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Partial Resection of Spinous Process for the Elderly Patients with Thoraco-Lumbar Hypo-Lordosis Patients: Technical Report

Hirohiko Inanami[1], Hiroki Iwai[2], So Kato[3], Takeshi Kaneko[1], Masahito Oshina[3], Nodoka Manabe[1], Yuichi Takano[2], Yohei Yuzawa[1], Tomohide Segawa[1], Kazuyoshi Yanagisawa[1], Fumiko Saiki[3], Masayoshi Fukusima[3], Hiroyuki Oka[4], Ko Matsudaira[4], Yasushi Oshima[3] and Hisashi Koga[2]*

[1]Department of Orthopedic Surgery, Inanami Spine and Joint Hospital, Japan

[2]Department of Orthopedic Surgery, Iwai Orthopedic Medical Hospital, Japan

[3]Department of Orthopedic Surgery, The University of Tokyo, Japan

[4]Department of Medical Research and Management for Musculoskeletal Pain, 22nd Century Medical & Research Center, The University of Tokyo, Japan

Abstract

Global sagittal imbalance with lumbar hypo-lordosis causes many problems in the elderly population and is often treated with long-segment fusion and osteotomy that may be associated with various complications and lead to wide range of rigid spines. We developed a minimally invasive treatment with partial resection of the spinous process. Consecutive five patients with over 60 mm of Sagittal Vertical Axis (SVA) underwent this surgical procedure. The average follow-up period was 13.6 months. The average blood loss and operation time were 12 ml and 51 min, respectively. The mean SVA improved from 111 mm to 89.5 mm, but deteriorated in one case. The mean numerical rating scale of low back pain improved from 6.0 to 3.6 with no exacerbations. The mean Oswestry Disability Index score was improved from 33.0 to 19.6 without worsening cases. This surgical procedure includes in minimally invasive and is effective in improving the symptoms of the elderly patients with lumbar hypo-lordosis.

Keywords: Lumbar; Hypo-lordosis; Spinous process; Partial resection

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Correspondence:
Hirohiko Inanami, Department of Orthopedic Surgery, Inanami Spine and Joint Hospital, 3-17-5 Higashi-shinagawa Shinagawa-ku, Tokyo, 140-0002, Japan, Tel: +81 3 3450 1773; Fax: +81 3 6433 3308; E-mail: ina@iwai.com

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Introduction

Global sagittal imbalance with lumbar hypo-lordosis has recently been well known as one of the major causes of reduced health-related quality of life in elderly populations [1,2]. This condition can cause a variety of problems, including Low Back Pain (LBP) while standing and walking. This outcome is mainly because the back muscles become exhausted to maintain an erect posture while the upper body spontaneously falls forward [2-5]. To correct the sagittal imbalance, highly invasive long-segment fusion surgery with posterior wedge osteotomy [6] is still the mainstream for these cases. Although the essence of these operations is the shortening of the posterior elements [7] and rationally correct, the procedures are highly invasive and cause severe complications frequently. Thus, to develop minimally invasive procedures has been expected. Decrease in disc space has been considered a well-known degenerative change that may decrease the lumbar lordosis, while an increase in the spinous process height of posterior elements has also been observed as one of the degenerative changes [8,9]. It has been reported that the cranio-caudal increase in size of the spinous processes as posterior elements may contribute to the decrease in lordosis of the lumbar spine [8]. That is, both shortening the height of the anterior element and the lengthening the height of the posterior element can lead to reducing the lordosis of the lumbar spine [10]. Therefore, we developed a treatment aiming at (1) to shorten the length of the posterior element by Partial Resection of the Spinous Processes (PRSP) and (2) to improve the flexibility of the anterior element by lumbar extension rehabilitation.

Materials and Methods

This is a retrospective study of five consecutive patients who underwent PRSP and lumbar extension exercise for thoracolumbar kyphosis between March 1st, 2019 and September 30th, 2019 at one single spine centre.

Table 1: Demographics.

Case No.	Sex	Age (yrs)	Height (cm)	Body Weight (kg)	BMI
1	F	82	143.5	49.1	23.8
2	F	77	147.6	42.2	19.4
3	F	87	146.0	61.7	28.9
4	M	79	168.5	64.0	22.5
5	F	77	149.0	57.5	25.9
Average		80.4	150.9	54.9	24.1

F: Female; M: Male; BMI: Body Mass Index

Patients

The inclusion criteria were 1) chief complaint being LBP on standing or walking, 2) Sagittal Vertical Axis (SVA) [11] >60 mm on a standing radiograph, 3) more than some mobility of the anterior element, 4) inter spinous distance < 2 mm at three levels or more on mid-sagittal computed tomography image, The exclusion criteria were as follows: 1) age < sixty years, 2) history of fusion operation, 3) scoliosis with lumbar curvature at a Cobb angle >15°, 4) lumbar spinal stenosis on magnetic resonance imaging, 5) lumbar zygapophysial arthrosis [12] 6) sacroiliac arthrosis [13] and 7) spondylolisthesis Meyerding grade ≥ II. These criteria were diagnosed radiologically or by physical findings or relevant block procedures if needed. The demographic data of the study population is shown in Table 1.

Operation procedure

A longitudinal skin incision 20 mm was made on every two spinous processes. The subcutaneous tissue was dissected. The supraspinous ligament was longitudinally separated. The periosteum was dissected to expose the spinous process and the multifidus muscle was preserved. The interspinous ligament was incised. A chisel was used to excise the cranial or caudal tip of the spinous process 10 mm long, 10 mm wide, and 20 mm deep. The ligament was re-sutured and the skin was closed (Figures 1-3).

Postoperative rehabilitation

Patients were instructed to perform six sets of stretch training each day for ten seconds in the thoracolumbar extension position. This exercise consisted of training to push up the upper body with both upper limbs in the prone position. Additionally, a rolled towel was placed under their back on the supine position and lumbar spine was extended and held for ten seconds. Each exercise was performed gradually, with care being taken not to cause severe pain. Compliance was monitored by physiotherapists checking the daily form filled by patients themselves. The performance was tested in three weeks and every three months thereafter.

Measurements and evaluation

A 64-slice CT scanner (Discovery 750 HD/Revolution GSI; GE Healthcare, Tokyo, Japan) was used. The original thickness of the CT images was 0.625 mm, and the re-formatted slice thickness was 2.0 mm. All measurements were performed using imaging software (DICOM Image Work Station XTREK F.E.S.T.A system; J-Mac System Inc., Sapporo, Japan). The operation time, blood loss and complications were assessed. The radiographic and clinical findings were compared before surgery and post-operatively. The radiographic assessment consisted of SVA, Lumbar Lordosis (LL) and pelvic incidence at the standing position. The clinical evaluation was performed at minimum twelve months post-operatively with patient-reported outcome measures including Numerical Rating Scale (NRS) of LBP and leg pain as well as Oswestry Disability Index (ODI).

Ethical standards

All procedures were performed in accordance with the ethical standards of the research committee of Iwai Medical Foundation and ethical approval of the committee was obtained (No. 20180926-1). Also, the study protocol was registered at the Japan Medical Association's Knowledge Center on February 27th, 2019 (JMA-IIA00411). Informed consent was obtained by the disclaimer documents for the surgical procedure and rehabilitation methods handed over to the patient with explanations and signed. Specifically, we explained the advantages and disadvantages of this operation method, the mechanism of this disease group we supposed, possible complications, and other treatment options. After that, we performed this operation on the patients who gave their consent.

Statistical analysis

We performed statistical analysis using SPSS 24.0 (SPSS Inc., Chicago IL, USA). Wilcoxon Matched Pairs Test for NRS of LBP pre and post operatively and ODI score. All reported p values were two-tailed, with differences reported as significant when $p<0.05$.

Results

Of the six cases who underwent PRSP, five cases were followed up for twelve months or more after we excluded one case whose daily activity became limited only to being bedridden due to Parkinson's syndrome during follow-up period. The age at surgery was 75 to 87 years old with the average being 80.4 years, and the average follow-up period was 13.6 months. Surgical time ranged from 37 min to 67 min with an average of 51 min. Several sites of Th11-S1 spinous processes were excised. Six sites were involved in two cases, five sites in one cases, and four sites in two cases. Intraoperative bleeding was 10 g to 20 g with an average of 12.0 g. There was no post-operative muscle weakness or nerve palsy. There were no other serious complications but one case experienced delayed wound healing, and the wound finally closed three weeks after the operation. Facet joint disease developed in two cases a few months after PRSP. The cauterization of poster medial branch of existing nerve roots going to the

Table 2: Operation time and complications.

Case No.	Level of PRSP	No. of PRSP	operation time (mins)	Blood loss (g)	Post-operative Complication	Post-operative Facet joint arthrosis	Follow up (mo)
1	Th12,L1,2,3,4,5	6	51	10	-	-	15
2	L1,2,3,4,5	5	37	10	+ (delayed wound healing)	+	12
3	Th11,12,L1,3,4,5	6	67	10	-	+ (treated by radiofrequency ablation)	16
4	L2,4,5,S1	4	54	10	-	-	13
5	L2,3,4,5	4	46	20	-	-	12
Average		5	51	12	-		13.6

PRSP: Partial Resection of Spinous Process

Table 3: Outcome: Radiographic.

Case No	SVA pre (mm)	SVA post (mm)	SVA change (mm)	LL (L1-S1) pre (°)	LL (L1-S1) post (°)	LL (L1-S1) change (°)	PI (°)
1	133	131	-2	-4.6	0.5	5.1	56.4
2	88	24.5	-63.5	-17.6	-8.5	9.1	35.2
3	113	63.5	-49.5	3.7	5.5	1.8	34.1
4	156.2	108.6	-47.6	10.2	11.9	1.7	52.8
5	65.5	119.9	54.4	25.1	14	-11.1	51.2
Average	111.1	89.5	-21.6	3.4	4.7	1.3	46

SVA: Sagittal Vertical Axis; LL: Lumbar Lordosis; PI: Pelvic Incidence

Table 4: Outcome: Patient oriented.

Case No	NRS of LBP pre	NRS of LBP post	LBP change	NRS of leg pain pre	NRS of leg pain post	leg pain change	ODI pre	ODI post	ODI change
1	7	5	-2	7	6	-1	49	27	-22
2	8	6	-2	3	4	1	20	13	-7
3	8	3	-5	0	0	0	56	40	-16
4	5	4	-1	0	0	0	31	18	-13
5	2	0	-2	0	0	0	9	0	-9
Average	6.0	3.6	-2.4	2.0	2.0	0	33	19.6	-13.4

NRS: Numerical Rating Scale; ODI: Oswestry Disability Index; LBP: Low Back Pain

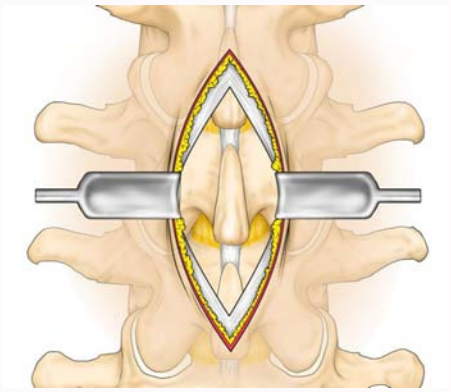

Figure 1: Operation procedure 1: exposure of spinous process. The skin and the supra-spinous ligament are incised and the spinous process are exposed.

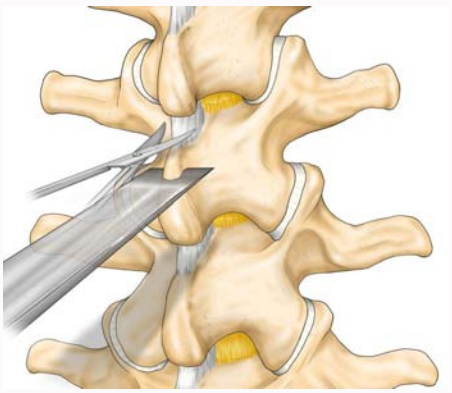

Figure 2: Operationn procedure 2: Excision of the cranial part the spinous process. Strike a chisel on the spinous process.

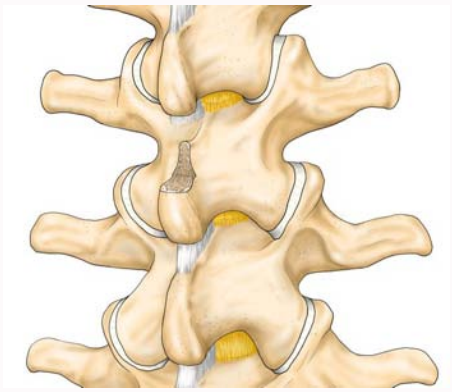

Figure 3: Operationn procedure 3. The cranial portion of the spinous process is removed.

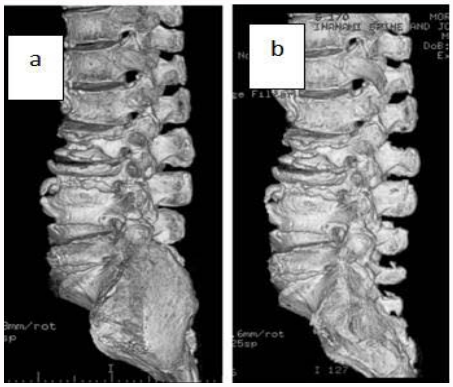

Figure 4: Computed tomography of lumbar spine at pre and post operation (Case #4). a pre-operative image, b Post-operative image. The cranial portion of spinous process of L,2,4, 5 and S1 were resected.

corresponding facet joint [12] was performed in one case (case No. 3). The detail of each operation is shown in Table 2. SVA improved from an average of 111.1 mm to 89.5 mm ($p<0.05$) (Table 3). Deterioration (+54 mm) was observed in one case, almost unchanged (-2 mm) in one case, and the remaining three cases improved by 53.5 mm on average. LL in the standing position was also improved except for one case. NRS of LBP improved from an average of 6.0 to 3.6 ($p<0.05$) (Table 4). Significant improvement of five point's loss was observed in one case (No. 3), while other cases showed mild improvement ranging from one to three points loss without any worsening cases.

Figure 5: Sagittal Vertical Axis (SVA) and Lumbar Lordosis (LL) on radiographs of total spine on standing position (Case #4). a pre-operative image SVA:156 mm, LL: 8°, b Post-operative image SVA:109 mm, LL: 2°

Lower extremity pain was almost unchanged. ODI score improved from preoperative average of 33.0 to postoperative average of 19.6 ($p<0.05$). Given that the minimum clinically important differences of ODI and NRS of LBP in lumbar spine surgery patients have been reported as 1.2 and 12.8, respectively 5, 14, four cases out of five showed clinically significant improvement in LBP, and three out of five showed improvement in quality of life measured by ODI.

Discussion

Many patients have undergone long-segment spinal fusion surgeries with osteotomy for the correction of sagittal imbalance [5]. These highly invasive operations may cause various complications and wide range of rigid spines. The key concept is to shorten the posterior elements with or without elongation of anterior elements as spinal kyphosis is primarily caused by anterior disc height collapse. However, in addition to anterior shortening, it has been advocated that enlargement of posterior elements such as spinous processes can be another source of kyphosis by blocking the back extension in some cases [10]. Thus, we developed minimally invasive procedures that is, PRSP to shorten the posterior elements without fusion operation and lumbar extension exercise to increase the flexibility of anterior elements. The present case series with technical description is the first report of PRSP for spinal flexible kyphosis to the best of our knowledge. SVA was markedly improved (>45 mm) in three out of five cases (60%), with LL being also recovered in four out of five cases (80%), which showed that our concept of posterior shortening was successful in majority of the cases selected. LBP and ODI improved in all cases. As a cause of back pain during standing or walking in kyphosis patients, fatigue pain for maintaining erect position against the tendency to fall forward has been previously discussed [2-5]. Therefore, our primary goal was to decrease SVA, aiming for unloading the back muscle to improve the back pain, However, interestingly, in this case series, low back pain improved even in cases where SVA did not improve. There are several explanations for this result. The positive relationship between LBP and paraspinal muscle pressure has been reported [14,15]. Another report argued that one of the parameters that influence the ability to maintain center of mass within "cone of economy" is flexibility of the spine [16].

In summary, the following three were considered to be the mechanism of improvement of LBP by this treatment method; 1) improvement of SVA reducing the load of the lumbar extensor muscles, 2) decreased paraspinal muscle pressure with decreasing of the compartment by PRSP, 3) improved flexibility of the spinal column contributing to optimized standing balance. Invasive surgery is often challenging for patients with global sagittal imbalance to whom this treatment is indicated. However, the present technique is minimally invasive and has very few and minor complications while having the significant effect on reducing LBP, and it may be one of the promising options for thoracolumbar kyphosis in the elderly. This study has some limitations. First, the follow-up period is relatively short, and the minimum follow-up period was 12 months in the present case series. Long-term outcomes should be confirmed with continuous observation. Second, the number of cases included was still limited. Thirdly, patients with mild lumbar kyphosis were not included. Symptoms related to kyphosis usually only develop after deformity becomes moderate or severe. It may be important to elucidate whether anterior shortening or posterior augmentation should proceed in order to determine the appropriate decision-making and timing for the treatment of this disease at early or advanced stages. Further study is warranted.

Conclusion

We performed PRSP and lumbar extension exercise for the patients with LBP during standing and/or walking due to lumbar kyphosis. This treatment method was minimally invasive and was considered to be effective in improving the symptoms of low back pain and health related quality of life of especially elderly patients.

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