in adolescents with a riser < 2 or any age thereafter.[8]

Table 20.1: Indications for anterior short segment fusion

1. Idiopathic scoliosis
2. Single major curves (Lenke types 1 and 5)
3. Major curve with Cobb measurement < 85°; thoracic modifier N or -.
4. Major and compensatory curves 50% flexible or reduce to 30° on 'stretch film'
5. Risser sign >2

Figure 20.1: A preoperative plan is based on the 'stretch' radiograph. The patient is laid supine on the radiograph table on a 36-inch film. Two other individuals (assistants and/or family members) well known to the patient are then instructed to 'stretch' the patient while the patient is instructed to relax and enjoy the experience. One provides forceful but non-violent traction to the patient's upper body (neck or shoulders) while the other provides forceful but nonviolent traction to the legs

Table 20.2: Contraindications for anterior short segment fusion
1. Abnormal preoperative pulmonary function tests
2. Infantile and Juvenile idiopathic scoliosis
3. Neuromuscular scoliosis
4. Double major curves, proximal thoracic structural curves
5. Large, stiff curves less than 50% flexible on the 'stretch film'
6. Risser <2

Contraindications (Table 20.2)

This procedure is not recommended in patients with abnormal lung function. A pre-operative lung function is a useful guide. Hence this is the approach not to be used in neuromuscular scoliosis. This technique is not used in skeletal immature patients with a Risser < 2, hence not recommended for infantile or juvenile scoliosis. This technique is outside the remit of double or triple major curves, proximal thoracic curves, as well as large stiff curves (Cobb >85°, <50% correction on the stretch radiographs).

Preoperative Analysis

Routine preoperative imaging includes an MRI to exclude an underlying cause for the scoliosis, erect full spine radiographs in 2 orthogonal planes (anteroposterior and lateral). The flexibility of the structural and compensatory curves and the changes in the truncal decompensation are assessed on a 'stretch' radiograph (Fig. 20.1) This is performed by laying the patient supine on the radiograph table on a 36 inch film. Two other individuals (assistants and/or family members) well known to the patient are then instructed to 'stretch' the patient while the patient is instructed to relax and enjoy the experience. One provides forceful but non violent traction to the patient's upper body (neck or shoulders) while the other provides forceful but non violent traction to the legs.

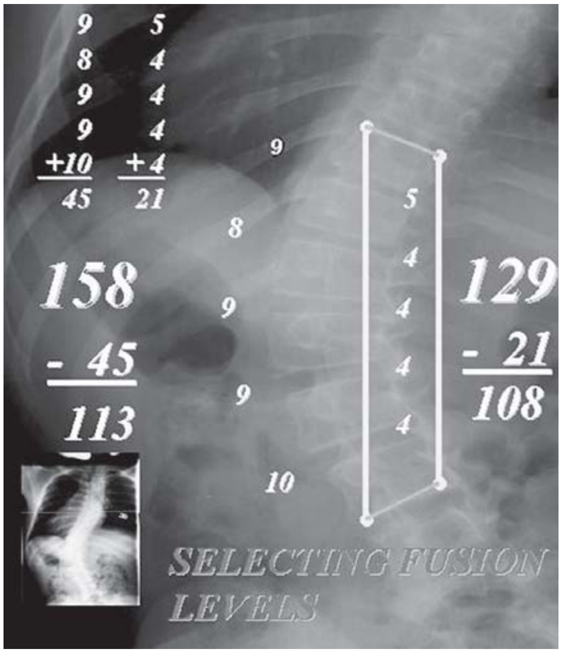

Figure 20.2: The fusion levels are determined by creating a blueprint on the stretch radiographs. The Cobb levels are identified on the stretch radiograph. The convex (158 cm) and the concave (129 cm) chord lengths are determined from the respective corners of the Cobb vertebrae. The individual disk heights are added on the concave (21 cm) and the convex sides (45 cm). Subtracting the disk heights from the corresponding chords gives us the measure for the corrected heights of the convex and the concave columns. A value within 5 mm between the convex and the concave sides would lead to a satisfactory correction as shown diagrammatically

Based on this 'stretch' radiograph a preoperative blue-print is created to determine the levels to be operated upon (Fig. 20.2). The Cobb levels are identified on the stretch radiograph. The convex and the concave chord lengths are determined from the respective convex and concave side corners of the Cobb vertebrae. The individual disk heights are added on the concave and the convex sides. Subtracting the disk heights from the corresponding chords gives us the measure for the corrected heights of the convex and the concave columns. A value within 5 mm between the convex and the concave sides would lead to a satisfactory correction as shown diagrammatically (Fig. 20.3). The actual correction achieved by the total discectomy and instrumentation using this technique is monitored by the use of the image intensifier during the operative procedure. Some curves can be overcorrected using this technique.

Figure 20.3: A diagrammatic representation of the correction of a type 5 (thoraco-lumbar curve), with a spontaneous correction of the compensatory curves

Figure 20.4: Positioning the patient in the right lateral decubitus position on a peg board. This secures the position throughout the procedure

Surgical Technique[9-11]

POSITIONING AND EXPOSURE

The patient is securely positioned on a peg-board lateral positioning table (Fig. 20.4).

Extra pleural, retroperitoneal exposure is performed when the instrumentation extends proximally to T11 or below, with removal of the 11th or 12th rib. Thoracotomy exposure is used when the instrumentation is contained within the thoracic cage. The segmental vessels are isolated and doubly clipped before they are transected. The levels that are to be instrumented are then exposed whilst protecting the contralateral segmentals.

RIB HEAD EXCISION AND IDENTIFICATION OF THE INTERVERTEBRAL FORAMEN

After exposing the spinal column, the corresponding rib heads (in the thoracic levels) are removed by osteotimizing through the neck of the rib distal to the posterior angle. This uncovers the costovertebral joint and guides the surgeon towards the inter-vertebral foramen. Identification of the foramen is the first step prior to the discectomy. Further, it helps in the identification of the posterior extent of the vertebral body precluding safe instrumentation. The intervertebral foramen is identified by careful dissection with a curved curette. Then, a Penfield dissector is placed into the spinal canal through the intervertebral foramen, and the posterior side of the intervertebral disk is palpated. This identifies the posterior annulus. Epidural bleeding is controlled by thrombin-soaked Gelfoam, applied through the foramen.

DISCECTOMY AND BONE-ON-BONE

The intervertebral disks are then resected over the levels predetermined by the preoperative plan. The discectomy levels proceed from the apical level outwards. The permits better visualization of the more peripheral disks with increasing correction. While performing the discectomy, all the disk tissue must be removed until the two

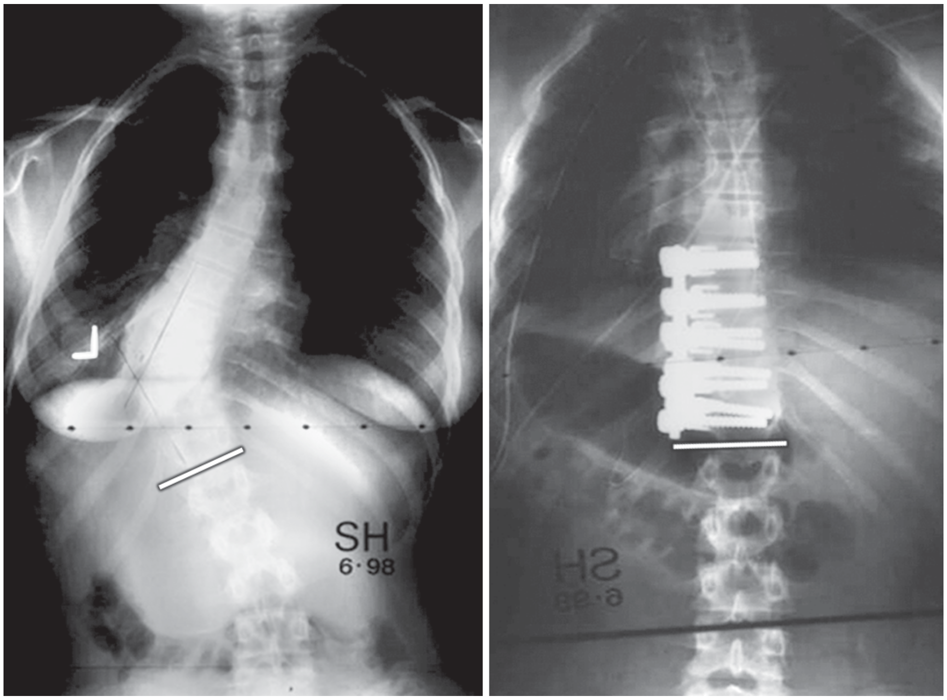

Figure 20.5: A complete discectomy followed by a bone-on-bone apposition leads to a deformity correction in the coronal plane with an improvement in the Cobb and the tilt angles

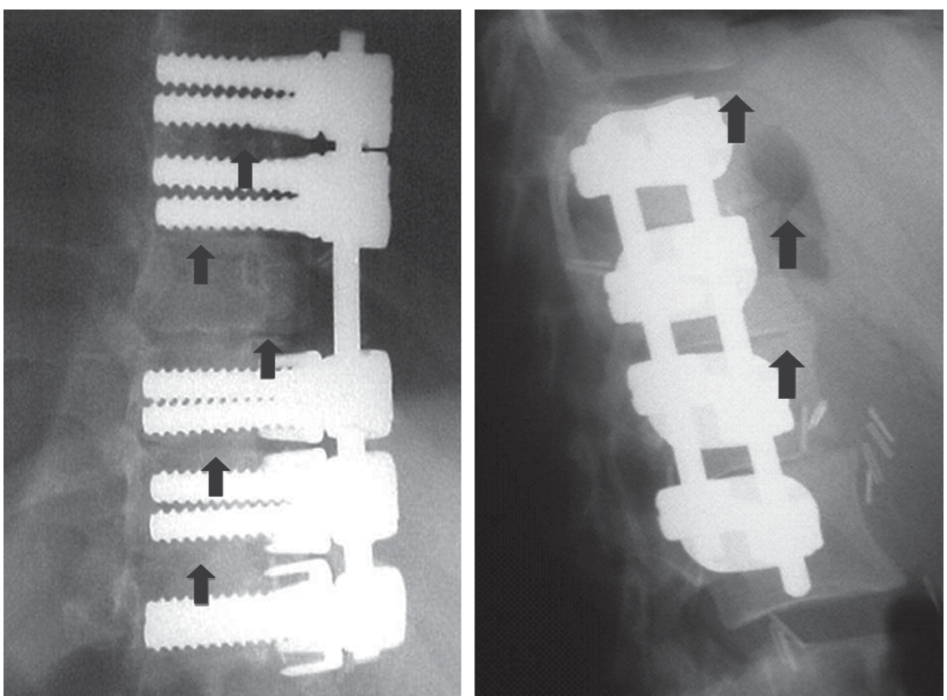

Figure 20.6: The end plate apposition is demonstrated a bone-on-bone interbody contact leading to a favorable position for the fusion and a successful correction of the deformity

vertebrae begin to collapse toward one another. The concave side, the posterolateral corner on the far side and the posterior annulus (with the PLL) must be removed using Kerrison rongeur, and a sharp straight long handled rongeur. Once the interspace closes with the bone-on-bone apposition, gelfoam is applied to the disk space and attention turns to the next disk. The cartilaginous end-plates are removed while the bony end-plates are not damaged. If there are voids in the interspaces, these can be filled with autograft chips.

A 'repositioning maneuver' is performed after all the disks are excised. This is done by stretching the patient, when the anesthetist or an unscrubbed assistant lifts the torso and gently pulls the lower shoulder upwards.

The final compression and the bone-on-bone apposition is achieved with the instrumentation. An appropriate sized vertebral body staple is selected and placed in the center of the vertebral bodies over the segment of the spine to be instrumented. The image intensifier is then used to assess the coronal plane correction of the major curve; the positioning of the vertebral body staples; the correction of the tilt angle; and sagittal plane correction. Any adjustments regarding selection of fusion levels are made at this time. Perfect placement of the staples is essential for proper screw placement. Two triangulated, bicortical vertebral body screws allow for a stable implant screw interface.

Once the screws are properly placed, the first rod is added onto the screws and secured with the caps. The compressor is used to bring the peripheral vertebrae toward the apex. Once bone-on-bone apposition can be palpated with a Penfield between the vertebrae being compressed, the setscrew is tightened, and the procedure moved to the next motion segment. The procedure is repeated until there is bone-on-bone apposition throughout the construct. No additional correction is achieved with the second rod, since it is used only to improve rotational stability of the construct. Interbody cages may be used below T11 in type 5 curves. The intraoperative assessment of the sagittal profile guides the need for cages.

An epidural catheter is placed into the intervertebral foramen at the top of the construct for postoperative analgesia. If the implants are in the chest, they are protected from the lung by either closure of the parietal pleura over them or by a Gore-Tex pericardial patch sewed to the edges of the pleural incision. Routine muscle and skin closure is then performed. A chest drain is used if the implants are within the chest. If thoracolumbar instrumentation is performed with the extrapleural retroperitoneal approach, no chest drain or other drain is necessary. The use of neuro-monitoring is increasing with deployment of SSEP and MEP's for safe corrections and instrumentation.

Complications

Spinal cord injury is disastrous though a very rare consequence. It can be avoided by a clear understanding of the anatomy, clear identification of the neural foramen and the spinal canal prior to performing the discectomy and a careful placement of instrumentation. The use of spinal cord monitoring (MEP and SSEP) has become more common in most units dealing with spinal deformities.

A meticulous surgical technique should be pursued to avoid any injuries to the visceral structures such as lung, pleura, diaphragm, mediastinal structures and secure ligation of the segmental vessels. Due care is to be exercised during closure to avoid an injury to the intercostals nerves, to prevent scar dysesthesia.

A good bone-on-bone end plate contact with a stable compression instrumentation will prevent a nonunion. If a gap exists it should be filled with morsellised chips. An inadequate correction can result from incorrect selection of levels, with 'adding-on' of levels in the segments above or below the instrumented segments. This may need to be addressed by further surgery either anteriorly or posteriorly.

Tips and Tricks for Short Segment Fusion for Scoliosis

1. Patient must be securely placed in lateral position on a peg board or similar table

2. If the proximal instrumented level is below T11, an extrapleural retroperitoneal approach can be performed
3. If a transpleural approach must be performed, there is no need to deflate the lung. Carefull retraction is enough for a wide operative field
4. The foramen must be identified in order to resect the posterior anulus. This allows the vertebrae to collapse one toward the other, with a bone-on-bone apposition
5. The discectomies proceed from the apical disk toward the ends of the curve to facilitate exposure of the more peripheral disks.
6. Although the authors prefer a dual rod system, this technique does not rely on the implant for success. Bone-on-bone apposition is the key factor.
7. BMP, allografts or bone substitutes are not required with the bone-on-bone technique.
8. Thoraco-lumbar curves (Lenke type 5) sometimes require the placement of a cage below T11 to restore the sagittal profile.

Postoperative Care

Analgesia is provided by the epidural catheter during the first few days. It is weaned off by the 3rd or the 4th day. If a chest tube is used, it is removed by the 4th postoperative day. The patients are nursed in the intensive care unit for 4-5 days. Patients are encouraged to start ambulation within 24-48 hours postoperative. With the stable instrumentation constructs bracing is not required. The functional rehabilitation of the patient proceeds promptly due to the excellent apposition afforded by the bone-on-bone technique, and the very short fused segments required by this approach. School children are back in school by 6-12 weeks following the surgery, and working adults are back to work, at least part-time, within 6-8 weeks of their surgery.

Illustrative Case (Figs 20.7A to C)

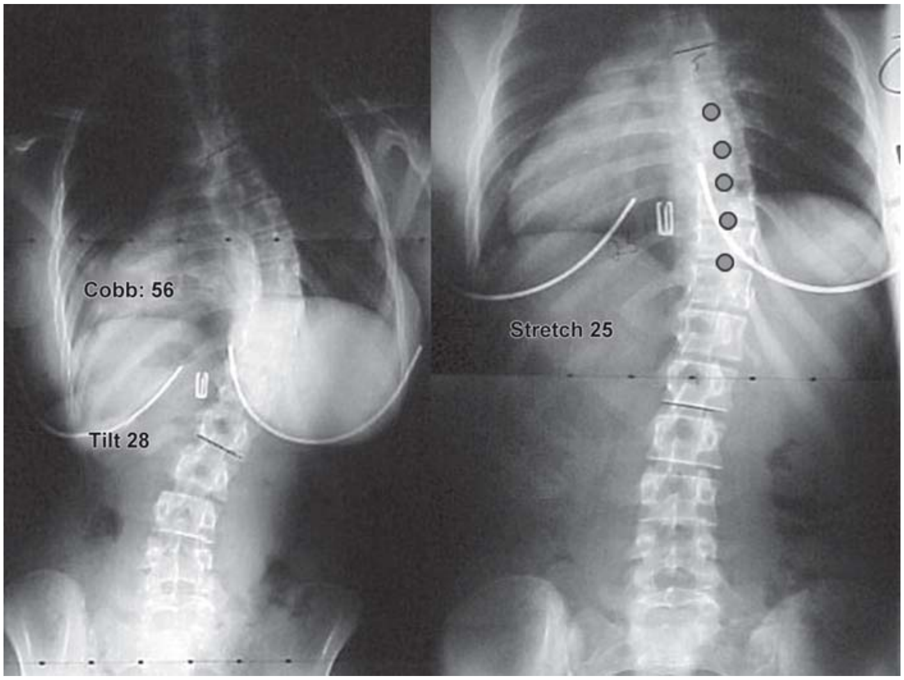

Figure 20.7A: 17-year-old female with a 56° right primary thoracic curve with a tilt angle of 28° (left), reduced to 25° on the stretch film (right)

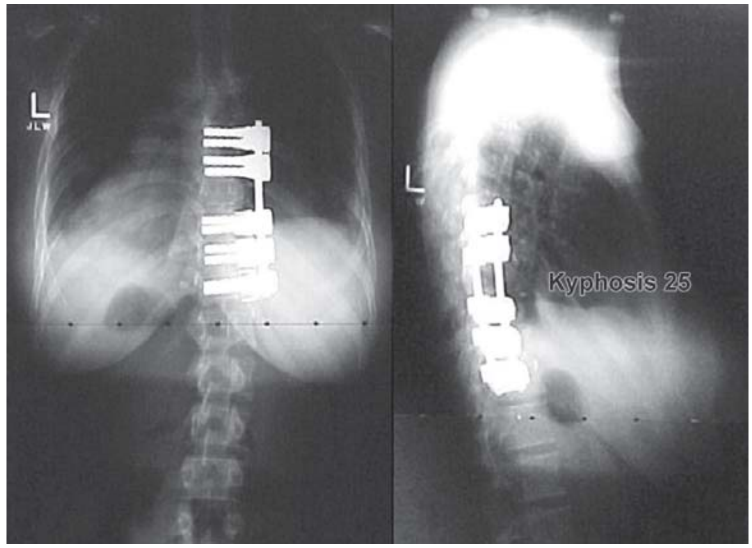

Figure 20.7B: 6 years after anterior KASS fixation from T6 to T10, the thoracic curve was fully corrected and fused with no further loss (left). The fused levels in the sagittal profile measured 25° of kyphosis (right) by fusion of 5 vertebrae 4 disks

Figure 20.7C: Clinical photographs before (left) and after (right) surgery

Conclusions

The short segment approach to treating moderate flexible idiopathic curves results in satisfactory correction of the curves whilst fusing as fewer levels than if these curves are treated by the pedicle screw based posterior constructs. The short segment bone-on-bone instrumentation and fusion technique shows a correction rate similar to those achieved by posterior techniques and favorably influences the coronal and the sagittal plane, while allowing a spontaneous correction of the compensatory curves, and truncal balance.

The bone-on-bone interbody contact leads to a rapid bone healing and an early functional recovery. This surgical approach presents an appealing option for the surgical management of adolescent idiopathic scoliosis when compared to standard posterior instrumentation and fusion with pedicle screws.

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