Acta Orthop. Belg., 2010, **76**, 536-542

ORIGINAL STUDY

Scoliosis surgery : correction not correlated with instrumentation, quality of life not correlated with correction or instrumentation

Rolf SOBOTTKE, Jan SIEWE, Jan HOKEMA, Ulf SCHLEGEL, Thomas ZWEIG, Peer EYSEL

From the University of Cologne, Germany, and the University of Bern, Switzerland

The authors conducted a retrospective study on 24 consecutive adolescent scoliosis patients, 11 of whom were instrumented with hooks and 13 with hooks and screws (hybrid technique). The mean preoperative Cobb angle was 62.2° (range : 48°-96°). The mean correction of the primary curve was 56.6% at follow-up after ±1.18 years ; there was no statistically significant difference between groups. Special attention was given to the postoperative quality of life (QOL) by means of the following scores : COMI patient self-assessment, SF-36, ODI, and VAS. Again, there was no statistical difference between groups but, interestingly, there was no correlation between QOL and degree of correction, after a follow-up period of ±2.1 years. Nevertheless, on the COMI patient self-assessment, there was a high level of satisfaction with treatment. Further studies should concentrate on how to achieve a high QOL, and abandon the best possible correction as a primary endpoint of success.

Keywords : adolescent scoliosis ; surgical correction ; patient satisfaction.

INTRODUCTION

Derotating corrective spondylodesis is a generally accepted treatment for progressive adolescent idiopathic scoliosis with a Cobb angle above 40°. Anterior, posterior and combined anterior-posterior approaches are possible. As to the posterior approach, one can use either pedicle screws only, hooks only, or screws and hooks (hybrid technique). The authors compared two groups of patients, all treated via a posterior approach : 11 with hooks and 13 with screws and hooks.

MATERIALS AND METHODS

Twenty-four consecutive patients, treated via a posterior approach between September 2002 and April 2007, were retrospectively evaluated : 11 were instrumented with hooks (group 1), 13 with hooks and screws (group 2 : hybrid technique). Were excluded : foreigners, because of insufficient follow-up and linguistic problems ; patients instrumented with screws only, because of their limited number (<10%) ; patients who had an additional thoracoplasty or an additional anterior release. The ART® - instrumentation of Advanced Medical Technologies (Nonnweiler, Germany) was used.

■ Rolf Sobottke, MD, Orthopaedic Consultant.
■ Jan Siewe, MD, Orthopaedic Resident.
■ Jan Hokema, MD, Orthopaedic Fellow.
■ Ulf Schlegel, MD, Orthopaedic Resident.
■ Peer Eysel, MD, Professor of Orthopaedic Surgery.
Department of Orthopaedic and Trauma Surgery, University of Cologne, Germany.
■ Thomas Zweig, MD.
Institute for Evaluative Research in Orthopaedic Surgery, University of Bern, Switzerland.
Correspondence : Rolf Sobottke, MD, Joseph Stelzmann-str. 9, 50924 Cologne, Germany.
E-mail : rolf.sobottke@uk-koeln.de

This study was supported financially by Advanced Medical Technologies AG, Germany.

The average follow-up period was 2.1 years for the quality of life (QOL) assessment, and 1.18 years for the radiologic evaluation. The following disease-specific and general quality of life scores were used at follow-up : the COMI (Core Outcome Measures Index) patient self-assessment (*21,26,27*), the Oswestry Disability Index (ODI) (100 = worst), the Short form-36 (SF-36 PCS and MCS) (100 = best), VAS back pain and VAS leg pain (10 = worst). For patients who could not be examined in the outpatient clinic, the questionnaires were mailed with a letter requesting return in provided postage-free envelopes ; 91.7% of the questionnaires were completed.

Radiologic evaluation was based on the classical Cobb angle. The Cincinnati Correction Index (CCI) (*32*) reflected the postoperative correction.

Because this was an observational study, all outcome variables were analyzed in a purely explorative manner, with no formal adjustment of p-values for multiple comparisons. In regard to actual scale levels as well as distributional characteristics, explorative comparisons between groups were performed using appropriate parametric and non-parametric test statistics (e.g. t-test, ANOVA, rank statistics (Wilcoxon-Mann-Whitney), and contingency table analysis), as well as measures of stochastic association (e.g. correlation analyses). Differences were considered to be significant at a probability level of 95% ($p<0.05$). Statistical evaluation was done using SPSS 16.0.

RESULTS

General

The average age at operation was 15.6 ± 3.4 years. The male/female ratio was 1/11 ; 20.8% of the patients had a positive family history. Prior to admission patients were treated conservatively by their transferring doctors, on average during 32.3 ± 36.8 months : 75% were treated with a brace and 84.2% received physiotherapy, while 3 patients had no treatment at all. The indication for surgery was always progressive scoliosis. Additionally, there was increasing back pain in 33.3% of the cases, restrictive lung disease in 42.1% and worsening pulmonary function in 4.2%.

Peri-operative course and follow-up

Hooks alone were used in 11 cases (45.8%) ; hooks and pedicle screws (hybrid technique) in 13 (54.2%). On average 10.3 ± 2.0 segments were fused (table I). Per patient, an average of 12.4 ± 2.1 screws or hooks was used (1.3 ± 0.4 per fused segment). The neurologic status was assessed in all cases, either intraoperatively with sensory-motor evoked potentials, or at the end of the procedure with the Stagnara wake-up test. Postoperatively, all patients spent 24 hours in the intensive care unit. They were fully mobilized after an average of 4.5 ± 1.9 days. The average hospital stay was 15.3 ± 3.2 days. Complications were noted in 20.8% of the cases, but there was no significant difference between groups. No implant-related complications occurred.

Clinical outcome and Quality of Life (QOL)

To the COMI question which postoperative complaints were the most burdensome, 54.5% answered back pain ; 18.2% tingling, numbness, or other paresthesiae in the back/legs/buttocks ; 9.1% leg or buttock pain ; and 18.1% none of the offered responses. The clinical outcome as a function of the type of instrumentation showed no significant differences (table II). But the question “Please reflect on the last week. How would you rate your quality of life ?” (COMI) revealed that the QOL seemed to be somewhat superior in the hook group (fig 1). The

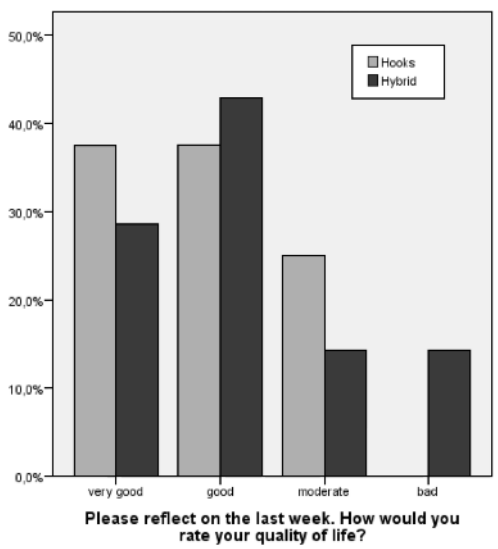

Fig. 1. — Spine Tango COMI patient self-assessment test. Answers to the question “Please reflect on the last week. How would you rate your quality of life ?”, as a function of the type of instrumentation : hooks versus hooks and screws (hybrid).

Table I. — Mean results and standard deviation as a function of instrumentation : hooks versus hooks and screws (hybrid)

	Hooks (11 cases)	Hybrid (13 cases)	Total (24 cases)
Primary curve (°)	61.7 ± 12.8	62.5 ± 13.4	62.2 ± 12.9
Secondary curve (°)	31.0 ± 4.0	42.5 ± 12.3 **(p = 0.031)**	37.8 ± 11.2
Correction primary curve (%)	54.4 ± 10.0	58.5 ± 15.3	56.6 ± 13.0
Correction secondary curve (%)	45.3 ± 10.9	55.7 ± 19.4	53.1 ± 17.4
Loss of correction primary curve (°)	5.0 ± 4.2	4.2 ± 4.9	4.4 ± 4.6
Loss of correction secondary curve (°)	5.0 ± 1.2	5.9 ± 6.8	5.7 ± 6.0
Span of instrumentation (segments)	10.3 ± 1.4	10.4 ± 2.5	10.3 ± 2.0
Operative time (min)	184.6 ± 52.5	200.0 ± 47.4	186.7 ± 49.8
Blood loss (ml)	1,255 ± 638	1,228 ± 657	1,239 ± 631
Radiation exposure	none	**present**	-
Inpatient stay (days)	13.5 ± 2.7	16.8 ± 3.2 **(p = 0.013)**	15.3 ± 3.2

question “Overall, how much did the operation help your back problem ?” (COMI) showed that 90.9% were better. There was no worsened outcome for patients suffering complications either in hospital or during follow-up.

Radiologic assessment

At surgery the Cobb angle amounted to 62.2° ± 12.9° (range 48°-96°) (table I). The mean CCI was 5.7 ± 10.1, and the mean correction of the primary curve 56.6% ± 13.0%, with no significant differences between the two groups. There were no correlations between clinical outcome and radiological findings (table III).

DISCUSSION

Correction

Using the continuously improving techniques and instrumentation in combination with a careful soft-tissue and bony release, posterior fusions are achieving a significantly better three-dimensional correction (*7,11,13,15*), barely inferior to anterior and anteroposterior procedures (*16*). A remaining question is, which instrumentation (screws, hooks, hybrid) should one use for a posterior fusion. The biomechanical advantage is with pedicle screws over laminar or pedicle hooks (*17*). They offer a better correction in terms of translation and a lesser

Table II. — Clinical outcome as a function of the typr of instrumentation : hooks versus hooks and screws (hybrid). No significant differences

	Hooks (11 cases)	Hybrid (13 cases)	Total (24 cases)
SF-36 PCS	49.2 ± 8.2	45.4 ± 9.8	47.4 ± 8.9
SF-36 MCS	49.1 ± 13.7	49.3 ± 10.5	49.2 ± 11.8
ODI	13.6 ± 11.6	15.1 ± 17.6	14.3 ± 12.0
VAS back pain	2.8 ± 2.6	3.7 ± 2.1	3.2 ± 2.4
VAS leg pain	1.1 ± 1.8	2.0 ± 2.8	1.5 ± 2.3

Table III. — Correlations between scoliosis variables and clinical outcomes

	SF-36 PCS	SF-36 MCS	ODI	VAS back pain	VAS leg pain
Preoperative COBB angle	r = 0.366 p = 0.180	r = 0.449 p = 0.093	r = - 0.449 p = 0.093	r = - 0.426 p = 0.114	r = 0.392 p = 0.148
Postoperative correction	r = - 0.385 p = 0.194	r = - 0.527 p = 0.064	r = 0.440 p = 0.132	r = 0.471 p = 0.104	r = - 0.243 p = 0.423
Postoperative COBB angle	r = 0.570 **p = 0.042**	r = 0.672 **p = 0.012**	r = - 0.610 **p = 0.027**	r = - 0.617 **p = 0.025**	r = - 0.035 p = 0.909
Length of fusion	r = - 0.433 p = 0.107	r = 0.035 p = 0.902	r = 0.115 p = 0.682	r = 0.177 p = 0.529	r = 0.192 p = 0.492
VAS back pain	r = - 0.800 **p < 0.001**	r = - 0.856 **p < 0.001**	r = 0.876 **p < 0.001**	-	-
VAS leg pain	r = - 0.470 p = 0.077	r = - 0.513 p = 0.051	r = 0.652 **p = 0.008**	-	-

p (underlined) = tendency towards significance ; p (bold) = significant ($p < 0.05$).

loss of correction (*3,9,29*). On the other hand, using the Cincinnati Correction Index in a retrospective cohort study (n = 72), Vora *et al* (*32*) found no significant difference between the three types of instrumentation. The hooks showed the greatest loss of correction after 2 years : 4°. With the pedicle screw construct, they observed further lordosis of the thoracic kyphosis. There was a tendency for better results with the hybrid procedure. In a retrospective study with 99 scoliosis patients, Liljenqvist *et al* (*18*) identified a significantly better correction of the primary and secondary curves, a significantly shorter fusion span (0.6 segments less), a significantly smaller blood loss, and a significantly shorter time of operation for instrumentation with screws or hybrid technique (screws and hooks) versus hooks only. Furthermore, in a retrospective study (n = 52) with scoliosis angles > 80°, Di Silvestre *et al* (*7*) found significantly better correction of the primary and secondary curves, but longer operation time and more complications with screws than with hybrid instrumentation. We found no significant advantages (table I) for the hybrid technique versus hooks regarding correction of primary and secondary curves, fusion span and loss of correction. Patients in the hybrid group had a significant (p = 0.013) longer hospital-stay. In our opinion, hooks require less radiologic exposure, as they are normally inserted without imaging.

Misplacement of pedicle screws

This occurs even with the most careful and observant insertion techniques, because of the distorted anatomy. According to a review study by Weiss *et al* (*33*) this occurs on average in 15.8% of the cases. Fortunately, the error is usually so minimal that it does not lead to spinal cord injury (*20, 28,33*). Neurologic deficits, mostly temporary, are seen in a mere 0 to 1.5% of cases (*12,28*). In general, Kim *et al* (*12*) call a breach of 2 mm or less a "definite safe zone", one of 2-4 mm a "probable safe zone", and one of 4-8 mm a "questionable safe zone". However, the concavity of the apex in a scoliosis curve tends to behave differently. In this area the cord, with an epidural distance of 1 mm, lies very close to the pedicle wall (*19*). Despite this, the incidence of screw-related complications is minimal (*7*). In our study, we found no complications related to screw misplacement.

Cord compression

This is a disadvantage of laminar hooks, especially at the thoracic apex. Polly *et al* (*24*) found that a mildly errant pedicle screw (with a 3 mm breach) is less invasive than a perfectly positioned laminar hook. It appears to be a theoretical risk, though. In our study no such problems were

observed. Moreover, laminar hooks not only offer less rigid anchoring than the pedicle screws, but also have risks of hook avulsion and laminar fractures (*29*).

Complication rate

In a review of the literature including all kinds of operative techniques, Weiss *et al* (*33*) found a total complication rate averaging 20% (10-78%). Our complication rate was in this range, with 20.8%.

Clinical outcome and Quality of life (QOL)

Scoliosis is psychologically burdensome and it affects the quality of life (*31*). Therefore, surgery should not only focus on curve progression, painful degeneration, pulmonary function and cosmetic aspect, but also on quality of life. Danielsson (*6*) reviewed the literature from 1990 to 2007, and found only 3 studies which compared preoperative and postoperative QOL (*22,23,30*) ; all three mentioned an improved QOL after scoliosis surgery. One of these three studies was a multicenter study (n = 242) by Merola *et al* (*22*), who identified a significant improvement in SRS-24, a scoliosis-specific health related QOL-questionnaire, 24 months after surgery. Pain, general self-image, function according to back condition, and levels of activity all demonstrated significant improvement when compared with the preoperative status ($p < 0.001$). Overall, patients were highly satisfied with the results of surgery. On the other hand, no significant correlation between QOL and degree of scoliosis, degree of correction, gender, or surgical procedure (anterior versus posterior) was identified. The study of Sweet *et al* (*30*) was also one of the three mentioned above. These authors used the SRS-24 to evaluate QOL in 63 scoliosis patients prior to and after anterior fusion. They found significantly improved function, pain, and self-image ($p < 0.01$). They also found that poor radiographic results did not correlate with QOL assessments. In his review of the literature, Danielsson (*6*) also found weak evidence (level IV) that the degrees of scoliosis and correction do not significantly influence quality of life. In any case, recent publications agree that there is no straight forward correlation between degree of correction and QOL (*5,10*). Also the current study established no correlation between postoperative correction and QOL. Indeed, the higher the correction of the scoliosis, the lower the SF-36 (PCS and MCS) and the higher the ODI and VAS (back pain). These findings became even more relevant (p-value with significance) in the correlations between postoperative Cobb angle and clinical outcomes / QOL (table III). In other words, both the literature and the current study contradict the opinion that the curve should be straightened as much as possible. With this background, further studies should concentrate on the best surgical approaches and instrumentations for a good QOL and abandon the best possible correction as a primary endpoint of success.

Is this improvement of QOL durable ? Indeed, the quality of life of operated scoliosis patients appears to be good in the long-term (*4,10*), although not as good as in a comparable population without scoliosis (*2*). In a prospective study of 100 posteriorly-instrumented scoliosis patients Bjerkreim *et al* (*4*) found that 10 years postoperatively the patients reported excellent QOL and back function (ODI 6.9 ± 9.5), although almost half of them complained of back pain. With 14.3 ± 12.0, our ODI results were higher, and thus less good, than this (table II). There was also a considerable number of patients (54.5%) complaining of back pain, leading to a mean VAS back pain of 3.2 ± 2.4 (table II). Obviously postoperative back pain continues to be a problem in scoliosis therapy, the more so because it shows a significant reverse correlation with QOL (table III). In a consecutive, comparative study (n=215) on QOL and pain over 10 years, Andersen *et al* (*2*) showed that back pain after conservative therapy (bracing) was less pronounced than in patients who underwent surgery. The average SF-36 PCS score for operated patients in their study was 49.3 and the SF-36 MCS was 51.9, although no scoliosis-specific data regarding radiologic measurements or operative procedure were given. In the current study (table II) the average SF-36 PCS of 47.4 ± 8.9 and SF-36 MCS of 49.2 ± 11.8 are somewhat worse.

Unfortunately, there are few published results available comparing QOL outcomes as a function

of the operative therapy chosen (*6,25*). In a retrospective analysis of 52 patients with high-grade thoracic scoliosis (> 80°) , post-screw or hybrid instrumentation, Di Silvestre *et al* (*7*) identified no differences in QOL (using SRS-30 and SF-36). The current study led to the same conclusion (table II).

In general, it remains difficult to compare results with those in literature because of the heterogeneity of the patient populations, treatments performed, and interpretation of the various questionnaires.

REFERENCES

1. **Akbarnia BA, Breakwell LM, Marks DS *et al.*** Dual growing rod technique followed for three to eleven years until final fusion : the effect of frequency of lengthening. *Spine* 2008 ; 33 : 984-990.
2. **Andersen MO, Christensen SB, Thomsen K.** Outcome at 10 years after treatment for adolescent idiopathic scoliosis. *Spine* 2006 ; 31 : 350-354.
3. **Barr SJ, Schuette AM, Emans JB.** Lumbar pedicle screws versus hooks. Results in double major curves in adolescent idiopathic scoliosis. *Spine* 1997 ; 22 : 1369-1379.
4. **Bjerkreim I, Steen H, Brox JI.** Idiopathic scoliosis treated with Cotrel-Dubousset instrumentation : evaluation 10 years after surgery. *Spine* 2007 ; 32 : 2103-2110.
5. **Bunge EM, Juttmann RE, de Kleuver M *et al*.** Health-related quality of life in patients with adolescent idiopathic scoliosis after treatment : short-term effects after brace or surgical treatment. *Eur Spine J* 2007 ; 16 : 83-89.
6. **Danielsson AJ.** What impact does spinal deformity correction for adolescent idiopathic scoliosis make on quality of life ? *Spine* 2007 ; 32 (19 Suppl) : S101-108.
7. **Di Silvestre M, Bakaloudis G, Lolli F *et al*.** Posterior fusion only for thoracic adolescent idiopathic scoliosis of more than 80 degrees : pedicle screws versus hybrid instrumentation. *Eur Spine J* 2008 ; 17 : 1336-1349.
8. **Götze C, Liljenqvist UR, Slomka A *et al.*** Quality of life and back pain : outcome 16.7 years after Harrington instrumentation. *Spine* 2002 ; 27 : 1456-1463.
9. **Hamill CL, Lenke LG, Bridwell KH *et al.*** The use of pedicle screw fixation to improve correction in the lumbar spine of patients with idiopathic scoliosis. Is it warranted ? *Spine* 1996 ; 21 : 1241-1249.
10. **Helenius I, Remes V, Lamberg T *et al***. Long-term health-related quality of life after surgery for adolescent idiopathic scoliosis and spondylolisthesis. *J Bone Joint Surg* 2008-A ; 90 : 1231-1239.
11. **Kadoury S, Cheriet F, Beausejour M *et al.*** A three-dimensional retrospective analysis of the evolution of spinal instrumentation for the correction of adolescent idiopathic scoliosis. *Eur Spine J* 2009 ; 18 : 23-37.
12. **Kim YJ, Lenke LG, Bridwell KH *et al.*** Free hand pedicle screw placement in the thoracic spine : is it safe ? *Spine* 2004 ; 29 : 333-342.
13. **Kuklo TR, Potter BK, Polly DW Jr *et al.*** Monaxial versus multiaxial thoracic pedicle screws in the correction of adolescent idiopathic scoliosis. *Spine* 2005 ; 30 : 2113-2120.
14. **Lai SM, Asher M, Burton D.** Estimating SRS-22 quality of life measures with SF-36 : application in idiopathic scoliosis. *Spine* 2006 ; 31 : 473-478.
15. **Lee SM, Suk SI, Chung ER.** Direct vertebral rotation : a new technique of three-dimensional deformity correction with segmental pedicle screw fixation in adolescent idiopathic scoliosis. *Spine* 2004 ; 29 : 343-349.
16. **Lehman RA Jr, Lenke LG, Keeler KA *et al.*** Operative treatment of adolescent idiopathic scoliosis with posterior pedicle screw-only constructs : minimum three-year follow-up of one hundred fourteen cases. *Spine* 2008 ; 33 : 1598-1604.
17. **Liljenqvist U, Hackenberg L, Link T *et al.*** Pullout strength of pedicle screws versus pedicle and laminar hooks in the thoracic spine. *Acta Orthop Belg* 2001 ; 67 : 157-163.
18. **Liljenqvist U, Lepsien U, Hackenberg L *et al.*** Comparative analysis of pedicle screw and hook instrumentation in posterior correction and fusion of idiopathic thoracic scoliosis. *Eur Spine J* 2002 ; 11 : 336-343.
19. **Liljenqvist UR, Allkemper T, Hackenberg L *et al.*** Analysis of vertebral morphology in idiopathic scoliosis with use of magnetic resonance imaging and multiplanar reconstruction. *J Bone Joint Surg* 2002 ; 84-A : 359-368.
20. **Liljenqvist UR, Link TM, Halm HF.** Morphometric analysis of thoracic and lumbar vertebrae in idiopathic scoliosis. *Spine* 2000 ; 25 :1247-1253.
21. **Mannion AF, Elfering A, Staerkle R *et al.*** Outcome assessment in low back pain : how low can you go ? *Eur Spine J* 2005 ; 14 :1014-1026.
22. **Merola AA, Haher TR, Brkaric M *et al*.** A multicenter study of the outcomes of the surgical treatment of adolescent idiopathic scoliosis using the Scoliosis Research Society (SRS) outcome instrument. *Spine* 2002 ; 27 : 2046-2051.
23. **Newton PO, Parent S, Marks M *et al.*** Prospective evaluation of 50 consecutive scoliosis patients surgically treated with thoracoscopic anterior instrumentation. *Spine* 2005 ; 30 suppl 17 : S100-109.
24. **Polly DW Jr, Potter BK, Kuklo T *et al*.** Volumetric spinal canal intrusion : a comparison between thoracic pedicle screws and thoracic hooks. *Spine* 2004 ; 29 : 63-69.
25. **Reddi V, Clarke DV Jr, Arlet V.** Anterior thoracoscopic instrumentation in adolescent idiopathic scoliosis : a systematic review. *Spine* 2008 ; 33 : 1986-1994.
26. **Röder C, Chavanne A, Mannion AF *et al.*** SSE Spine Tango—content, workflow, set-up. **www.eurospine.org-Spine** Tango. *Eur Spine J* 2005 ; 14 : 920-924.

27 **Röder C, Müller U, Aebi M.** The rationale for a spine registry. *Eur Spine J* 2006 ; 15 suppl 1 : S52-S56.
28. **Suk SI, Kim WJ, Lee SM *et al*.** Thoracic pedicle screw fixation in spinal deformities : are they really safe ? *Spine* 2001 ; 26 : 2049-2057.
29. **Suk SI, Lee CK, Min HJ *et al.*** Comparison of Cotrel-Dubousset pedicle screws and hooks in the treatment of idiopathic scoliosis. *Int Orthop* 1994 ; 18 : 341-346.
30. **Sweet FA, Lenke LG, Bridwell KH *et al.*** Prospective radiographic and clinical outcomes and complications of single solid rod instrumented anterior spinal fusion in adolescent idiopathic scoliosis. *Spine* 2001 ; 26 : 1956-1965.
31. **Tones M, Moss N, Polly DW Jr.** A review of quality of life and psychosocial issues in scoliosis. *Spine* 2006 ; 31 : 3027-3038.
32. **Vora V, Crawford A, Babekhir N *et al.*** A pedicle screw construct gives an enhanced posterior correction of adolescent idiopathic scoliosis when compared with other constructs : myth or reality. *Spine* 2007 ; 32 :1869-1874.
33. **Weiss HR, Goodall D.** Rate of complications in scoliosis surgery - a systematic review of the Pub Med literature. *Scoliosis* 2008 ; 3 : 9.
34. **Wilson PL, Newton PO, Wenger DR *et al*.** A multicenter study analyzing the relationship of a standardized radiographic scoring system of adolescent idiopathic scoliosis and the Scoliosis Research Society outcomes instrument. *Spine* 2002 ; 27 : 2036-2040.