

(Fixed Sagittal Imbalance) Smith-Petersen

· Keith H. Bridwell[#] · · · ·

, Washington University Department of Orthopedic Surgery, St. Louis USA[#]

Comparison of Smith-Petersen Osteotomy versus Pedicle Subtraction Osteotomy for the Correction of Fixed Sagittal Imbalance

Kyu Jung Cho, M.D., Keith H. Bridwell, M.D.[#], Seung Rim Park, M.D., Myung Ku Kim, M.D.,
Tong Joo Lee, M.D., Sung Wook Choi, M.D.

Department of Orthopedic Surgery, College of Medicine, Inha University, Incheon, Korea
Washington University in St. Louis, Department of Orthopedic Surgery, USA[#]

– Abstract –

Study Design: A retrospective study.

Objectives: The purpose of this study was to compare the results between Smith-Petersen and pedicle subtraction osteotomies for fixed sagittal imbalance, and to determine the specific indications for each.

Literature Review Summary: Smith-Petersen (SPO) and pedicle subtraction osteotomies (PSO) are the techniques most commonly used to correct fixed sagittal imbalance of the spine, but there are no reports regarding the superiority of either technique. A Smith-Petersen osteotomy is an anterior opening wedge osteotomy, which hinges on the posterior edge of the intervertebral disc, while a pedicle subtraction osteotomy is a posterior closing wedge osteotomy, without distracting the anterior column, with the hinge on the anterior aspect of the vertebral body.

Materials and Methods: Thirty patients (mean age 40.1 years, range 20–64 years), who underwent a SPO, were compared with forty-one patients (mean age 54.5 years, range 21–73 years) who underwent a PSO. The SPO was carried out in more than three segments (3 SPOs) in fourteen of the SPO group. The average follow-up periods were 4.6 years, ranging from 2 to 11.5 years, and 3.8 years, ranging from 2 to 7.1 years, for the SPO and PSO groups, respectively. Patients were evaluated by standing radiographs, chart review and outcome questionnaires.

Results: The mean correction of the kyphotic angle at the osteotomy sites for the SPOs was 10.7 per segment, and for those with 3 SPOs and the PSO group the average total corrections were 33.0 ± 9.2 and 31.7 ± 9.0 , respectively. However, the improvement in sagittal balance was less statistically significantly with 3 SPOs (5.5 ± 4.5 cm) than with a PSO (11.2 ± 7.2 cm; $p < 0.01$). Comparing 3 SPOs to one PSO, the SPO group decompensated the patients more substantially to the concavity ($p < 0.02$). The mean estimated blood loss (adding up all anterior and posterior surgeries) for the procedures were 1398 ± 738 (1392 ± 664 mL in the 3 SPO group), and 2617 ± 1645 mL in the SPO and PSO groups, respectively ($p < 0.001$; $p < 0.01$). The total operative times for the SPO versus the PSO groups were similar, with no statistical difference. There were substantial complications in

Address reprint requests to

Seung Rim Park, M.D.

Department of Orthopedic Surgery, Inha University Hospital
7-206, 3-Ga Shinheung-dong, Jung-gu, Incheon 400-103, Korea

Tel: 82-32-890-3568, Fax: 82-32-890-3099, E-mail: SRP@inha.com

both groups, with 13 in the 30 SPO and 30 in the 41 PSO patients. In the SPO group, 1 patient had a non-union at an osteotomy site; in the PSO group, 2 patients had a non-union at an osteotomy site. The mean Oswestry score improved from 42.3 ± 14.2 to 21.3 ± 14.8 postoperatively at the last visit for the SPO group and, it improved from 47.9 ± 15.8 preoperatively to 29.7 ± 18.3 at the last visit in PSO group ($p=0.35$).

Conclusions: When comparing 3 Smith-Petersen osteotomies to one pedicle subtraction osteotomy, the corrections of kyphosis were almost identical, but the improvement in the C7 plumb was significantly better in the PSO group. There was a significantly greater likelihood of decompensating the patient to the concavity with the 3 SPOs than with a single PSO ($p<0.02$). The total operative time for the SPO versus the PSO groups showed no statistical difference. However, the blood loss was substantially greater in the PSO group ($p<0.001$).

Key Words: Fixed sagittal imbalance, Smith-Petersen osteotomy, Pedicle subtraction osteotomy.

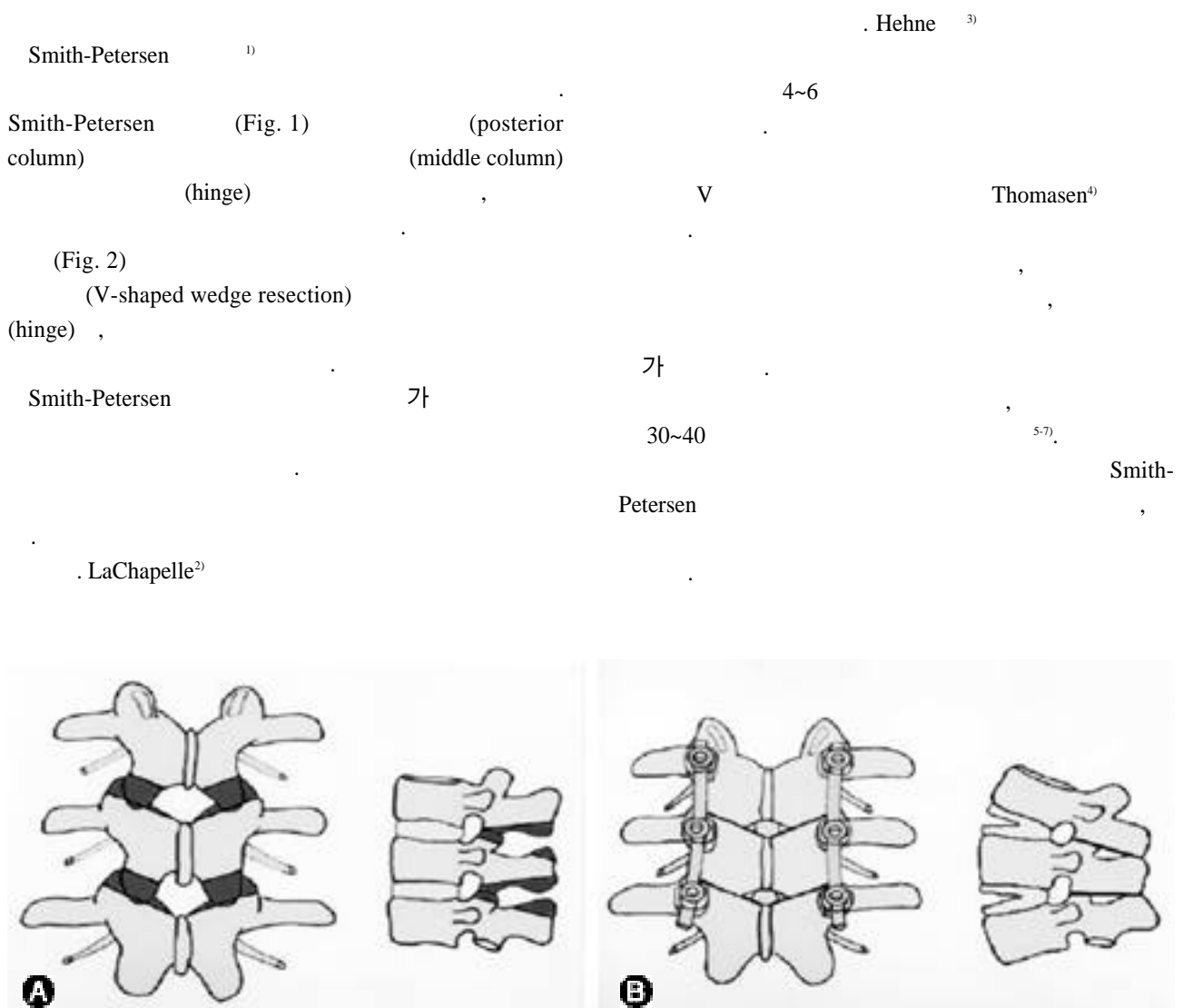


Fig. 1. Smith-Petersen osteotomy (A) Resection of bone from the posterior elements. (B) By closing the wedge posteriorly, the disc space opens anteriorly.

1.

1989

2001

. Smith-Petersen

SPO

30 (6 , 24)

40.1 (20~64)

PSO 41 (8 , 33)

54.5 (21~73) . PSO SPO

. SPO

4.6

(2~13) PSO

3.8

(2~7.1) . SPO

(n=23), (n=1), (n=2),

(n=4) . PSO

(n=23), (n=11),

(n=4), (n=3) (Table 1).

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(Washington University in St. Louis,

Department of Orthopedic Surgery, USA)

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1 2 3

. Smith-Petersen 1-

2, 2-3, 3-4

4 1

45

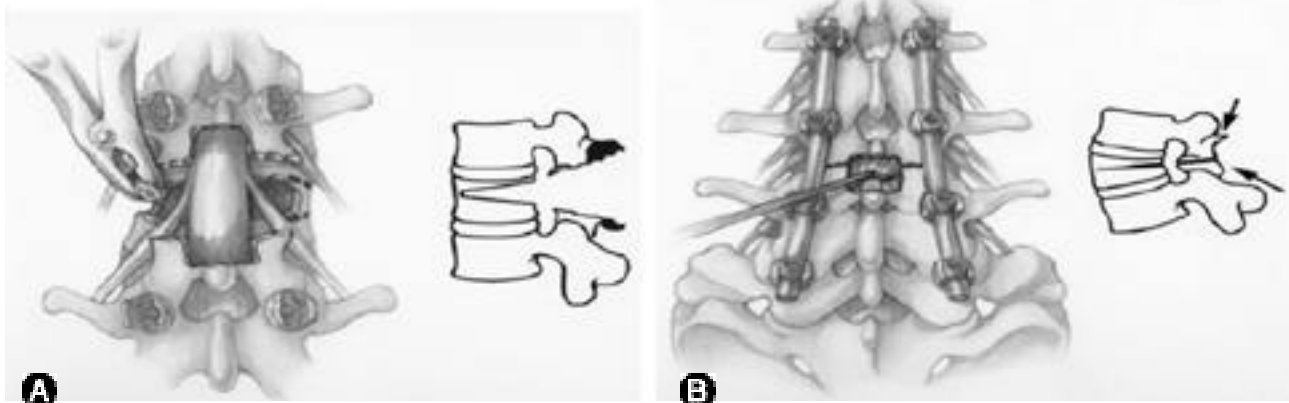


Fig. 2. Pedicle subtraction osteotomy. (A) V-shaped wedge resection of the vertebral body including both pedicles and posterior elements. (B) This osteotomy does not create an anterior bony defect.

Table 1. Demographic Data

	Smith-Petersen Osteotomy (n=30)	Pedicle subtraction Osteotomy (n=41)	P value
Age (years)	40.1 ± 11	54.5 ± 11.7	P<0.0001
Male/Female	7/23	8/33	
Followup (years)	4.6 ± 2.83	3.8 ± 1.48	
Number of prior surgeries (n)	1.77 ± 1.14	2.13 ± 1.52	P=0.47
Etiology of deformity (n)			
Idiopathic scoliosis	23	23	
Degenerative sagittal imbalance	1	11	
Post-traumatic kyphosis	2	4	
Ankylosing spondylitis	4	3	

1 .

7

가 2, 3

가 4, 5 . SPO

가 1 4

7 . 가 11, 12

Cobb 5 가 4, 5 . PSO

12 , 1 1, 2 15, 3 가 24

12 4 가 1 .

가

1 (segmental) 2 (global) 8).

1 SPO $24.9 \pm 10.6^\circ$

7 $10.7 \pm 3.2^\circ$.

1 0~5 cm SPO $33.0 \pm 9.2^\circ$, PSO

, 2 가 $31.7 \pm 8.97^\circ$

7 1 가 (p>0.5)(Table 2).

5 cm . 1

2 Smith-Petersen

2

SPO 3.95 ± 5.0 cm,

Smith-Petersen 10 SPO 5.49 ± 4.5 cm .

가 PSO 11.2 ± 7.2 cm (Fig. 3).

SAS version 8.2 . PSO SPO

Fisher's exact test, t-test, (P<0.001)(Table 3),

Pearson chi-square test Wilcoxon test 가 SPO 1.37 ± 4.5 cm, PSO 2.49 ± 3.4 cm

P<0.05 . 가 (P=0.58).

SPO -0.73 ± 1.9 cm

PSO 0.48 ± 1.4 cm (Table 3),

(P=0.003)(Fig. 4).

Smith-Petersen 7 1 , 9

2 , 9 3 , 3

4 , 2 5

. SPO 2.47 . SPO (-0.84 ± 1.8) cm

SPO (-0.61 ± 2.1) cm

(P=0.77). SPO 4

Table 2. Correction of Kyphotic Angle at Osteotomy Site

	Correction (°)	Correction per segment (°)
Smith-Petersen osteotomy (n=30)	24.9 ± 10.6	10.7 ± 3.2
3 segments of SPO (n=14)	33.0 ± 9.2	9.7 ± 2.6
Pedicle subtraction osteotomy (n=41)	31.7 ± 9.0	31.7 ± 9.0
P value between (3 SPO and PSO)	>0.5	

4 cm				가			
SPO	30	26 (87%)		SPO		1398 ± 738 mL, PSO	
	23		, 3	2617 ± 1645 mL			
		PSO	41	(P=0.001)(Table 4).		SPO (1392 ± 664	
			16 (39%)	mL)	PSO		
			8			(P<0.001).	
		, 8					
. PSO							SPO
				12.6 ± 3.7	, PSO	12.1 ± 3.6	

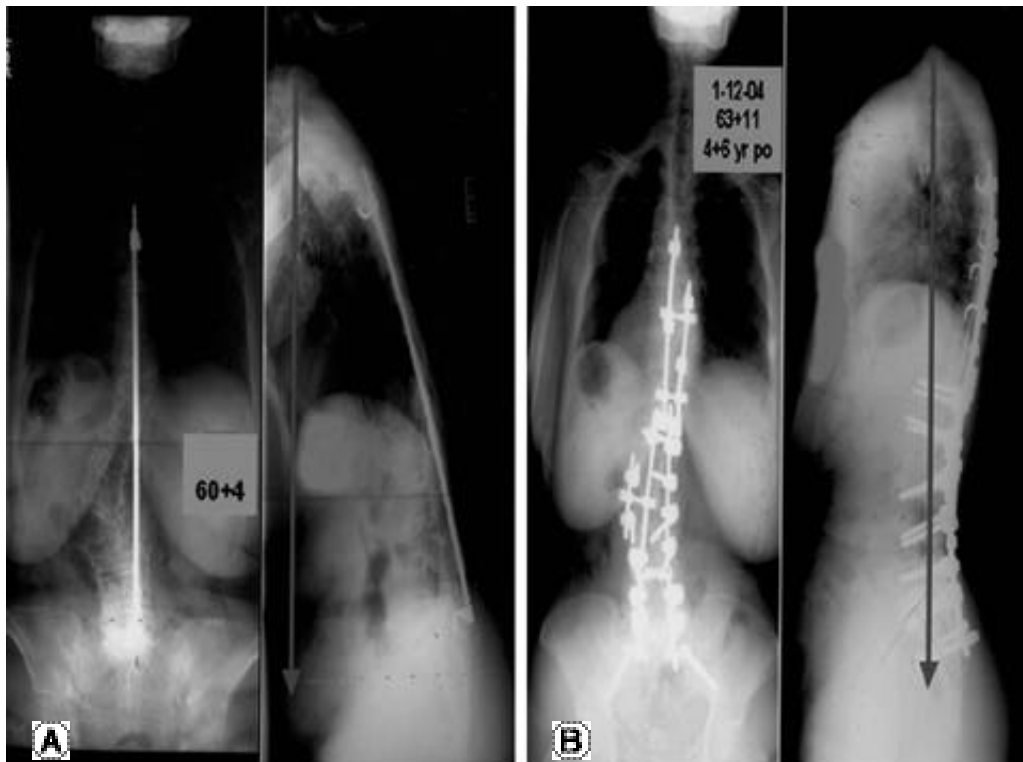


Fig. 3. An example of preop and 4 year postop treatment of a fixed sagittal imbalance with a one-level pedicle subtraction osteotomy. multiple Smith-Petersen osteotomies. **(A)** Preoperative long-cassette standing coronal radiograph and sagittal radiograph **(B)** Post-operative long-cassette standing coronal radiograph and sagittal radiograph

Table 3. Correction of Sagittal and Coronal Balance

	SVA* Preop (cm)	SVA Ultimate Postop (cm)	Correction Sagittal balance (cm)	Correction Coronal Balance** (cm)
Smith-Petersen osteotomy (n=30)	5.83 ± 4.23	1.88 ± 4.45	3.95 ± 5.0	-0.73 ± 1.9
High SPO (3; n=14)	5.99 ± 5.89	0.50 ± 3.35	5.49 ± 4.5	-0.84 ± 1.8
Pedicle subtraction osteotomy (n=41)	16.04 ± 7.22	4.85 ± 5.27	11.19 ± 7.2	0.48 ± 1.4
P value between 3 SPO and PSO			<0.001	<0.02

*Sagittal Vertical Axis: Measured as a plumb dropped from C7 on the standing lateral radiograph referable to the posterior aspect of the L5-S1 disc

**(-) means worsening of coronal balance.

가 (P=0.596).

157가 28가
 . SPO 30 10 (33%)
 , PSO 41 22 (55%)
 (Table 5).

PSO

2

1

. 2

(cauda equina)

. 2

SPO

6

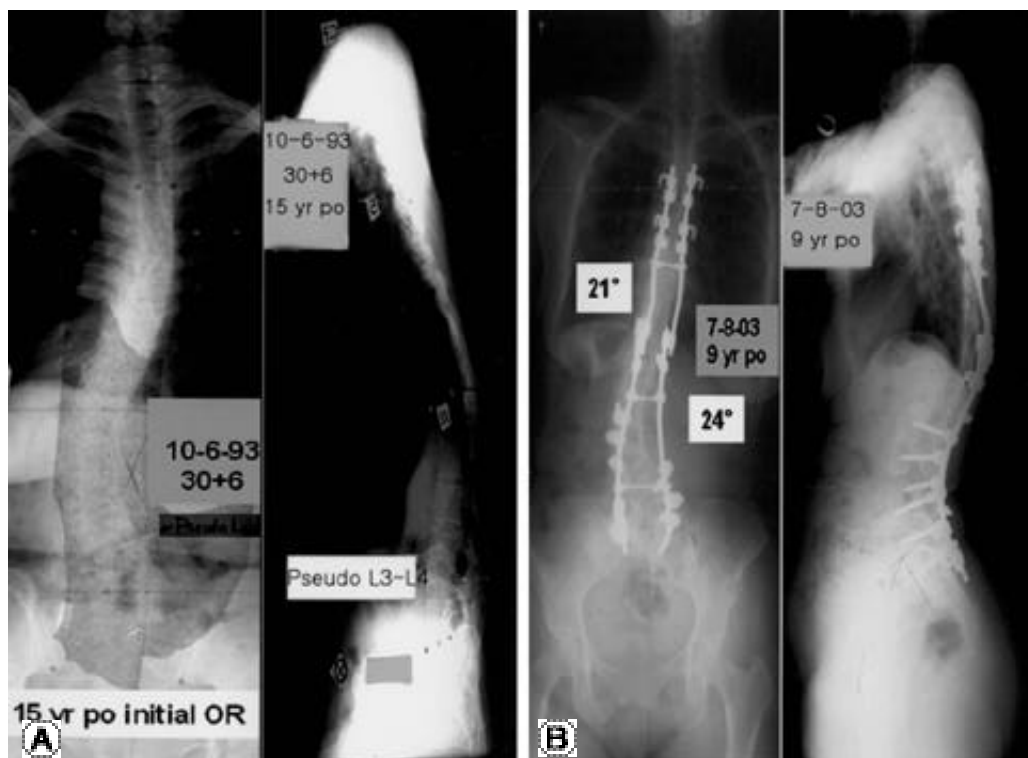


Fig. 4. An example of multiple Smith-Petersen osteotomies. (A) Preoperative long-cassette standing coronal radiograph and sagittal radiograph (B) Postoperative long-cassette standing coronal radiograph and sagittal radiograph showing excellent correction of the sagittal deformity, but worsening of the coronal balance.

Table 4. Estimated Blood Loss and Operative Time

	Blood Loss (mL)*	Operative Time (hours)*
SPO (n=30)	1398 ± 738	12.6 ± 3.7
3 SPO (n=14)	1392 ± 664	13.6 ± 4.6
PSO (n=41)	2617 ± 1645	12.1 ± 3.6
P value between 3 SPO and PSO	<0.01	>0.5

*Includes all the anterior and posterior procedures, under the same anesthetic or a staged operation.

Does not include subsequent revision surgeries.

Table 5. Complications

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- Smith-Petersen equina) 가 15-17).
- . Lagrone ¹¹⁾ 55 ,
- Smith-Petersen 8.2 cm ¹¹⁾,
- 4.2 cm .
- Voos ¹²⁾ 3.3 ± 6 cm ¹⁸⁾,
- 1.9 ± 4.2 cm .
- Bridwell ⁵⁾ 7 .
- 17.74 cm 4.23 cm . Bridwell ⁵⁾
- , Berven ¹³⁾ 14.5 cm
- 5.4 cm .
- 11.2 ± 7.2 cm ^{10,18)}
- Smith-Petersen 5.49 ± 4.5 cm .
- 가 .
- Smith-Petersen Smith-Petersen
- Smith-Petersen Petersen
- . Lagrone ¹¹⁾ 55 .
- 16
- , Booth ⁸⁾ Smith-Petersen ¹⁹⁾.
- PSO
- 6 ,
- 60 .
- Smith-Petersen
- 가 ,
- 가 ^{3,8)}
- Smith-Petersen
- (trapezoid-shaped) 가
- 20)
- 13)
- Smith-Petersen
- Smith-Petersen
- Smith-Petersen Smith-
- 14) 가 Petersen
- (cauda . Bipolar electrocautery, gelform, thrombin

agent	aprotinin	antifibrinolytic
	.	

and transpedicular fixation in 22 cases. *J Bone Joint Surg* 1995; 77-B: 117-21.

Smith-Petersen

Smith-Petersen

Smith-Petersen

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Smith-Petersen

(Fixed Sagittal Imbalance) Smith-Petersen (Smith-Petersen
 Osteotomy, SPO) (Pedicule Subtraction Osteotomy, PSO),

: 1989 2000 Smith-Petersen SPO (30)
 PSO (41) . SPO (6 , 24 , 40.1) 14
 3 , PSO (8 , 33 , 54.5)

1

SPO 10.7 .3 SPO 30.7 ± 7.1
 , PSO 31.7 ± 9.1 .(p=0.75). 3 SPO (5.5
 ± 5.9 cm) PSO (11.2 ± 7.2 cm) (p<0.001). PSO (0.48 ±
 1.4 cm) 3 SPO (-0.73 ± 1.9cm) (p=0.003). SPO 1398 ± 738 mL,
 PSO 2617 ± 1645 mL (p=0.001). SPO PSO
 SPO , PSO Oswestry score SPO 42.3 ±
 14.2 21.3 ± 14.8 , PSO 47.9 ± 15.8 29.7 ± 18.3 (p=0.43).
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Tel: 82-32-890-3568 Fax: 82-32-890-3099 E-mail: SRP@inha.com