

Selective Thoracic Fusion with Segmental Pedicle Screw Fixation for the Treatment of Thoracic Idiopathic Scoliosis: More than Five Year's Follow-Up

Se-Il Suk, M.D., Ph.D., Jin-Hyok Kim, M.D., Ph.D., Sung-Soo Kim, M.D.,
Jeong-Joon Lee, M.D., Yong-Taek Han, M.D., Eul-O Choi, M.D.

Seoul Spine Institute, Inje University Sanggye-Paik Hospital, Seoul, Korea

– Abstract –

Study Design: This is a retrospective study.

Objectives: We wanted to evaluate the outcomes of selective thoracic fusion with segmental pedicle screw fixation for treating thoracic idiopathic scoliosis with a minimum 5-year follow-up.

Summary of the Literature Review: Segmental pedicle screw fixation has been proven to achieve true segmental control and greater correction of scoliosis in both the coronal and sagittal planes. However, there is no long-term study of selective thoracic fusion with segmental pedicle screw fixation for treating thoracic idiopathic scoliosis.

Materials and Methods: We analyzed 203 thoracic idiopathic scoliosis patients (236 thoracic curves) who underwent selective thoracic fusion with segmental pedicle screw fixation. The mean patient age at the time of operation was 13.8 years (range: 8.9–18 years).

Results: The preoperative thoracic curve of $51 \pm 12^\circ$ was corrected to $16 \pm 7^\circ$ (69% correction with 3% loss of correction) at the most recent follow-up. The non-instrumented lumbar curve of $30 \pm 10^\circ$ was corrected to $10 \pm 8^\circ$ (66% correction with 5% loss of correction) at the most recent follow-up. The preoperative thoracic kyphosis of $18 \pm 11^\circ$ and the lumbar lordosis of $43 \pm 10^\circ$ were improved to $23 \pm 8^\circ$ and $46 \pm 9^\circ$, respectively, at the most recent follow-up. There was no junctional kyphosis at the most recent follow-up. Coronal decompensation at the most recent follow-up occurred in 10 patients. Postoperative adding-on occurred in 17 patients who were fused two levels short of the neutral vertebra. Of the 2867 thoracic pedicle screws inserted at the thoracic level, 43 screws were found to be malpositioned (1.5%), but they did not cause neurologic complications or adversely affect the long-term results.

Conclusions: Selective thoracic fusion with segmental pedicle screw fixation for treating thoracic idiopathic scoliosis had satisfactory radiographic and clinical outcomes after surgery, and the outcomes were well-maintained for a minimum of 5 years follow-up. It is a safe and effective method for preserving segments of lumbar motion as well as for the restoration and maintenance of both the coronal and sagittal alignments.

Key Words: Thoracic idiopathic scoliosis, Selective thoracic fusion, Segmental fixation, Pedicle screw

Address reprint requests to

Sung-Soo Kim, M.D.

Seoul Spine Institute, Inje University Sanggye Paik Hospital

761-1 Sanggye Dong, Nowon-Ku, Seoul, 139-707, Korea

Tel: 82-2-950-1288, Fax: 82-2-3392-1101, E-mail: toetotoe1@sanggyepaik.ac.kr

* 2005

가 가 . (Fig. 1) 170
 (Fig. 2) 33 . King
 2 122 , 3 29 , 4 19
 , 5 33 13.8
 (8.9~18) 가 172 , 가 21 .
 1959 5 (5~11.6)
 Boucher¹⁾ , 1960 Risser 5 .
 Roy-Camille^{2,3)}
 가 (anchor) 가 Cobb
 가 4) 가 20 가
 3 가 가 7
 가 (C7 plumb line)
 (decompensation) 가 (center sacral vertical line) 2 cm
 5) 가 (adding-on
 (selective thoracic fusion) phenomenon)
 6,7), (rod derotation)
 6,7,8,9) 10,11,12) . Kruskal-Wallis , ANOVA, Chi-square
 p<0.05
 (King II Lenke 1C)
 , (com- 51% 30 ± 10 °
 pensatory nature) (King III, IV Lenke 1A, (9~54 °) 118% King
 1B) 가 King 3 47 ± 7 °, King 4 58 ± 16 °, King 5 56
 ± 18 ° . King
 (hook) 가 (p=0.275).
 13,14,15,16,17) (double thoracic (T5~T12) 18 ± 11 °
 curve) (T12~S1) 43 ± 10 ° (Table 1).
 가 1.
 1
 5 가 가 Cobb
 가 .
 18) . King
 19) (stable vertebra)
 가 (mobile transitional
 segment)
 5 .
 가 가 203 , 236
 K-



Fig. 1. A 13- year 3-month-old girl with single thoracic curve. (A) Preoperative anteroposterior radiograph shows 68 °main thoracic curve and 49 °lumbar curve. (B) Preoperative lateral radiograph. (C) Anteroposterior radiograph taken 1 month after surgery. The main thoracic curve was corrected to 20 °, and the lumbar curve was spontaneously corrected to 20 °. (D) Lateral radiograph taken 1 month after surgery. Thoracic kyphosis was improved also. (E, F) Anteroposterior and lateral radiographs taken 6 years and 3 months after surgery. Coronal and sagittal alignments were well maintained during the follow-up.

(hand drill) (tunnel) (awl) (concave side) 가
, (convex side) 2~3 가
(blunt-ended probe) , 가
(rigid rod)

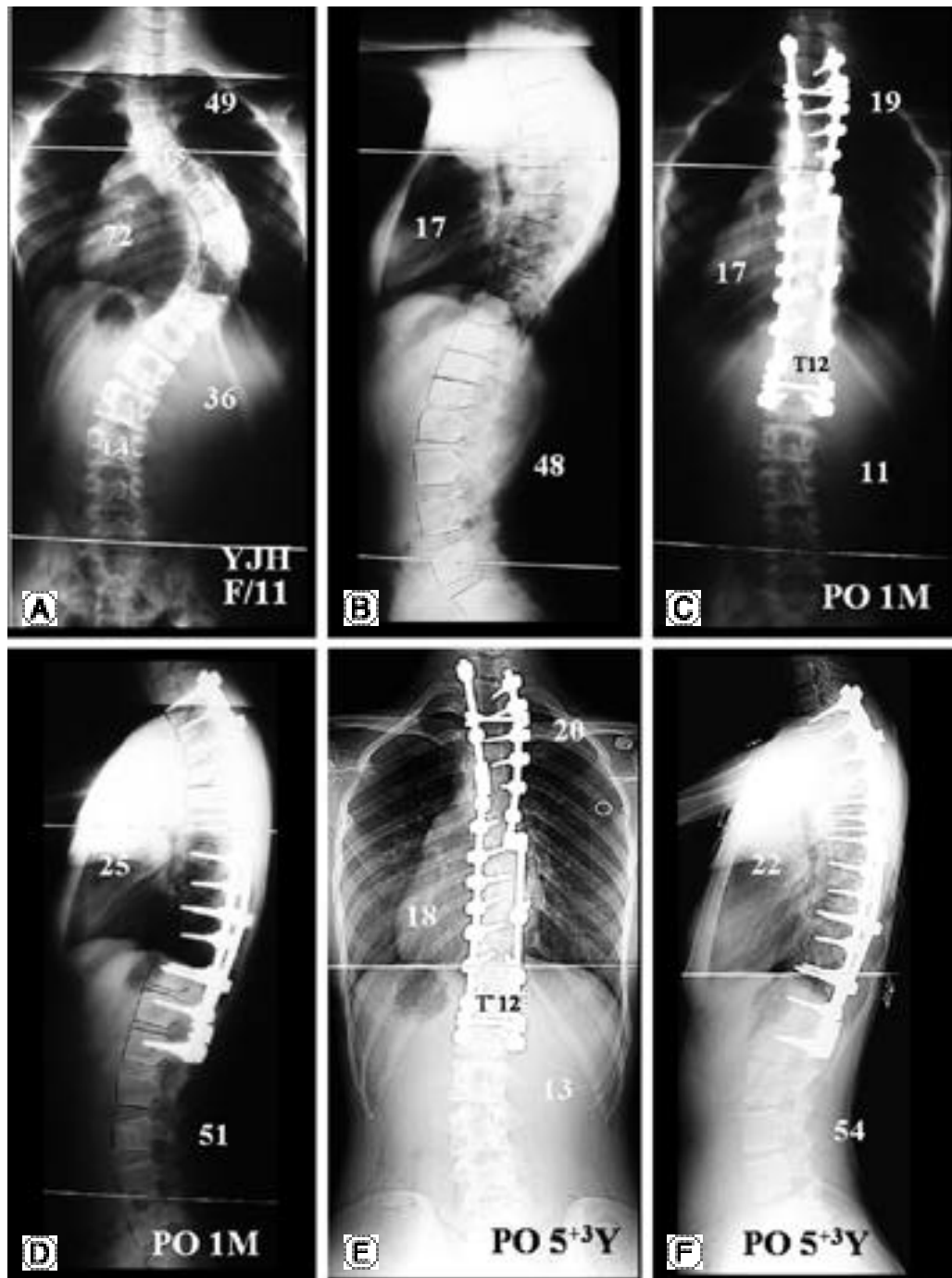


Fig. 2. A 11-year-old girl with double thoracic curve. (A) Preoperative anteroposterior radiograph shows 72 ° main thoracic curve and 49 ° proximal thoracic curve. (B) Preoperative lateral radiograph. (C) Anteroposterior radiograph taken 1 month after surgery. The main thoracic curve was corrected to 17 °, and the proximal thoracic curve was corrected to 19 °. (D) Lateral radiograph taken 1 month after surgery. Thoracic kyphosis was improved also. (E, F) Anteroposterior and lateral radiographs taken 5 years and 3 months after surgery. Coronal and sagittal alignments were well maintained during the follow-up.

Table 1. Radiological data of preoperative deformity

Table 2. Coronal curve

corr* : correction rate

Table 3. Thoracic kyphosis (T5~T12) and lumbar lordosis (T12~S1)

	King II		King III		King IV		King V		Total	
	Thoracic	Lumbar	Thoracic	Lumbar	Thoracic	Lumbar	Thoracic	Lumbar	Thoracic	Lumbar
Preop.	17 ± 10 °	42 ± 11 °	20 ± 14 °	46 ± 7 °	22 ± 15 °	47 ± 12 °	19 ± 8 °	45 ± 8 °	18 ± 11 °	43 ± 10 °
PO 1M	23 ± 8 °	43 ± 8 °	21 ± 9 °	43 ± 6 °	28 ± 11 °	45 ± 7 °	27 ± 7 °	45 ± 8 °	24 ± 8 °	44 ± 8 °
PO 1Y	22 ± 8 °	43 ± 9 °	19 ± 6 °	41 ± 9 °	24 ± 13 °	45 ± 5 °	23 ± 9 °	50 ± 7 °	22 ± 8 °	44 ± 9 °
PO 2Y	23 ± 8 °	47 ± 8 °	19 ± 9 °	40 ± 10 °	26 ± 13 °	49 ± 2 °	25 ± 10 °	49 ± 11 °	23 ± 9 °	46 ± 9 °
PO 5Y	23 ± 8 °	46 ± 10 °	19 ± 4 °	42 ± 9 °	25 ± 11 °	47 ± 3 °	24 ± 7 °	49 ± 9 °	23 ± 8 °	46 ± 9 °

Table 4. Thoracic pedicle screw malposition

Screw malposition	Screws [n (%)]
Lateral	12 (28)
Medial	3 (7)
Superior	8 (19)
Inferior	20 (46)
Total	43 (100)

King 2 23 ± 8 °; King 3
19 ± 4 °, King 4 25 ± 11 °, King 5 24 ± 7 °

(p=0.326). 43 ± 10 ° 1 44 3)
± 8 °, 46 ± 9 ° (Table 3). King 5 33

(p=0.357,p=0.095).

2.

1)

203 , 7

가 2 cm

34

가

10

King 2

7 , King 1

1

King 5

2

. 10

가

4

가

34

6

2)

(가)

가

17

King 3

6 (6/29, 21%), King 4

7 (7/19, 37%)

King 5

King 3

4

4 (4/33, 12%)

. King

(p=0.218).

가

.

(, end vertebra+1)

가 0

± 1

가

(0/163)

가

2

가

(17/40, 43%).

가

12 mm(3~30)

1

8 mm(0~22),

4 mm(0~12)

.

6

(>10 mm),

1 3 (3/33, 9%),

2

(2/33, 6%)가

가

45 °

22

.

3.

(misplacement)

(T1~T12)

2867

1

14 (10~22)

. 20

281

(281/2867,10%)

(2586/2867, 90%)

.

24 (1.2%)

43

(1.5%)

5

가

17

King 3

6 (6/29, 21%), King 4

7 (7/19, 37%)

King 5

12(12/43,28%) ,

.

3(7%) ,

가 8(19%) ,

가 20(46%)

(Table 4).

가 가

가

(8/24, 33%).

4. 203
2867 , 43 (1.5%)가
3 2
(junctional kyphosis)
Harrington
(stable vertebra)
18) (, end vertebra+1)
가 163 (163/203, 80.3%) 0 ± 1 CD
16) 1.1
1.5~25%
0~0.9% 16,20,21,22,23)
가 King 2 , Lenke 1B, 1C, 3 CD
7,24) 가
1 1988 16) King 2 122
7 (7/122, 5.7%) 가 6,7,8,9), 24)
(hook) 75%
(pullout) 30%
가 King 3 , 4 , Lenke 1A
가 가 25)



- 1) **Boucher HH:** *A method of spinal fusion. J Bone Joint Surg Br 1959; 41:248-259.*
- 2) **Roy-Camille R, Saillant G, Mazel C:** *Internal fixation of the lumbar spine with pedicle screw plating. Clin Orthop 1986; 203:7-17.*
- 3) **Roy-Camille R, Saillant G, Mazel C:** *Plating of thoracic, thoracolumbar, and lumbar injuries with pedicle screw plates. Orthop Clin North Am 1986; 17:147-159.*
- 4) **Boos N, Webb JK:** *Pedicle screw fixation in spinal disorders: a European view. Eur Spine J 1997; 6:2-18.*
- 5) **Cochran T, Irtam L, Nachemson A:** *Long-term anatomic and functional changes in patients with adolescent idiopathic scoliosis treated by Harrington rod fusion. Spine 1983; 8:576-584.*
- 6) **Moore MR, Baynham GC, Brown CW, Donaldson DH, Odom JA Jr:** *Analysis of factors related to truncal decompensation following Cotrel-Dubousset instrumentation. J Spinal Disord 1991; 4:188-192.*
- 7) **Thompson JP, Transfeldt EE, Bradford DS, Ogilvie JW, Boachie-Adjei O:** *Decompensation after Cotrel-Dubousset instrumentation of idiopathic scoliosis. Spine 1990; 15:927-931.*
- 8) **Bridwell KH, McAllister JW, Betz RR, Huss G, Clancy M, Schoenecker PL:** *Coronal decompensation produced by Cotrel-Dubousset "derotation" maneuver for idiopathic right thoracic scoliosis. Spine 1991; 16:769-777.*
- 9) **Marson DE, Carango P:** *Spinal decompensation in Cotrel-Dubousset instrumentation. Spine 1991; 8:S394-S403.*
- 10) **Arlet V, Marchesi D, Papin P, Aebi M:** *Decompensation following scoliosis surgery: treatment by decreasing the correction of the main thoracic curve or "letting the spine go." Eur Spine J 2000; 9:156-160.*
- 11) **Benli IT, Tuzuner M, Akalin S, Kis M, Aydin E, Ton-**

- dogan R:** *Spinal imbalance and decompensation problems in patients treated with Cotrel-Dubousset instrumentation.* *Eur Spine J* 1996; 5:380-386.
- 12) **Margulies JY, Floman Y, Robin GC, et al:** *An algorithm for selection of instrumentation levels in scoliosis.* *Eur Spine J* 1998; 7:88-94.
 - 13) **Suk SI, Kim WJ, Lee CS, et al:** *Indications of proximal thoracic curve fusion in thoracic adolescent idiopathic scoliosis.* *Spine* 2000; 25:2342-2349.
 - 14) **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.
 - 15) **Suk SI, Kim WJ, Kim JH, Lee SM:** *Restoration of thoracic kyphosis in the hypokyphotic spine: A comparison between multiple-hook and segmental pedicle screw fixation in adolescent idiopathic scoliosis.* *J Spinal Disord* 1999; 12:489-495.
 - 16) **Suk SI, Lee CK, Kim WJ, Chung YJ, Park YB:** *Segmental pedicle screw fixation in the treatment of thoracic idiopathic scoliosis.* *Spine* 1995; 20:1399-1405.
 - 17) **Suk SI, Lee CK, Min HJ, Cho KH, Oh JH:** *Comparison of Cotrel-Dubousset pedicle screws and hooks in the treatment of idiopathic scoliosis.* *Int Orthop* 1994; 18:341-6.
 - 18) **Suk SI, Kim WJ:** *Pedicle screw fixation for thoracic scoliosis.* In: Brown CW, ed. *Spinal instrumentation techniques.* Rosemont, IL: Scoliosis Research Society, 1998.
 - 19) **King HA, Moe JH, Bradford DS, Winter RB:** *The selection of fusion levels in thoracic idiopathic scoliosis.* *J Bone Joint Surg Am* 1983; 65:1302-1312.
 - 20) **Akbarnia BA, Asher MA, Hess WF:** *Safety of pedicle screw in pediatric patients with scoliosis and kyphosis. Presented at the annual meeting of the Scoliosis Research Society, Ottawa, Ontario, Canada, 1996.*
 - 21) **Brown CA, Lenke LG, Bridwell KH, Geideman WM, Hasan SA, Blanke K:** *Complications of pedicle thoracic and lumbar pedicle screws.* *Spine* 1998; 23:1566-1571.
 - 22) **Liljenqvist UR, Halm HF, Link TM:** *Pedicle screw instrumentation of the thoracic spine in idiopathic scoliosis.* *Spine* 1997; 22:2239-2245.
 - 23) **Suk SI, Kim WJ, Lee SM, Kim JH, Chung ER:** *Thoracic pedicle screw fixation in spinal deformities: Are they really safe?* *Spine* 2001; 26:2049-2057.
 - 24) **Lenke LG, Bridwell KH, Baldus C, Blanke K:** *Preventing decompensation in King type II curves treated with Cotrel-Dubousset instrumentation. Strict guidelines for selective thoracic fusion.* *Spine* 1992; 8:S274-S281.
 - 25) **Suk SI, Lee SM, Chung ER, Kim JH, Kim WJ, Sohn HM:** *Determination of distal fusion level with segmental pedicle screw fixation in single thoracic idiopathic scoliosis.* *Spine* 2003; 28:484-491.



:
 :
 가
 : 5 (5~11.6) 가 203
 236 13.8 (8.9~18)
 Risser 5
 , 1 , 1 , 2
 : $51 \pm 12^\circ$ 1 15 ± 6 (72%) , 16 ± 7 (69%) , 3%
) $30 \pm 10^\circ$ 1 9 ± 8 (71%) ,
 10 ± 8 (66%) , 5%) $18 \pm 11^\circ$ $43 \pm 10^\circ$
 1 $24 \pm 8^\circ$ $44 \pm 8^\circ$, $23 \pm 8^\circ$ $46 \pm 9^\circ$.
 10 2
 (n=40) , 17 (43%) 가 가
 . 2867 , 43 (1.5%)가
 : 5

:

7 761-1

Tel: 82-2-950-1288 Fax: 82-2-3392-1101 E-mail: toetotoe1@sanggyepaik.ac.kr