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Selection of the Optimal Distal Fusion Level in Posterior Instrumentation and Fusion for Thoracic Hyperkyphosis: The Sagittal Stable Vertebra Concept

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– Abstract –

Study design: A retrospective study for clinical, radiographic assessment.

Objectives: To determine the appropriate level of distal fusion for the posterior instrumentation and fusion for thoracic hyperkyphosis by investigating the relationship between the sagittal stable (the most proximal vertebra touched by the vertical line from the posterior-superior corner of the sacrum), first lordotic (just caudal to the first lordotic disc) and lowest instrumented vertebrae.

Literature Review Summary: It has been recommended that the distal level of fusion for thoracic hyperkyphosis should include not only the distal end vertebra of kyphosis, but also the first lordotic disc beyond the transitional zone, distally. However, distal junctional breakdown was noted, even when these rules have been followed.

Materials and Methods: Thirty-one patients, with a mean age of 18, ranging from 13 to 38 years, who underwent long posterior instrumentation and fusion for thoracic hyperkyphosis, with a minimum of 2 years of follow up, were reviewed. The preoperative diagnosis included: Scheuermann's disease (n=29), posttraumatic kyphosis (n=1) and postlaminectomy kyphosis (n=1). According to the level of distal fusion, the patients were divided into two groups. Group I (n=24): lowest instrumented vertebra (LIV), including the sagittal stable vertebra (SSV), Group II (n=7): lowest instrumented vertebra proximal to the sagittal stable vertebra. Patients were evaluated utilizing both standing radiographs and chart reviews.

Results: The mean thoracic kyphosis was 86.6 ± 8.5 before surgery, which had been corrected to 53.0 ± 10.4 by the final follow-up, with a correction rate of 39%. The average sagittal balance was slightly negative (0.24 ± 3.8 cm) before surgery, and became more negative (1.33 ± 2.8 cm) by the final follow-up. There were no statistical differences in the thoracic kyphosis between the two groups. However, there was a statistically significant difference, with Group II having a more posterior translation of the center of the LIV from the posterior sacral vertical line, preoperatively, than at the final follow-up in Group I ($p=0.003$). In Group I, distal junctional problems developed in only 2 of the 24 (8%) patients, whereas in Group II, they occurred in 5 of the 7

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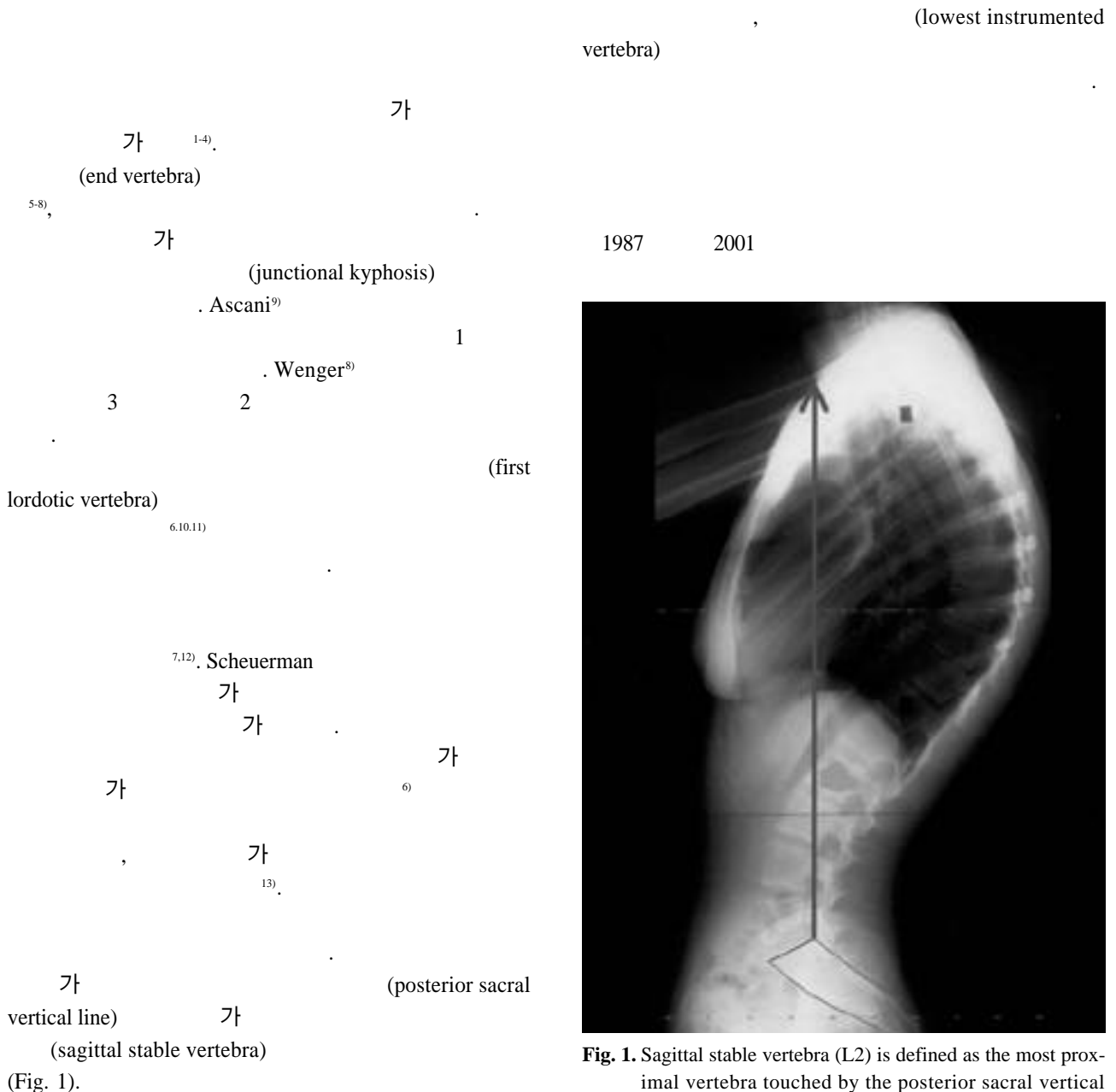
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(71%) patients ($p<0.05$). Despite extending the fusion to the first lordotic vertebra, distal junctional problems developed in 3 of the 8 (38%) patients.

Conclusions: The distal end of the fusion for thoracic hyperkyphosis should include the sagittal stable vertebra. The levels of distal fusion that include the first lordotic vertebra, but not the sagittal stable vertebra, are not always appropriate for the prevention of postoperative distal junctional kyphosis.

Key words: Thoracic spine, Hyperkyphosis, Distal fusion level, Sagittal stable vertebra



31
 3.8 ± 1.7 (2~8.1) . 20 , 11
 18 ± 5.0 (13~38) . 4~5
 Scheuermann 28 , 1 , .
 1 . 31 5 9
 가 I , 7 2 , 8 7 , 9
 II 12 , 10 10 .
 I 24 , II 7 . ,
 , 가 (Table 1). 가
 2 , 2 (pre-bent rods)
 Cobb
 5 12 cantilever
 12 1 .
 45 가
 (locking screw) .
 7 (C7 plumb 13 18
 line) 1 . SPSS (ver-
 7 sion 11.5) Mann-Whitney U test
 (p< 0.05).
 가
 .
 .
 1.

31 29 86.6 ± 8.5

Table 1. Demographic Data

	Group 1 (n=24)	Group 2 (n=7)
Age (year)	18.5 ± 5.4	17.5 ± 1.1
M:F	14:8	4:3
Follow-up (year)	3.6 ± 1.4	4.7 ± 2.3
Diagnosis		
Scheuermann's Disease	22	7
Posttraumatic Kyphosis	1	0
Postlaminectomy kyphosis	1	0

Table 2. Correction of Thoracic Kyphosis

	Total (n=31)	Group I (n=24)	Group II (n=7)	P-value*
Preop (°)	86.6 ± 8.5	86.3 ± 8.7	87.9 ± 8.0	0.74
Hyperextension (°)	56.6 ± 8.8	57.8 ± 7.9	52.7 ± 16.7	0.06
PO (°)	49.6 ± 11.8	51.5 ± 11.8	41.1 ± 8.8	0.07
Final F/U (°)	53.0 ± 10.4	53.3 ± 11.1	52.0 ± 8.4	0.43
Correction rate (%)	39%	38.6%	40.7%	0.37
Loss of correction (°)	2.9 ± 6.5	1.83 ± 5.6	7.3 ± 8.2	0.2

* P-value between Group I and Group II by Mann-Whitney test

53.0 ± 10.4	39%	86.3 ± 8.7
2.9 ± 6.5	1	53.3 ± 11.1
		2

Table 3. Correction of Sagittal Balance

	Total (n=31)	Group I (n=24)	Group II (n=7)	P-value*
Preop (cm)	-0.24 ± 3.8	-0.31 ± 2.7	0.01 ± 6.6	0.96
PO (cm)	1.01 ± 3.4	0.48 ± 3.2	3.1 ± 3.5	0.12
Final F/U (cm)	-1.33 ± 2.8	-1.23 ± 2.5	-1.67 ± 3.9	0.72
Loss of correction (cm)	-2.33 ± 3.6	-1.71 ± 3.5	-4.85 ± 3.5	0.08

* P-value between Group I and Group II by Mann-Whitney test

Table 4. Distance from LIV+ to PSVL++

	Group I (n=24)		Group II (n=7)		P-value*
Preop (cm)	-0.31	1.5	-2.57	1.5**	0.003
PO (cm)	1.41	1.5	-0.5	1.7	0.02
Final F/U (cm)	0.27	1.6	-2.25	1.5	0.003

+ LIV: Lower instrumented vertebra

++PSVL: Posterior sacral vertical line

* P-value by Mann-Whitney test

** (-) means that the center of LIV is placed behind PSVL.

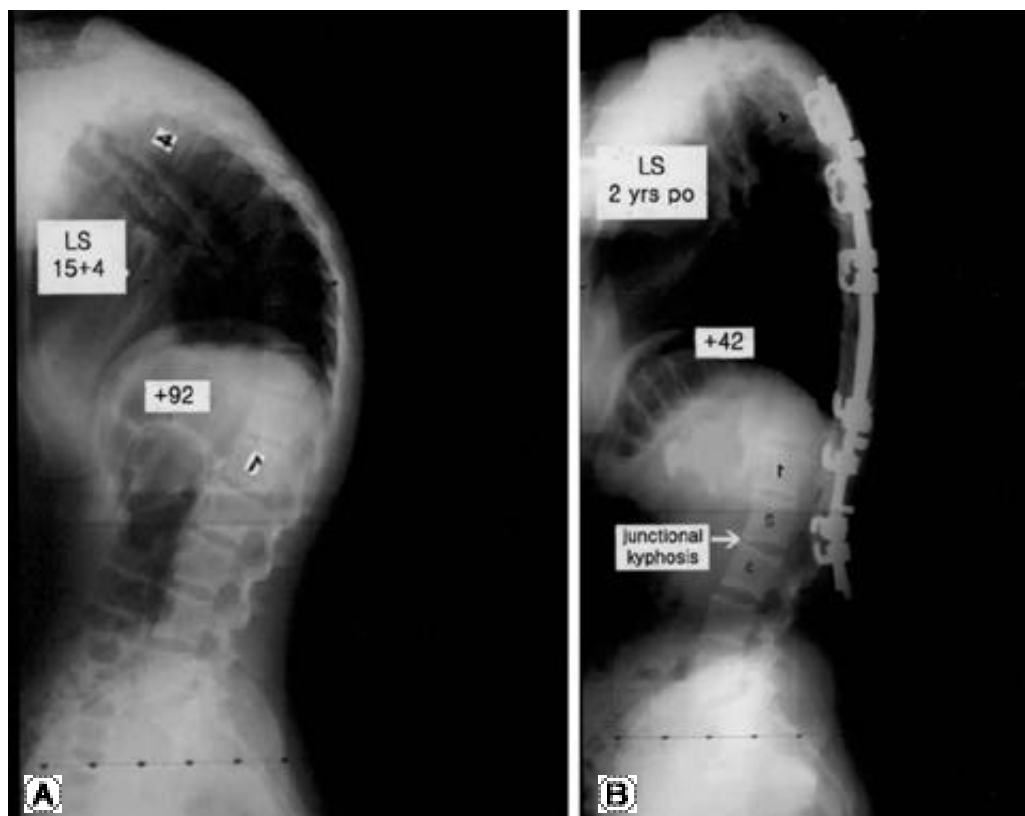


Fig. 2. Even though sagittal stable vertebra and first lordotic vertebra were L3, the fusion stopped at L2 (A). The short fusion caused distal junctional kyphosis (B).

87.9 ± 8.0 52.0 ± 8.4 1 24 2 (8%) , 2
가 7 5 (71%) (p<0.05).
가 (p=0.20)(Table 2). 가 1 2
(sagittal balance) 1 -0.31±2.7 , 2 5
cm -1.23±2.5 cm 2 3
0.01±6.6 cm - 2 (loosening of distal
1.67±3.9 cm hooks) (Fig. 2A, Fig. 2B).
1 가
(Table 3). . 1
2 2 1
가 , 1 1 . 2
(p=0.03). 1 2
가(-0.31 ± 1.5 cm), 가 2
(1.41 ± 1.5 cm), . 2
.(0.27 ± 1.6 cm). 1
2 , 4
가(-2.57 ± 1.5 cm), 1 가 , 3
(-2.25 ± 1.5 cm)(Table 4).
2.
(distal junctional problems) (Fig. 3A, Fig. 3B).

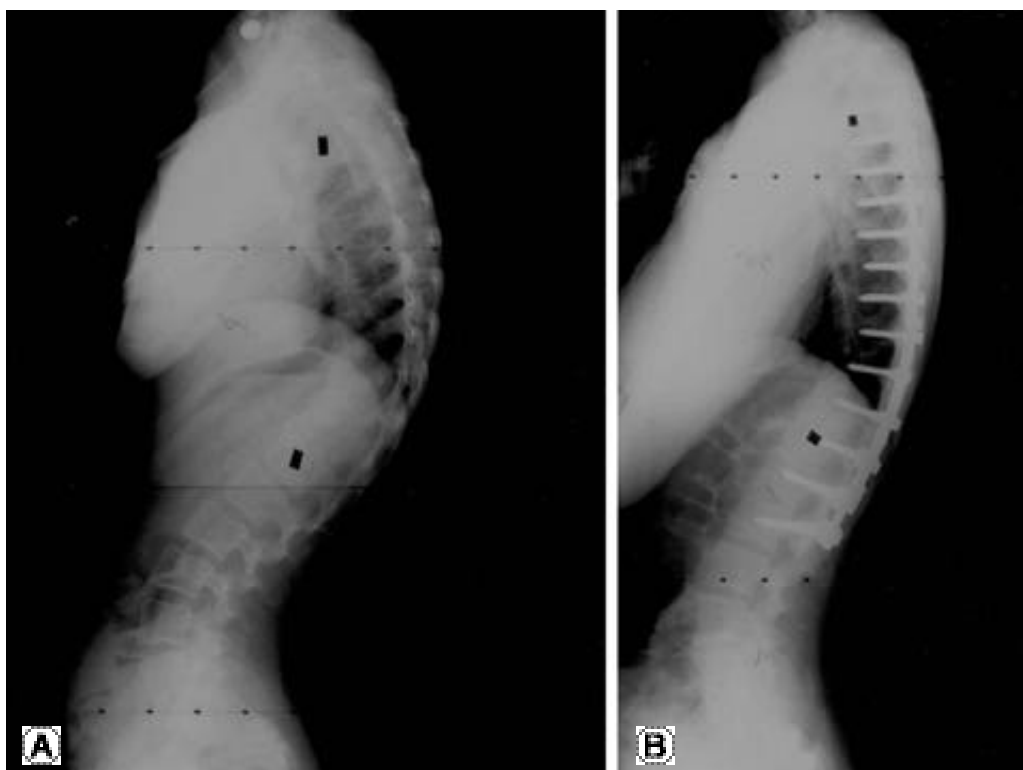


Fig. 3. The distal fusion was extended to the sagittal stable vertebra (A), which showed no problem (B).

3. . 3 가
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 가 .
 2 가
 8 3 (38%)
 , 21
 1 , 2 (instantaneous axis of rotation)
 21 2 (9.5%)
 , 15)
 7 가
 4. 가 2
 가 1
 , 2 , 1
 4
 50%
 6,10)
 3 1 가
 50% 50% (52%)
 2 3
 가
 2 1
 가
 1 16)
 6,12). Lowe Kasten⁶⁾ 9
 5 1 7
 9 8
 . Bradford ¹²⁾ 24 5
 가
 3
 2
 . King ¹⁴⁾
 1

19 (61%)

31

. Poolman ¹⁷⁾

2

가

가

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:
 : (sagittal stable vertebra)
 (first lordotic vertebra), (lowest instrumented vertebra)
 : 1987 2001 31
 3.8 ± 1.7 (2~8.1) . 20 , 11 18 ± 5.0 (13~38) .
 Scheuermann 28 , 1 , 1 .
 31 가 I , II
 I 24 , II 7 .
 : 86.6 ± 8.5 53.0 ± 10.4 39% .
 가(-0.24 ± 3.8 cm), (-1.33 ± 2.8 cm).
 가 1 2 ,
 가 (posterior sacral vertical line)
 가 1 24 2 (8%)
 2 7 5 (71%) . 1 8 3
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 :
 가 ,
 (distal junctional kyphosis) .

:

3가 7-206

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