Segmental pedicle screw instrumentation in idiopathic thoracolumbar and lumbar scoliosis

Abstract  The role of posterior correction and fusion in thoracolumbar and lumbar scoliosis as well as pedicle screw instrumentation in scoliosis surgery are matters of debate. Our hypothesis was that in lumbar and thoracolumbar scoliosis, segmental pedicle screw instrumentation is safe and enables a good frontal and sagittal plane correction with a fusion length comparable to anterior instrumentation. In a prospective clinical trial, 12 consecutive patients with idiopathic thoracolumbar or lumbar scolioses of between 40° and 60° Cobb angle underwent segmental pedicle screw instrumentation. Minimum follow-up was 4 years (range 48–60 months). Fusion length was defined according to the rules for Zielke instrumentation, normally ranging between the end vertebrae of the major curve. Radiometric analysis included coronal and sagittal plane correction. Additionally, the accuracy of pedicle screw placement was measured by use of postoperative computed tomographic scans. Major curve correction averaged 64.6%, with a loss of correction of 3°. The tilt angle was corrected by 67.0%, the compensatory thoracic curve corrected spontaneously according to the flexibility on the preoperative bending films, and led to a satisfactory frontal balance in all cases. Average fusion length was the same as that of the major curve. Pathological thoracolumbar kyphosis was completely corrected in all but one case. One patient required surgical revision with extension of the fusion to the midthoracic spine due to a painful junctional kyphosis. Eighty-five of 104 screws were graded “within the pedicle”, 10 screws had penetrated laterally, 5 screws bilaterally and 4 screws medially. No neurological complications were noted. In conclusion, despite the limited number of patients, this study shows that segmental pedicle screw instrumentation is a safe and effective procedure in the surgical correction of both frontal and sagittal plane deformity in thoracolumbar and lumbar scoliosis of less than 60°, with a short fusion length, comparable to anterior fusion techniques, and minimal loss of correction.

Key words  Idiopathic scoliosis · Surgery · Pedicle screw · Posterior instrumentation
enables a shorter fusion length, saving distal motion segments, compared to HI remains a matter of debate [2, 18, 19, 22, 27]. Since introduction of the VDS-Zielke instrumentation [44], this procedure has become an accepted technique for correction of thoracolumbar and lumbar curves [11, 12, 20, 28, 29, 31–33]. In comparison to CDI, VDS-Zielke is reported to provide a better frontal plane correction with a shorter fusion length [12, 29, 38]. In thoracic scoliosis, Suk et al. demonstrated a shorter fusion length and a better three-dimensional correction with posterior pedicle screw instrumentation compared to hooks [39]. However, both neural and vascular, as well as visceral, structures are at potential risk from misplaced pedicle screws [6, 10, 16, 35, 40–42]. In order to evaluate frontal and sagittal plane correction in thoracolumbar and lumbar scoliosis by use of segmental pedicle screw instrumentation, with special regard to fusion length and accuracy of pedicle screw placement, a prospective clinical trial was conducted.

Materials and methods

Twelve consecutive patients, eight adolescents and four adults with idiopathic thoracolumbar and lumbar scoliosis ranging from 41° to 59° Cobb angle were surgically treated with the Münster Posterior Doublerod System (MPDS, Schäfer Micromed GmbH, Göttingen, Germany). The adult patients (aged 21–34 years) had curves comparable to the adolescent patients, without degenerative changes in the area of the compensatory curves, and with approximately the same flexibility of the major and compensatory curves on the bending films. In particular, any possibility that they were suffering from de novo scoliosis, which has a completely different etiology, was ruled out.

The MPDS consists of two interlinked 5- or 6-mm solid, fluted rods with pedicle screws of 6.0 and 6.5 mm in diameter. The screw-rodd interface is secured using cap nuts with integrated set screws. The indication for surgery was curve progression in the adolescent patients and persistent, disabling back pain in the adult group.

Surgical technique

The selection of fusion levels was performed according to the rules established for Zielke instrumentation [11, 44], normally ranging between the end vertebrae of the major curve. These fusion levels were chosen because we were sure, and wanted to prove, that with pedicle screw instrumented fusion in moderate curves (less than 60° Cobb angle) the extent of the fusion could be kept as short as with anterior instrumentation without adverse effects. A few exceptions were made. The fusion was extended an additional level distally in two curves, in which the distal end vertebra was horizontalized by less than 15° on the reverse bending films, and in which a convex disc space gapping below the lower end vertebra was found. This procedure was also proposed by Zielke for VDS in comparable instances, and is particularly useful in avoiding the so-called “adding-on phenomenon”. In two cases with a partially rigid thoracic compensatory curve, the instrumentation was carried out one segment short of the cranial end vertebra, in order to let this segment (disc space) contribute to spontaneous correction of the compensatory thoracic curve. At this point it must be mentioned that in all cases we would have chosen the same fusion length had we performed an anterior instrumented fusion with VDS. In choosing the fusion levels, we also took the sagittal plane into consideration. In particular, the option of ending the instrumentation below the pathological kyphosis was ruled out. A standard pedicle screw placement technique was performed using the “Weinstein” approach [42], with segmental pedicle screw fixation on the convexity of the curve, including the apical vertebra in every case (Figs. 1, 2). After entering and widening the pedicle with an awl, the pedicular cavity was explored with a sounder to verify intact pedicular walls and exclude any cortical penetration. To confirm appropriate length and placement of the screws, anteroposterior and lateral fluoroscopy was used during surgery. Curve correction was achieved by the rod rotation maneuver of the contoured convex rod, according to the principles established by Cotrel and Dubousset [7, 8], followed by slight convex compression and concave distraction. The rationale for using a pedicle screw at every level on the convexity is that the rod rotation maneuver is the major force for obtaining correction. We therefore aimed at as much force distribution as possible. Finally, the frame construct was completed with two transverse connectors followed by spinal arthrodesis with autologous iliac bone grafts.

Evaluation

All patients underwent frontal and sagittal plane analysis on long cassette posteroanterior and lateral standing radiographs preoperatively, postoperatively, 2 years postoperatively (follow-up 1) and at final follow-up (follow-up 2). Minimum follow-up was 4 years (range 48–60 months, mean 52 months). For evaluation of curve flexibility and fusion levels, preoperative maximum supine bending films were obtained. Primary and cranial compensatory curves were analyzed according to Cobb as well as measurement of the tilt angle of the lowest instrumented vertebra. Frontal plane decompensation was measured by drawing a line between the spinous processes of C7 and S1.

The sagittal curves were measured with the Cobb method from T4 to T12 (thoracic spine), from T10 to L2 (thoracolumbar junction) and from L1 to S1 (lumbar spine). Angles were considered to be physiological if thoracic kyphosis was in the range of +20° to +40°, the thoracolumbar junction in the range of +10° to –10° and lumbar lordosis in the range of –30° to –55° [3]. Data collection and radiographic measurements were performed by an unbiased observer.

In order to evaluate the accuracy of pedicle screw placement, computed tomographic (CT) scans (Tomoscan LX, Philips, Hamburg, Germany) were performed postoperatively. Each screw was studied with 3-mm-thick sections, strictly parallel to the longitudinal axis of each screw. To minimize artifacts, a special filter and an individually adjusted window (2500–4000HE) were used (Figs. 3, 4). All screws were evaluated by a radiologist and two spine surgeons for intrapedicular placement and length. Any penetration of bony cortex was registered and measured in millimeters with a

Fig. 1 A–E A 17-year-old female with a progressive idiopathic thoracolumbar curve of 48°. A Segmental pedicle screw instrumentation and fusion from T11 to L3. Good frontal curve correction with abalanced spine is evident on both postoperative (B) and 4-year follow-up films (C). The thoracic hypokyphosis is corrected from 12° (D) to 20° (E), resulting in a normal thoracolumbar and lumbar profile

Fig. 2 A–E A 16-year-old female with a progressive idiopathic thoracolumbar curve of 50°. A Segmental pedicle screw instrumentation and fusion from T10 to L3. Good frontal curve correction with a balanced spine is evident on both postoperative (B) and 4-year follow-up films (C). Note the slight adding-on with convex disc space gapping of L3/L4, which is stable during follow-up. D, E Correction of thoracolumbar kyphosis and thoracic hypo kyphosis.