

## Crankshaft

### Prevention of the Crankshaft Phenomenon with Posterior Pedicle Screw Fixation in Scoliosis of the Skeletally-Immature Spine

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#### – Abstract –

**Study Design:** A retrospective study.

**Objectives:** To evaluate the results of posterior segmental pedicle screw fixation in skeletally immature patients with scoliosis.

**Summary of Literature Review:** Scoliosis correction, in the immature spine, frequently necessitates additional anterior surgery to prevent the crankshaft phenomenon. With the advent of posterior segmental pedicle screw fixation, it is unclear whether an additional anterior procedure will be required.

**Material and Methods:** Seventeen scoliosis patients (10 idiopathic, 4 congenital and 3 others; 3 males and 14 females) were treated with segmental pedicle screw fixation only. Their results were reviewed for a deformity progression of more than 10°, a rib vertebra angle difference (RVAD) progression of more than 10°, and evidence of adding-on. All the patients had a 0 Risser index at the time of the operation. The mean age and follow-up times were 10.4, ranging from 7.2 to 11.8 years old, and 4.0, ranging from 3.0 to 5.4 years, respectively.

**Results:** The mean preoperative thoracic curve of 55° was corrected to 22° (58% correction) at last follow-up and the non-structural lumbar curve of 31° was corrected to 10° (67% correction) at last follow-up. Preoperative thoracic kyphosis of 28° was improved to 34° at last follow-up. The RVAD were 23° and 13°, preoperatively and postoperatively, respectively. No patient showed a progression of 10° or more in the postoperative coronal curve or RVAD. One patient had a progression of the deformity caudal to the instrumented segments. There were no neurological or screw-related complications.

**Conclusions:** Posterior segmental pedicle screw fixation in skeletally immature patients with scoliosis may be effective in preventing the crankshaft phenomenon.

**Key Words:** Idiopathic scoliosis, Crankshaft phenomenon, Segmental Pedicle screw fixation, Immature spine

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**Table 1.** Patient data.

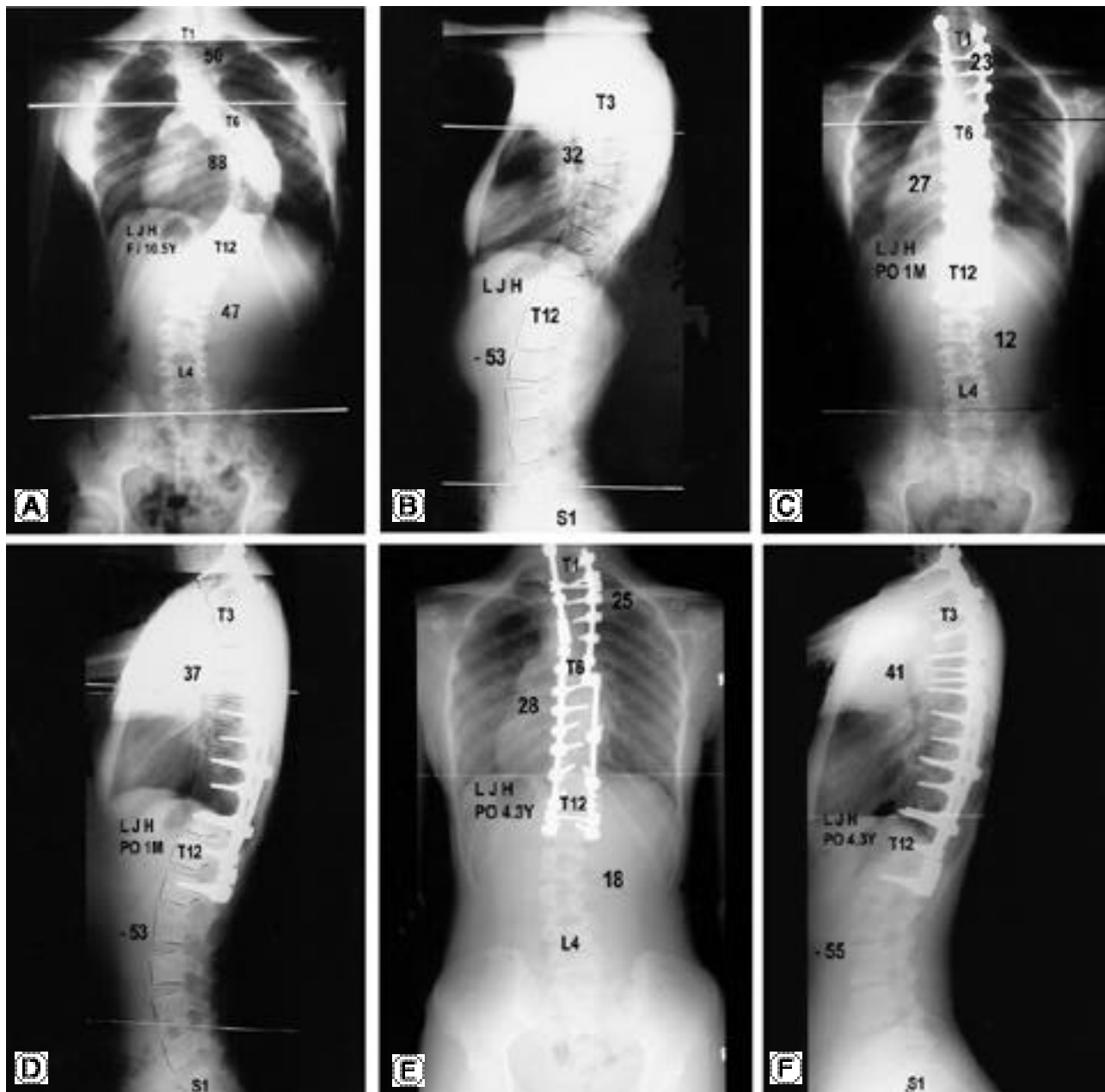
Patient No.	Age at operation	Sex	Diagnosis	TRC	PHV	Curve	Fusion Levels
1	7.2	F	CS	Open	Prior	MT	T8-T11
2	8.8	M	NMS	Open	Prior	MT	T3-S1
3	8.9	F	CS	Open	Prior	MT	T1-T4
4	9.6	F	CS	Closed	Past	MT	C7-T4
5	9.8	F	JIS	Closed	During	MT	T2-L2
6	10.1	F	Homocystinuria	Open	During	MT	T3-L1
7	10.2	F	JIS	Closed	Past	MT	T5-L3
8	10.4	F	JIS	Closed	Past	MT	T4-T12
9	10.5	F	JIS	Closed	During	PT	T1-T5
						MT	T5-L1
10	10.8	F	AIS	Closed	Past	MT	T4-T12
11	11.2	F	AIS	Closed	During	MT	T3-L2
12	11.3	F	JIS	Closed	Past	MT	T2-L2
13	11.4	M	AIS	Open	Prior	MT	T4-L1
14	11.5	F	NFS	Open	Prior	PT	T2-T7
						MT	T7-L1
15	11.6	F	AIS	Open	During	PT	T1-T6
						MT	T6-L1
16	11.8	M	JIS	Closed	Prior	PT	T2-T8
						MT	T8-L2
17	11.8	F	CS	Open	Past	PT	T1-T7
						MT	T7-L2

TRC: triradiate cartilage,  
NMS: neuromuscular scoliosis,  
AIS: adolescent idiopathic scoliosis,

PHV: peak height velocity,  
NFS: neurofibromatosis scoliosis,  
MT: main thoracic,

CS: congenital scoliosis  
JIS: juvenile idiopathic scoliosis  
PT: proximal thoracic

10	20.0 ± 10.3 °	: 5~42 °	, 62%
4 3	22	1	21.8 ±
	10.5 °		22.0 ± 10.8 °
10.4 ( : 7.2~11.8 )	4~44 °	58%	5%
(Table 1).	1	10 °	
3 , 14	(Table 2, 3) (Fig. 1).		
4 ( : 3.0~5.4 )	30.7 ± 10.6 °	: 13~47 °	1
4 5	7.9 ± 6.2 °	: -2~19 °	, 74%
	1	9.0 ± 6.8 °	
(Risser )	10 ± 7.4 ° ( : -2~20 °		
가	67%	(Table 3).	
가	27.8 ± 13.6 °	: 3~54 °	
가	1	29.5 ± 8.0 °	1 31.3 ± 8.0 °
가	34.4 ± 10.5 °	: 18~59 °	49.5 ±
Sanders <sup>20)</sup> peak height velocity (PHV)	8.6 °	: 35~65 °	1 49.0 ±
가 PHV , PHV	5.2 °	1	50.5 ± 5.7 °
PHV	9.1 °	: 36~67 °	(Table 3).
8 , 9	19.9 ± 20.0 mm ( : 4~80		
8 PHV 5 , PHV	mm) 10		1
2 , PHV 가 1	3.5 ± 3.3 mm, 1	2.9 ± 4.2 mm,	
9 PHV 1 , PHV	3.2 ± 3.9 mm ( : 0~12 mm)		10 mm
3 , PHV 가 5	1	(Table 3).	
(Table 1).	29.2 ± 27.0 mm ( : 0~90		
1 , 1	mm) 1	3.7 ± 6.2 mm	
	1	4.2 ± 5.2 mm,	5.2 ± 5.7 ( : :
(apical vertebral translation), rib	0~20 mm)	62%	(Table 3).
vertebra angle difference (RVAD) <sup>14)</sup> 가	RVAD	22.6 ± 13.9 °	: 6~65 °
가	14.5 ± 10.4 °	: 2~45 °	1
	13.2 ± 10.2 °		13.0 ± 10.4 ° ( : :
Cobb	2~43 °		
12 , 12	10 °	가	(Table 2, 3).
1	26.5 ± 15.0 mm ( : 0~68 mm)		
7	1	13.3 ± 8.9 mm	
ter sacral vertical line	13.6 ± 9.5 mm	12.9 mm ( : 0~35 mm)	
가 10 mm	(Table 3).		
	가 1		
	가		
	1	PHV	
RVAD가 10. crankshaft	가	가	
	가		
	5		
Risser 0 , PHV	2 , 3		
55.0 ± 15.1 ° ( : 23~88 °)	1	3	.5



**Fig. 1.** Case 9. 10.5-year-old girl with juvenile idiopathic scoliosis. She was during her peak height velocity at operation, and had closed triradiate cartilage.

**A, B.** Preoperative anteroposterior and lateral radiographs showed 88° of main thoracic and 50° of proximal thoracic curve. Preoperative RVAD was 31°.

**C, D.** Anteroposterior and lateral radiographs taken 1 month after operation. Main thoracic curve and proximal thoracic curve were corrected to 27° and 23°, respectively. RVAD was 27°.

**E, F.** Anteroposterior and lateral radiographs taken 4 year after operation. Main thoracic curve and proximal thoracic curve were 28° and 25°, respectively. RVAD was 24°. In serial radiographs, there was neither curve nor RVAD progression more than 10°.

**Table 2.** Curve magnitude and rib vertebra angle difference.

Patient No.	Curve	Cobb (°)				RVAD (°)			
		Pre	IMPO	PO 1 yr	Last	Pre	IMPO	PO 1 yr	Last
1	MT	23	20	22	23	18	13	14	18
2	MT	50	8	9	10	12	10	6	2
3	MT	35	27	25	20	25	12	10	5
4	MT	52	32	30	38	15	12	13	15
5	MT	75	20	22	16	31	25	26	17
6	MT	86	33	36	37	65	45	42	43
7	MT	65	39	44	44	6	4	4	4
8	MT	55	10	11	9	10	9	4	6
9	PT	50	23	23	25	20	13	6	4
	MT	88	27	29	28	31	27	23	24
10	MT	61	19	22	23	40	30	23	23
11	MT	58	5	6	4	21	5	2	4
12	MT	51	8	15	16	10	10	8	8
13	MT	48	9	10	10	37	18	12	10
14	PT	40	14	11	13	26	11	8	12
	MT	57	24	20	19	32	27	30	30
15	PT	47	19	20	25	15	6	14	15
	MT	46	9	12	13	18	2	3	5
16	PT	49	16	20	20	13	15	17	12
	MT	48	15	20	24	12	7	8	2
17	PT	57	42	45	42	6	5	4	6
	MT	68	22	27	25	34	15	14	20

IMPO: Immediate postoperative measures were made from radiographs taken 1 month after surgery.

RVAD: rib vertebra angle difference of Mehta

**Table 3.** Results.

	Preoperative	Immediate Postoperative	1 year Follow up	Last Follow up
Thoracic curve* (°)	55.0 ± 15.1	20.0 ± 10.3	21.8 ± 10.5	22.0 ± 10.8
(Correction)		(62%)	(59%)	(58%)
Lumbar curve (°)	30.7 ± 10.6	7.9 ± 6.2	9.0 ± 6.8	10.0 ± 7.4
(Correction)		(74%)	(71%)	(67%)
Thoracic kyphosis (°)	27.8 ± 13.6	29.5 ± 8.0	31.3 ± 8.0	34.4 ± 10.5
Lumbar lordosis (°)	49.5 ± 8.6	49.0 ± 5.2	50.5 ± 5.7	52.0 ± 9.1
Coronal balance (mm)	19.9 ± 20.0	3.5 ± 3.3	2.9 ± 4.2	3.2 ± 3.9
(Imbalance)	(10/17)	(0/17)	(1/17)	(1/17)
AVT (mm)	29.2 ± 27.0	3.7 ± 6.2	4.2 ± 5.2	5.2 ± 5.7
RVAD* (°)	22.6 ± 13.9	14.5 ± 10.4	13.2 ± 10.2	13.0 ± 10.4
Thoracic hump (mm)	26.5 ± 15.0		13.3 ± 8.9	13.6 ± 9.5

IMPO: Immediate postoperative measures were made from radiographs taken at discharge after surgery

AVT : apical vertebral translation

RVAD : rib vertebra angle difference of Mehta

\* No patient had a 10 °or more progression in the serial radiographs after operation

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 : Risser 0 17 ( 10 , 4 3 ) 10 ° 가 , rib  
 vertebral angle difference (RVAD)가 10 ° 가 crankshaft  
 crankshaft 가 14 , 3 ,  
 10.4 (7.2~11.8 ) , 4 (3.0~5.4 )  
 : 55 ° 22 ( 58% ) , 31 °  
 10 ( 67% ) 28 ° 34 ° 가 RVAD  
 23 ° 13 ° 10 ° 가  
 가 RVAD가 10 ° 가 가 1  
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