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ORIGINAL PAPER

Less invasive and less technically demanding decompressive procedure for lumbar spinal stenosis—appropriate for general orthopaedic surgeons?

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Abstract This article presents the clinical and radiological results of the modified spinous process osteotomy decompressive procedure (MSPO), which affords excellent visualisation and provides wide access for Kerrison rongeur use and angulation while minimising destruction of tissues not directly involved in the pathological process. A total of 50 patients with degenerative lumbar spinal stenosis underwent MSPO between 2002 and 2005. The minimum follow-up period was five years. Patient's walking distance ability was 85.4 m (5–180 m) preoperatively and 2,560 m (1500–8000 m) at the last follow-up. Leg pain improved in 100% of the patients and back pain improved in 89% at the last follow-up. The overall results were good to excellent in 90% of the patients, fair in 16% and all patients were satisfied with the outcome at the last follow-up. The osteotomised spinous process eventually united with the retained laminar bridge in all patients within nine months after surgery. Degenerative lumbar spinal stenosis can be adequately decompressed with less violation of the integrity of the posterior elements using MSPO. The described technique of MSPO yielded promising results with few complications. The authors believe MSPO is less technically demanding and appropriate for general orthopaedic surgeons, occasional spine surgeons and chief residents.

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Introduction

Degenerative lumbar spinal stenosis is the most common condition leading to spine surgery in the geriatric population [6, 12–14]. With the increasing longevity of our population and a continually rising proportion of elderly patients, back and leg pain may cause loss of functional capabilities including activities of daily living and is a significant health care issue [3, 4, 13]. Therefore, surgery for symptomatic lumbar spinal stenosis is becoming increasingly more common for orthopaedic surgeons.

Extensive lumbar laminectomy has been used for the treatment of degenerative lumbar spinal stenosis, while affording wide surgical exposure and complete decompression [6, 9, 10]. However, this technique causes destruction of surrounding tissues, postoperative low back pain secondary to paraspinal muscle atrophy and iatrogenic biomechanical instability [3, 7, 9, 10, 12, 19, 21, 22].

Currently, there has been increased awareness of the need to preserve stability and minimise destruction to tissues not directly involved in the pathological process. Several authors have described their experiences with minimally invasive surgery (i.e. microscopic/microendoscopic decompression) for this pathology and reported its efficacy and safety. However, these techniques are technically demanding even though their results have been reported to be favourable [1, 5, 11, 15, 22].

Less invasive and less technically demanding alternatives are needed. The surgical technique of spinous process osteotomy decompressive procedure (SPO), which affords excellent visualisation and a wide access available for Kerrison use and angulation while minimising destruction of tissues not directly involved in the pathological process, was initially described by Yong Hing and Kirkaldy-Willis [23] and some modifications have been added [21]. Although excellent clinical outcomes of SPO with a short-term follow-up were described in 1999 [21], further analysis has not been performed. Also, the fate of the osteotomised spinous processes has remained uncertain.

We have modified the original SPO and have performed modified SPO (MSPO) for patients with degenerative lumbar spinal stenosis. The purpose of this study was to assess clinical and radiological outcomes of MSPO for degenerative lumbar spinal stenosis and determine the fate of the osteotomised spinous processes.

Surgical technique

In order to decompress one segment, a posterior-midline skin incision of approximately 30 mm was made. The dorso-lumbar fascia was incised to preserve the supra-spinous ligamentous attachment to the fascia. Only one cephalad spinous process at the involved segment should be included (Fig. 1a,b). To obtain excellent visualisation, one level of spinous process should be fully exposed. When L4/L5 spinal canal stenosis is decompressed, the L4 spinous process should be located and exposed. The spinous process of the involved segments is located and paraspinal musculature is stripped unilaterally from its spinous and laminar attachments, with care being taken not to extend subperiosteal dissection beyond the medial portion of the facet joint. Then, at the base of the spinous process, superficially to the junction of the lamina, the spinous process is osteotomised using a curved osteotome (Fig. 1c). A Cobb elevator was used to retract through the inter spinous notch on the contralateral side and against the multifidus ipsilaterally, which provides wide exposure of the segments to be decompressed with the use of the Gelpy self-retaining retractor. Then, a full view of the interlaminar space is afforded (Fig. 1d). Stripping and retraction of paraspinal musculature should not extend to the facet joint on the contralateral side. Decompression through a limited laminotomy of the cephalad lamina was performed under excellent visualisation and was extended in a trumpeted undercutting technique to enhance decompression of the spinal canal, lateral recess and foraminal stenosis. Limited laminotomy is also performed on the caudal lamina. The authors also suggest the use of laminar spreaders to avoid major bone resection as the majority of neurological compression occurs not under the lamina but at the level of the interlaminar window and under the facet joints. The ligamentum flavum is resected from cephalad to caudal, from medial to lateral. Finally, complete decompression for the dural sac and the nerve roots is confirmed (Fig. 1e, f). This limited laminotomy should be performed to preserve the facet joints and pars interarticularis completely.

The authors suggest the contralateral lamina should be retained as much as possible to contact with the osteotomised spinous process after the retractor is removed, while complete decompression is performed. The retractor was removed and the osteotomised spinous process resumes its native position in contact with the cotralateral retained lamina. The dorsolumbar fascia was resutured to the supraspinous ligament/dorsolumbar fascia complex with the ostetomised spinous process. An standard skin suture was performed with one drainage tube (Fig. 1g, h). Figure 2 shows the surgeon's angle of view.

Materials and methods

A total of 50 patients (30 males and 20 females) with degenerative lumbar spinal stenosis underwent MSPO between 2002 and 2005. Inclusion criteria required that each patient had: (1) neurological claudication as defined by leg pain limiting standing, ambulation, or both; (2) a history of exercise intolerance; (3) magnetic resonance imaging (MRI), myelogram confirmation of one-level compressive cetral stenosis with or without lateral recess stenosis; (4) no or mild back pain; and (5) failure of conservative therapy after an adequate trial. Patients with degenerative sondylolisthesis, developmental stenosis, radiographic signs of instability and incomplete decompression from previous surgery were not involved in this study. Thirty-two patients were operated on by the corresponding author (M.T.) and 18 patients were operated on by two general orthopaedic surgeons or two chief residents. All patients were available for a minimum of five-years follow-up.

A distinction was made between leg and back pain, each of which was scored subjectively for severity on the visual analogue scale (VAS). A thorough medical history was obtained to identify comorbid medical factors. Walking tolerance was described in terms of distance.

After surgery, an independent observer who was not involved in the patients' care contacted all patients on two separate occasions (at two years after surgery and at the last follow-up)

Outcome variables and nomenclature were adopted from a published meta-analysis to permit comparisons with the existing literature. The ultimate clinical outcome was assessed by the criteria by Stucki et al. [18] at two years after surgery

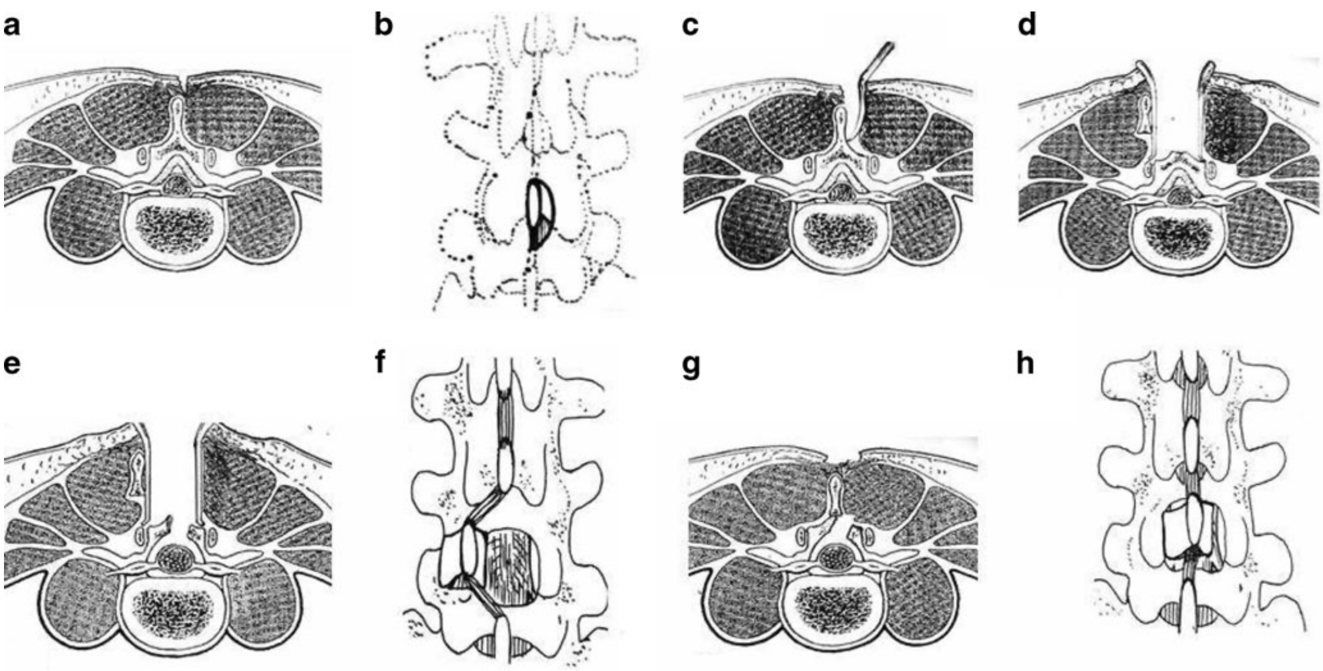

Fig. 1 Surgical technique. **a**, **b** Midline posterior incision. **c** Spinous process osteotomy using curved osteotome. **d** Retraction by Gelpy self-retaining retractor. **e**, **f** Spinal canal decompression by undermining of lamina. **g**, **h** Closure of dorso-lumbar fascia

and at the last follow-up. In that report, functional outcome was divided into one of three categories (Table 1).

A self-administered questionnaire was sent to the all patients to determine patient satisfaction with the outcome using a four-point patient satisfaction measure (dissatisfied, minimally satisfied, satisfied, very satisfied) at two years after surgery and at the last follow-up.

CT scans were performed to determine the fate of the osteotomised spinous process at three months, six months, nine months and 12 months after surgery and at the last follow-up.

Results

Fifty patients were enrolled into this study. Table 2 reflects the patient demographics and surgical parameters. The average age at surgery was 72 years (range, 50–86 years). The average follow-up period was 6.7 years (range, five to eight years). Forty-one patients had decompression at L4/5, six at L3/4, and three L2/3. The average operating time was 42 minutes (range, 29−66 minutes). The average estimated blood loss was 55 ml (range, 22–112 ml). No blood transfusion was required in any of the patients.

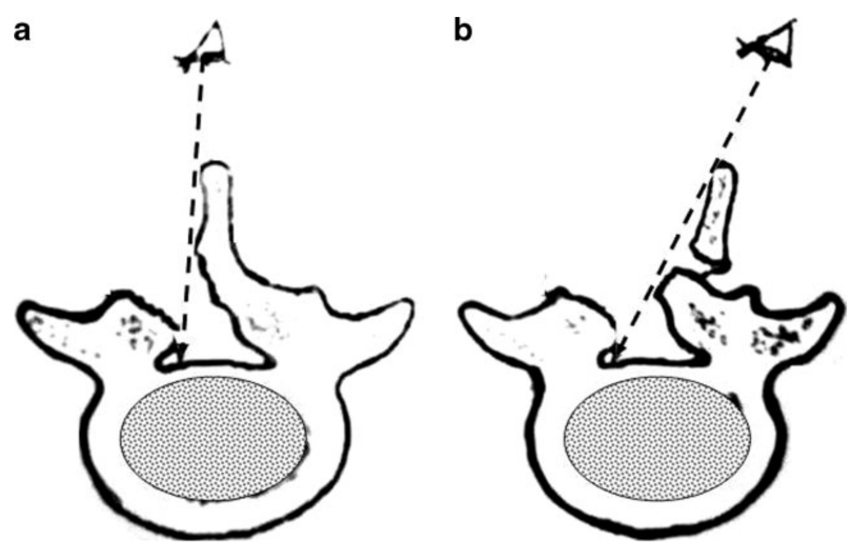

Fig. 2 The surgeon's angle of view. **a** In a case without spinous process osteotomy. The retained midline posterior structures significantly limit visualization and Kerrison angulation as the surgeon attempts to undercut the lateral zone in cases of nerve root canal stenosis. **b** In a case with spinous process osteotomy. The angle of view is increased to permit easy examination of the lateral recess and foramen

Table 1 Clinical and functional outcome

Rating	Description
Good to excellent	A patient with a good to excellent outcome had absent or occasional mild back and leg pain. Additionally, it was required that good to excellent patients be able to ambulate more than one mile or 20 minutes, and that they not restrict themselves from their usual activities.
Fair	A fair result implied persistent mild back or leg pain with occasional moderate pain, and less than one mile or 20 minutes of ambulation endurance. These patients also acknowledged some mild restrictions in their customary physical activity.
Poor	A poor result implied little to no pain relief from surgery, major activity limitations, or both. A repeat operation for any reason was considered a poor result, regardless of the ultimate level of function.

Intraoperative complications occurred in two patients, both of which were dural tears (one by the corresponding author and one by a chief resident). All tears were a result of Kerrison rongeur work and repaired immediately without clinical sequelae. No postoperative complication occurred in any of our series. There was no re-operation during the follow-up period.

The result of this study is summarised in Table 3. According to the meta-analysis criteria, the overall results were good to excellent in 84% (42/50) of the patients and fair in 16% (8/50) at two years after surgery. At the last follow-up, the overall results were good to excellent in 90% (45/50) of the patients and fair in 16% (5/50).

Table 2 Patient demographics and surgical details

Demographic	Description
Gender	30 males; 20 females
Age (years)	Average 72 years (range, 50–86 years)
Comorbidities	
HT	20% (10/50)
CAD	6% (3/50)
MI	4% (2/50)
NIDDM	20% (10/50)
CVA	4% (2/50)
COPD	6% (3/50)
Osteoporosis	14% (7/50)
Rheumatoid arthritis	4% (2/50)
Operating time	42 minutes (range, 29–66 minutes)
Blood loss	55 ml (range, 22–112 ml)

HT hypertension, *CAD* history of coronary artery disease, *MI* history of myocardial infarction, *NIDDM* non-insulin-dependent diabetes mellitus, *CVA* cerebrovascular accident, *COPD* chronic obstructive pulmonary disease

Table 3 Two-year and last surgical follow-up

Rating	Two-year follow-up	Last follow-up
Good to excellent	84% (42)	90%
Fair	16% (8)	10%
Poor	0% (0)	0%
Improvement		
Leg pain	100% (50/50)	100% (50/50)
Back pain	80% (36/45)	89% (40/45)
Satisfaction	100% (50/50)	100% (50/50)

Before surgery, walking distance ability was 85.4 m (range, 5–180 m). It was 2,066 m (1200–8000 m) at two years after surgery and 2,560 m (1500–8000 m) at the last follow-up.

The average preoperative leg pain level was 6.7 (range, 4–10). The average leg pain level was 1.0 (range, 0–2) at two years after surgery and the last follow-up was 0.7 (range, 0–2). At two years after surgery, 80% (40/50) of the patients reported that leg pain had resolved; 20% (10/50) judged the pain to be better. At the last follow-up, 90% (45/50) of the patients reported that leg pain had resolved; 10% (5/50) believed the pain to be better.

In 10% (5/50) of the patients, back pain was not a preoperative problem. The average preoperative low back pain level was 1.5 (range, 0–3). The average low back pain level was 0.7 (range, 0–2) at two years after surgery and at the last follow-up it was 0.5 (range, 0–2). At two years after surgery, 40% (18/45) of the patients reported back pain was absent; 40% (18/45) believed the pain was improved; 20% (9/45) stated no change in the level of pain. At the last follow-up, 60% (27/45) of the patients reported back pain was absent; 40% (18/45) believed the pain was improved. Ninety percent (45/50) of the patients were very satisfied with their outcome, 8% (4/50) were satisfied, and 2% (1/50) were minimally satisfied. No patients were dissatisfied.

CT scans were performed to assess fusion status between the osteotomised spinous process and the retained laminar bridge. CT scans demonstrated the osteotomised spinous process united with the contralateral retained laminar bridge in 10% (5/50) of the patients at three months after surgery, in 80% (40/50) at six months after surgery and in 100% (50/50) at nine months after surgery. The union was maintained in all patients at the last follow-up.

Figure 3 shows a patient example.

Discussion

Commonly used techniques of lumbar decompression that include bilateral elevation of paraspinal musculature and aggressive bony resection can result in significant iatrogen-

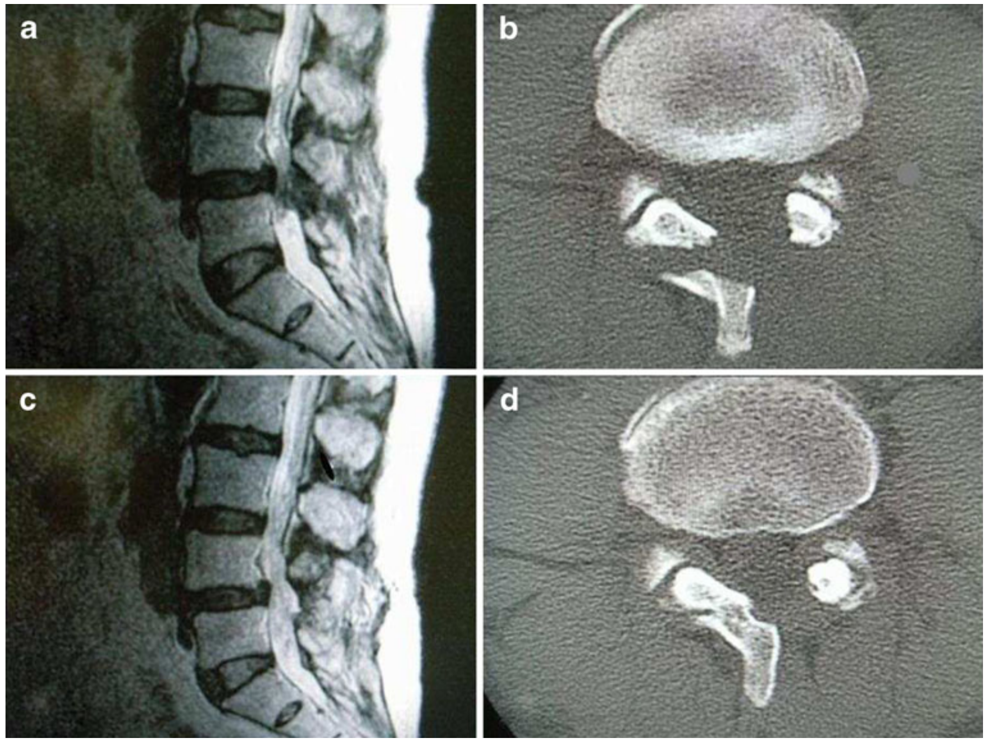

Fig. 3 A 60-year-old male with degenerative lumbar spinal stenosis at the L4/5 level. Before surgery, walking ability distance was 90 m. Preoperative low back pain level was 3 (10-point visual analogue scale). Preoperative leg pain level was 7. **a** A preoperative MRI. **b** The osteotomised spinous process. **c** An MRI at three months after surgery. **d** The osteotomised spinous process united with the retained laminar bridge at six months after surgery. At 2.5 years after surgery, walking distance was 7000 m. Leg pain level was 1 and low back pain level was 1. This patient was very satisfied with the outcome

ic sequelae. The paraspinal muscles may be denervated and subsequent atrophy may occur. Theses changes have been associated with the postoperative failed back syndrome. Also, classical surgical decompression has involved extensive removal of the posterior elements including the lamina, spinous processes, supra-/interspinous ligaments, and occasionally the facet joints [6, 7, 10]. Surgical removal of these posterior elements compromises spinal stability. Older techniques of laminectomy or unroofing of the spinal canal, while affording wide decompression, often resulted in destruction or insufficiency of the pars interarticularis or facet joints with resultant iatrogenic instability [3, 9, 12, 21]. Extensive decompression is a must while preserving spinal stability. Concomitant spinal arthrodesis should be considered when spinal stability is lost [3, 4, 8, 9]. However, spinal fusion in elderly patients is associated with higher complication and pseudarthrosis rates [2–4, 16, 17].

Fenestration techniques allow preservation of the spinous processes and supra-/interspinous ligaments, while decompression is afforded by bilateral elevation of the paraspinal musculature followed by bilateral laminotomies [21, 24]. However, the paraspinal muscles are still stripped and the retained midline posterior structures significantly limit visualisation and Kerrison angulation as the surgeon attempts to undercut the lateral zone in cases of nerve root canal stenosis [21].

Surgical treatment of degenerative lumbar spinal stenosis has become progressively less invasive. Several techniques of minimally invasive decompressive surgery for the treatment of lumbar spinal stenosis have been reported and their results have also been favourable [1, 5, 11, 15, 19, 22]. Microscopic/microendoscopic techniques involve unilateral paraspinal retraction, ipsilateral decompression, and contralateral decompression, using microscope/microendoscope and under the midline posterior structures. However, the ipsilateral portion of this technique is limited by visualisation and Kerrison angulation of the lateral zone. Also, working through the small operative window at a significant angle to address the contralateral side requires an extensive knowledge of lumbar microanatomy and considerable experience with both Kerrison and microscope/microendoscope to either obtain a complete decompression or avoid damage to neurological structures [5, 19, 22]. This technique has been described to be technically demanding and not a case for occasional spine surgeons or chief residents [22].

The recent rise in minimally or less invasive surgical techniques has been based on the honourable goals of minimisation of destruction to unaffected tissues and optimisation of the cosmetic results. These goals should be to achieve decompressive surgery completely and safely. MSPO appears to achieve these goals, while affording excellent visualisation and complete decompression. MSPO saves the posterior midline elements while allowing them to be retracted away from the working area, and it scrupulously respects the integrity of the spinous processes and supra-/interspinous ligaments while removing the ligamentum fravum and decompressing the lateral recess. In addition, the authors confirmed each osteotomised spinous process united with the retained laminar bridge within nine months after surgery in all patients. Therefore, preservation of bony stability could be achieved.

Commonly used techniques of exposure for lumbar decompression that include elevation of the multifindus bilaterally with subsequent wide retraction have potentially serious consequences [7, 21]. Innervation of the multifidus derives from the medial branch of the dorsal ramus. Retraction of multifidus beyond the midpoint of the facet joint tethers the medial branch of the dorsal ramus, risking muscular denervation [21]. MSPO limits bilateral retraction to the level of the medial facet border. The authors believe MSPO minimises the risk of iatrogenic muscular trauma, and potential postoperative low back pain secondary to paraspinal muscle atrophy is avoided.

The process of MSPO can be accomplished with less surgical exposure and complexity, translating into decreased blood loss and operating time, with no major complication even though 18 operations were performed by several general orthopaedic surgeons and chief residents. Furthermore, the use of MSPO does not require any specific instruments or extensive experience. The authors believe MSPO is appropriate for chief residents or general orthopaedic surgeons.

Overall patient satisfaction was 100%. Leg pain was relieved in 100%. Back pain was improved in 89% of the patients even though this was not a primary goal of the surgery. Despite stricter outcome criteria than that used in the meta-analysis, good and excellent results after MSPO were 26% higher than that described by Turner et al. (90% vs. 64%) [20].

As with previous studies, the patients in this study had many comorbid medical conditions (Table 1). These conditions had an impact on their quality of life and functional capacity. Any surgery should offer significant functional benefits as the older and less healthy patient population is at high risk for complications. The authors also recommend MSPO for surgical treatment of degenerative lumbar spinal stenosis in elderly patients.

Conclusion

MSPO is less invasive and less technically demanding than other techniques. Degenerative lumbar spinal stenosis can be adequately decompressed with less violation of the integrity of the posterior elements using MSPO. MSPO provides for excellent visualisation and room to work while minimising resection and injury to tissues not directly involved in the pathological process. The osteotomised spinous process eventually united with the retained laminar bridge in all patients. The described technique of MSPO yielded promising results with few complications. Patient-focussed outcomes improved significantly after surgery. Patient's satisfaction was high.

Study limitations

There are some limitations to this study. There was no randomised control group. However, the purpose of this study was to compare the current technique of MSPO with established decompression and/or arthrodesis procedures described in the existing literature. In this study, only patients who had one-level decompression were included. It remains to be seen whether the described technique is adequate for multilevel decompression.

Conflict of interest statement No funds were received in support of this study.

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No benefits in any form have been or will be received from a commercial party related directly or indirectly to the subject of this manuscript.

Informed consent was obtained from the all patients before entering the study.

Institutional review board approval of Kitasato University was obtained for this study.

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