Treatment of idiopathic scoliosis with CD-instrumentation

Lumbar pedicle screws versus laminar hooks in 66 patients

Cornelius Wimmer[1], Herbert Gluch[2], Michael Nogler[1] and Nadja Walochnik[1]

Departments of [1]Orthopedic Surgery, University of Innsbruck, Anichstrasse 35, AT-6020 Innsbruck, Austria, [2]Spinal Surgery, BHZ-Vogtareuth, Vogtareuth. E-mail: cornelius.wimmer@uibk.ac.at
Submitted 00-03-06. Accepted 01-04-29

ABSTRACT – We studied whether the pedicle screw is better than laminar hooks for fixation of the lumbar spine in the treatment of idiopathic scoliosis.

66 consecutive patients with idiopathic scoliosis (King I and II) were studied retrospectively. Group S included 33 patients (25 females) treated with pedicle screws. Their mean age at operation was 17 (13–54) years. Group H included 33 patients (30 females) treated exclusively with hooks. Their mean age at operation was 16 (11–40) years. The preoperative mean angles of the thoracic curve in group S was 66 (42–115)°, and in group H 65 (42–121)°. The lumbar curve averaged 46 (20–85)° in group H and 53 (33–86)° in group S. All patients were fused only posteriorly with Cotrel-Dubousset instrumentation and an autogenic bone graft. The mean follow-up time was 4 (2–7) years.

Mean correction of the thoracic curve was 45% in group S and 50% in group H. The lumbar curve was corrected by 50% in group S and 51% in group H. Loss of correction of the thoracic curve occurred in 5% in group S and 6% in group H and of the lumbar curve in 3% in group S and 10% in group H (p = 0.04). Group S better maintained the correction of the lateral tilt of the uninstrumented segment adjacent to the fusion (p = 0.04). Derotation, according to Perdriolle, in the distal segment adjacent to the fusion was 6% in group S and 2% in group H.

We found no difference between correction of the thoracic and lumbar curves using pedicle screws and laminar hooks in the lumbar spine. Pedicle screws better maintained the correction of the lumbar curve and the lateral tilt in the distal segment adjacent to fusion.

■

Cotrel-Dubousset instrumentation (CDI) was designed to facilitate selective and 3-dimensional correction of spinal deformities and strong fixation without wiring (Cotrel and Dubousset 1984, Cotrel 1987, Cotrel et al. 1987). It consists of a rod, hooks and/or screws for fixation, and a device for transverse traction.

Hook insertion technique is generally accepted as the standard procedure for treating idiopathic scoliosis. Pedicle screw fixation of the lumbar spine has received widespread acceptance for the treatment of fractures and degenerative diseases. We found 3 recent reports regarding segmental pedicle screw fixation in idiopathic scoliosis (Suk et al. 1994, Hamil et al. 1996, Barr et al. 1997). Lumbar pedicle screws may improve lumbar curve correction, maintenance of correction and correction of the non-instrumented spine below.

We assessed whether pedicle screw fixation of the lumbar spine is more effective than the use of laminar hooks in the treatment of idiopathic scoliosis for King I and II curves (King et al. 1983).

Patients and methods

From 1985 to 1994, 482 patients with idiopathic scoliosis underwent surgical treatment of idiopathic scoliosis in our Departments of Orthopedic Surgery and Spinal Surgery. Only patients meeting the following criteria were included in the study: idiopathic scoliosis King I and II, treatment solely with CD-instrumentation, fusion with autogenic bone

grafts, no anterior release or instrumentation, and a minimum of 2 years of follow-up. 66 patients, retrospectively included in the study, were divided into 2 groups. Group S consisted of 33 patients (25 females) treated with pedicle screws in the lumbar spine. Their mean age at surgery was 17 (13–54) years. Group H consisted of 33 patients (30 females) treated with hooks alone, their mean age at surgery was 16 (13–54) years. The preoperative mean angles of the thoracic curve in group S were 66 (42–121)° and 65 (33–86)° in group H. The lumbar curves averaged 46 (30–85)° in group H, and 53 (33–86)° in group S.

Surgical treatment

Patients were operated on in a standard prone position on a scoliosis frame. The use of pedicle screws or hooks in the lumbar spine was decided by the surgeon. Antibiotic prophylaxis was given. Somatosensory-evoked potentials during the operation and a wake-up test were done. Autogenic bone grafts from the iliac crest were used in all patients.

Thoracic instrumentation, a traditional construct, was described by Barr et al. (1997). The lumbar spine was instrumented in group H with laminar hooks and in group S with pedicle screws. The point of insertion into the pedicle was defined by the intersection of a vertical line passing through the middle of the inferior articular facet and a horizontal line passing through the upper border of the transverse process. A K-wire was inserted into the entrance point of the pedicle checked under fluoroscopy. Drilling through the pedicle was done under fluoroscopic control. Pedicle screws of 6 mm in diameter were inserted into the pedicle.

In both groups, L3 was the commonest fused distal segment. There was no statistically significant difference in the distal fused segments between the groups. Length of surgery and blood loss were similar in the groups.

Radiographic analysis

Posteroanterior and lateral standing radiographs were taken preoperatively, postoperatively, at 6 months, 12 months, and then annually up until the most recent follow-up examination. The thoracic and lumbar curve Cobb angles were measured. Derotation of the distal segment adjacent to the fusion was measured using Perdriolle's method (1985). The tilt of the inferior endplate of the distal not instrumented segment to the superior endplate of the adjacent not instrumented level was determined (Figure 1). Lateral displacement from the midline of C7 to S1 was measured. Sagittal measurements included kyphosis from T1 to T12, and lordosis from L1 to S1. The measurements were made by an independent observer.

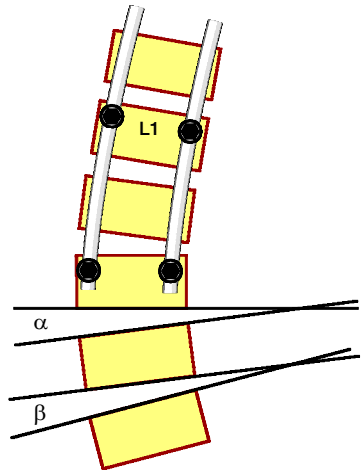

Figure 1. Schematic drawing of the measurement of the lateral tilt of the distal segment adjacent to the fusion. α angle—angle of the first uninstrumented segment (FUS) and β angle—angle of the second uninstrumented segment (SUS).

Flexibility was calculated: % flexibility = 100 × (preoperative angle – bending angle) / preoperative angle

For correction, the following formula was used: % correction = 100 × (preoperative angle – postoperative angle) / preoperative angle

For loss of correction, the following formula was used: % loss of correction = 100 × (follow-up angle – postoperative angle) / postoperative angle

The mean follow-up time was 4 (2–7) years with no difference between the groups. Rip hump, balance of pelvis, and shoulder before and after surgery were determined by an independent observer. Cosmetic satisfaction was evaluated by a questionnaire.

We used the 2-sample Wilcoxon test for the statistical analysis.

Table 1. Radiographic data of 66 patients before surgery and at follow-up, mean (SD)

Group	Cobb angle (°) Thoracic curve	Lumbar curve	Rotation FUS (°)	Rotation SUS (°)
Preoperative				
H	65 (17)	47 (15)	7 (7)	8 (7)
S	65 (17)	53 (14)	4 (5)	6 (5)
Postoperative				
H	32 (15)	24 (15)	7 (7)	9 (7)
S	27 (16)	27 (12)	3 (6)	3 (5)
24 mos. after surgery				
H	37 (14)	33 (14)	7 (8)	10 (4)
S	40 (16)	30 (15)	3 (4)	4 (5)
Follow-up (last)				
H	37 (16)	31 (17)	7 (6)	10 (5)
S	38 (13)	28 (11)	3 (5)	5 (4)

H group with hooks, S group with pedicle screws.
FUS first distal uninstrumented segment.
SUS second distal uninstrumented segment.

Table 2. Lateral tilt in the first and second uninstrumented distal segments, mean (SD)

	Group	FUS (°)	SUS (°)
Preoperative	H	9.6 (4.3)	10 (6)
	S	12 (4.3)	13 (8)
Postoperative	H	8.6 (4.9)	11 (5.6)
	S	9 (5.2)	9.4 (7.9)
Follow-up (last)	H	8.2 (5.7))	13 (5.6)
	S	11 (5.8)	14 (11)

For abbreviations, see Table 1

Table 3. Kyphosis and lordosis on radiographs, mean (SD)

	Group	Kyphosis (°)	Lordosis (°)
Preoperative	H	21 (12)	30 (9.1)
	S	25 (14)	42 (16)
Postoperative	H	20 (11)	31 (9.0)
	S	26 (9.8)	42 (16)
Follow-up (last)	H	21 (11)	32 (9.4)
	S	28 (10)	42 (15)

For abbreviations, see Table 1

Table 4. Derotation using Perdriolle's (1985) method in the distal segment adjacent to the fusion, mean (SD)

	Group	Derotation (°)
Derotation	H	0.4 (1.3)
	S	1.5 (1.8)
Loss of derotation	H	2.1 (4.1)
	S	0.6 (1.8)

For abbreviations, see Table 1

Table 5. Lateral displacement (mm) from the midline of C7 to S1, mean (SD)

Group	Preoperative	Postoperative	Follow-up
H	15 (35)	18 (4)	11 (25)
S	17 (70)	14 (36)	9 (16)

For abbreviations, see Table 1

Results

There were no differences between the groups in clinical and cosmetic outcome. Bony fusion was achieved in all patients.

The mean immediate postoperative corrections of the thoracic curve were 28° (45%; SD 8) in group S with a flexibility of 35%, and 33° (50%; SD 14) in group H with a flexibility of 31% (Table 1). The mean correction of the lumbar curve in group S was 26° (50%; SD 7) with a flexibility of 50%, and 23° in group H (51%; SD 10) with a flexibility of 63%. We found no statistically significant difference in correction of the lumbar curve between the groups. The average loss of correction of the thoracic curve was 3° (10%; SD 2) in group S versus 5° (15%; SD 3) in group H. In the lumbar curve, the mean loss of correction was 3° (9%; SD 2) in group S versus 8° (35%; SD 3) in group H ($p = 0.02$).

The results of correction and lateral tilt in the first and second distal not instrumented segment are summarized in Table 2. There was a greater loss of correction in the first distal segment adjacent to the fusion in group H than in group S.

The thoracic kyphosis was corrected in group S to 3° and in group H to 2° (Table 3).

The results of derotation, using Perdriolle's method (1985), in the distal segment adjacent to the fusion and the loss of derotation are summarized in Table 4.

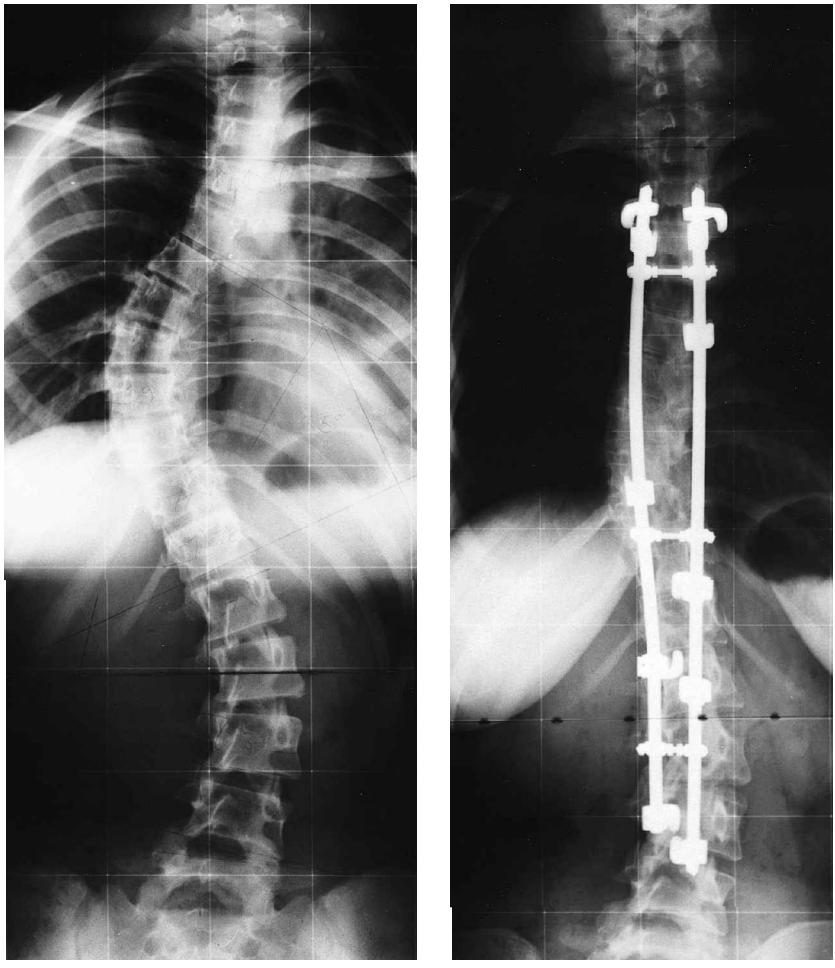

Figure 2. A14-year-old girl with adolescent idiopathic scoliosis with hooks in the lumbar spine.

The correction of the lateral displacement was larger from the midline of C7 to S1 in group S than in group H ($p = 0.04$; Table 5).

No infections or neurological complications occurred. In 2 patients, the distal laminar hooks pulled out. 1 patient had a broken transverse link device detected on the radiograph. In another patient, the distal laminar hook pulled out necessitating fusion with the adjacent segment. In group S, 3 pedicle screws were found on radiographs to have come out of the pedicle, 1 in the disc space and 2 laterally.

Discussion

Fixation of the rod in CDI can be obtained with hooks and/or screws (Shuffelberger et al. 1989, Kostuik 1990). Although hooks minimize the risk of nerve root injuries, cord injuries may occur when using laminar hooks, especially the convex apical hook. Lumbar pedicle screws have been used in the surgical treatment of scoliosis since 1988 (Suk et al. 1994). Screw malposition rates range between 28% and 40% in clinical studies with postoperative computed tomography (Jerosch et al. 1993, Sjöström et al. 1993, Gertzbein and Robbins 1994, Schlenzka 1998). Roy-Camille et al. (1986) reported that neurological complications caused by the implantation of screws in the pedicle are extremely rare. Whitecloud et al. (1989) reported 6 nerve root lesions in 40 patients treated with transpedicular fixation and fusion, 3 improved within 3 months and the others improved after the

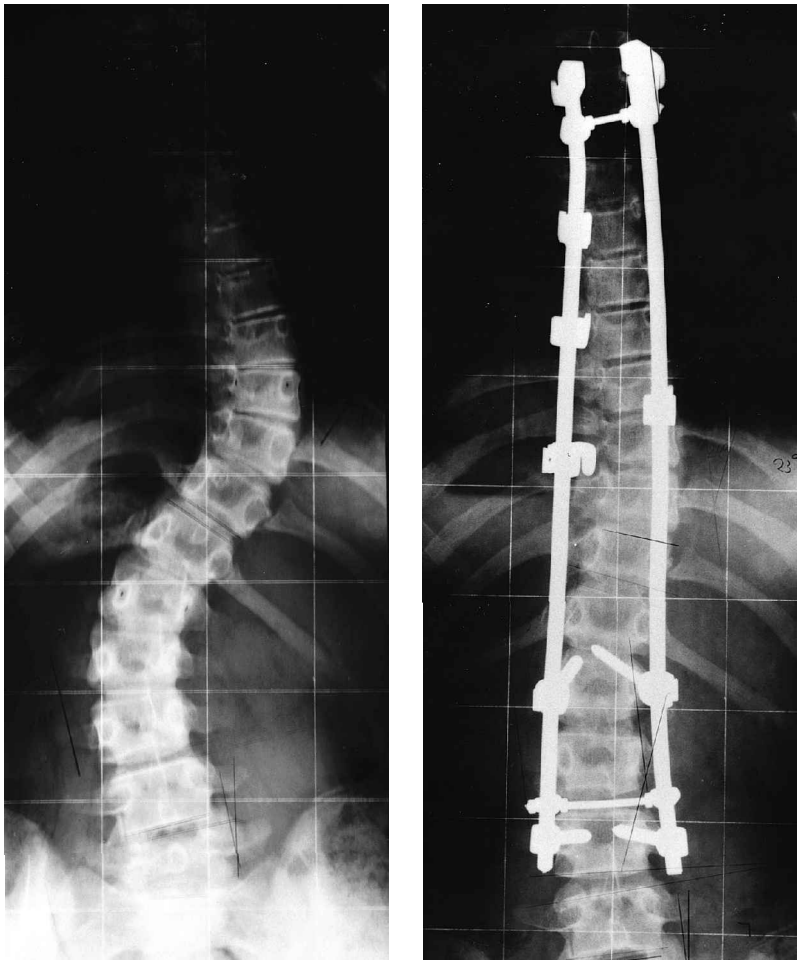

Figure 3. A 15-year-old girl with adolescent idiopathic scoliosis with pedicle screws in the lumbar spine.

screws were removed.

In our patients, 10% of the pedicle screws were malpositioned, but no neurological complications occurred.

Various surgical methods for correction of lumbar curves with posterior pedicle screws have been described. (Suk et al. 1995, Hamil et al. 1996). Barr et al. (1997) reported 39 patients with double major curves who underwent thoracic and lumbar instrumentation. Lumbar pedicle screws and hooks were used in 20 patients, 19 were treated solely with lumbar hooks. Both groups had thoracic CDI with hooks. Pedicle screws appeared to offer some advantages for lumbar curve correction—i.e., in maintaining the correction, and in correcting the uninstrumented spine below the fusion. Suk et al. (1995) used 3 types of instrumentation, hooks, pedicle screws inserted in a hook pattern, and segmental pedicle screws in 78 patients with idiopathic thoracic scoliosis. The major curve corrections were 55% with hooks, 66% with hook pattern screws, and 72% with segmental screws, a statistically significant difference. The losses of correction were 6%, 2%, and 1% in the respective groups. We found no differences in correction of the thoracic and lumbar curves between group S and group H. However, in group H, the preoperative flexibility of the lumbar curve was 63% and in group S, it was 50% (not significant). We found a significantly smaller loss of correction of the major curve in group S than in group H, as reported by others (Suk et al. 1995, Barr et al. 1997). Hamil et al. (1996) studied the advantages of pedicle screw fixation in order to improve correction of

the lumbar spine and obtained a correction of 38% with hooks and of 52% with screws vs. 51% with hooks in our study. Other studies on frontal curve correction using hooks, by Cotrel (1987), Cotrel and Dubousset (1984) and Schuffelberger et al. (1989), report about 60% correction of the lumbar curve.

Barr et al. (1997) noted a larger correction of the lateral tilt with screws (62%) than hooks (11%). We found that no significant difference occurred in the correction of the lateral tilt adjacent to the distal uninstrumented segment.

Pedicle screws are associated with neurological complications. The advantage of better derotation in the unfused segment adjacent to the fusion and significantly better maintenance in correction of the lumbar curve needs to be weighed against possible neurological risks.

No funds were received to support this study.

Barr S J, Schuette A M, Emans J B. Lumbar pedicle screws versus hooks; results in double major curves in adolescent idiopathic scoliosis. Spine 1997; 22: 1369-79.

Cotrel Y. New instrumentation for surgery of the spine. London, Freud Publishing House1987; 4: 129.

Cotrel Y, Dubousset J. Nouvelle technique d'osteosynthèse rachidienne segmentaire par voie posterieure. Rev Chir Orthop 1984; 40: 489.

Cotrel Y, Dubousset J, Guillaumat M. New universal instrumentation in spinal surgery. Clin Orthop 1987; 227: 10-22.

Gertzbein S D, Robbins S E. Accuracy of pedicular screw placement in vivo. Spine 1990; 15: 11-4.

Hamil C L, Lenke L G, Bridwell K H, Chapman M P, Blanke K, Baldus C. The use of pedicle screw fixation to improve correction in the lumbar spine of patients with idiopathic scoliosis: Is it warranted? Spine 1996; 21: 1241-9.

Jerosch J, Malms J, Castro M, Wagner R, Wieser L. Accuracy of pedicle screws in dorsal lumbar fusion (in German). Z Orthop 1993; 130: 479-83.

King A, Moe J H, Bradford D S, Winter R B. The selection of fusion levels in thoracic idiopathic scoliosis. J Bone Joint Surg (Am) 1983; 56: 1302-13.

Kostuik J P. Current concepts review. Operative treatment of idiopathic scoliosis. J Bone Joint Surg (Am) 1990; 72: 1108-13.

Perdriolle R, Vidal J. Thoracic idiopathic scoliosis curve evolution and prognosis. Spine 1985; 10: 785-91.

Roy-Camille R, Saillant G, Mazel C. Plating of thoracic, thoracolumbar and lumbar injuries with pedicle screw plates. Clin Orthop 1986; 17: 147-59.

Schlenzka D. Multi-center results of CAS. Oral presentation. Minimally invasive approaches to the spine; critical assessment and future innovations. 23.6.1998 Innsbruck

Shuffelberger H L, Ellis R D, Clark C E. Cotrel-Dubousset instrumentation (CDI) in adolescent idiopathic scoliosis: Minimum 2-year follow-up. Orthopedic Transaction 1989; 13: 79-80.

Sjöström L, Jacobsson O, Karlström G, Pech P, Rauschnig W. CT analysis of pedicle and screw tracts after implant removal in thoracolumbar fractures. J Spinal Disord 1993; 6: 225-31.

Suk S, Lee C K, Mim H J, Cho K H, On J H. Comparison of Cotrel-Dubousset pedicle screws and hooks in the treatment of idiopathic scoliosis. Int Orthop 1994; 18: 341-6.

Suk S, Lee C K, Kim W J, Chung Y J, Park Y B. Segmental pedicle crew fixation in the treatment of thoracic idiopathic scoliosis. Spine 1995; 20: 1399-405.

Whitecloud T S, Butler J C, Cohen J L, Candlora P D. Complications with the variable spinal plating system. Spine 1989; 14: 472-6.