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Original Article

Study on the effect of limited laminectomy combined with foraminal stenosis decompression on multi-segment cervical spondylotic myelopathy

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Abstract: Objective: To explore the effect of limited laminectomy and foraminal decompression with fixation (LLFDF) on multi-segment cervical spondylotic myelopathy. Methods: From January 2016 to December 2018, 90 patients with Multi-segment cervical spondylotic myelopathy (M-CSM) were selected as the subjects in this research. Their clinical data was analyzed retrospectively. These patients were divided into two groups. Each group had 45 cases. Patients in the LLFDF group underwent LLFDF surgery. Patients receiving normal laminectomy with fixation (NLF) were assigned into the NLF group. The intraoperative blood loss, operative time, laminectomy width, Spinal cord drift distance, CCI, length of stay, incidence rate of C5 palsy, VAS scores, and JOA scores were recorded and analyzed between the two groups. Results: No significant differences were found regarding operation time, intraoperative blood loss and CCI between the two groups ($P>0.05$). The laminectomy width, spinal cord drift distance, VAS scores, incidence rate of C5 palsy in the LLFDF group were lower than those in the NLF group ($P<0.05$). Compared with those in the NLF group, JOA scores were significantly higher after surgery in the LLFDF group ($P<0.001$). Conclusions: Compared with NLF, LLFDF can promote cervical neurologic functional recovery, restricts excessive spinal cord back drift, relieve patients' pain and reduce the incidence rate of C5 palsy. Thus, it is worthy of clinical application.

Keywords: Cervical spondylotic myelopathy, limited laminectomy, foraminal stenosis decompression, internal fixation, therapeutic effect

Introduction

Clinically, multi-segment cervical spondylotic myelopathy (M-CSM), is a common disease treated in the department of Orthopedics, and it is characteristic by upper-limb numbness, abnormal touch and pain sensations, diminished strength of muscles controlled by the involved nerve, and reduced fine-motor functions of the affected fingers, which poses a great threat to the health and life quality of these patients [1, 2]. The main method of treatment is posterior decompression. Normal laminectomy with fixation (NLF), which is a common method of posterior decompression, is widely used in clinical practice and has an exact effect in relieving symptoms [3, 4]. After embedding of internal instruments and laminectomy, however, the incidence of postoperative C5 palsy can be significantly increased [5, 6]. Some studies reported that postoperative C5 palsy is related to increased nerve root tension caused by excessive posterior drifting of the spinal cord after adequate spinal cord decompression [7, 8]. So far, it remains unclear what the necessary parameters of the required width of the vertebral plate is that needs to be taken out intraoperatively to reduce the incidence of C5 palsy [9], and literature that could provide exact data is not available. In recent years, limited

laminectomy is gradually used for the treatment of lumbar diseases. The main difference with normal laminectomy is the laminectomy width. Some studies reported that the postoperative stabilization of the spine in limited laminectomy was better maintained than that in normal laminectomy [10]. Other studies indicated that the therapeutic effect of limited laminectomy for lumbar stenosis with severe back pain is significantly better than that of normal laminectomy [11, 12]. Furthermore, for the patients with multi-segment cervical spondylotic myelopathy, it remains unclear whether the therapeutic effects of limited laminectomy are beneficial. In order to achieve better therapeutic effect and decrease nerve root tension, foraminal stenosis decompression is conducted in the process of limited laminectomy. Therefore, this research adopted two treatment methods, limited laminectomy combined with foraminal stenosis decompression and normal laminectomy, to treat the multi-segment cervical spondylotic myelopathy and then compared the short-term effects, in order to provide an experimental foundation for the treatment of multi-segment cervical spondylotic myelopathy using limited laminectomy and foraminal stenosis decompression.

Materials and methods

Subjects

From January 2016 to December 2018, 90 patients with M-CSM admitted to our hospital were enrolled as subjects. A retrospective analysis of clinical data was conducted. The patients included in this study signed a written informed consent and this study was approved by our Hospital Ethics Committee. The inclusion criteria were as follows: Age is greater than 18 years old; Patients meet the diagnostic criteria of multi-segment cervical spondylotic myelopathy according to the symptoms, signs and imaging examination [13]; Patients were followed for over 6 months; After normal non-operative therapy, patients had explicit indications for LLFDF or NLF surgery; Patients possessed complete clinical data and complied with regulations of this research. Exclusion criteria was as follows: Patients had operative contraindications and severe underlying diseases such as cardiovascular and cerebrovascular diseases and hepatic and renal dysfunction which made them unable to tolerate the operation; Patients had a history of cervical vertebra surgery, osteoporosis, cervical ossification of the posterior longitudinal ligaments, infectious diseases or tumors. According to the surgical methods, the patients were divided into the LLFDF group and NLF group.

Surgical methods

The surgeries in this study were conducted by the same group of surgeons. After general anesthesia, patients were placed in a prone position and their cervical spine was kept in anteflexion status through fixing the head with a Mayfield head frame. The incision was made in the posterior median of the cervical spine. The tissues were separated to expose the lamina and cervical lateral mass. The pedicle screws were placed into the diseased cervical spine segment according to the Magerl technique. The internal fixation was conducted in the diseased segment. Then, the spinous process and ligament tissue were taken out. In the LLFDF group separate slots were made along both sides 7-9 mm away from the external region of the midline; while in the NLF group they were created 2 mm away from the internal edge of lateral mass using the high-speed drill. Next, the internal cortex from the vertebral plate was polished, and the ligamentum flavum was cut off between the head and tail end, and the epidural adhesion was separated carefully. In the LLFDF group, the vertebral plate was placed via a limited laminectomy and the posterior wall of C5 nerve root canal was decompressed to reduce the tension, while in the NLF group the vertebral plate was placed with a normally laminectomy. After the operation, the drainage tube was placed internally and the incision was sutured hierarchically.

Outcome measures

The indexes of intraoperative blood loss, operative time, laminectomy width [14], Spinal cord drift distance [15], CCI [16] and length of stay were compared between two groups.

JOA score was applied to assess preoperative and postoperative cervical neurological function [17]. The total scores ranged from 0 to 17.

Table 1. Comparison of basic information between the two groups

Variable	LLFDF group (N=45)	NLF group (N=45)	T/χ^2 value	*P* value
Male/Female (n)	26/19	24/21	0.180	0.671
Age (year)	56.4±4.3	55.2±3.9	1.387	0.169
BMI (kg/m^2)	21.3±0.4	21.5±0.6	1.861	0.066
Hypertension (n)	12	14	0.465	0.642
Diabetes (n)	10	8	0.527	0.598
Hyperlipidemia (n)	8	11	0.600	0.438
Course of disease (months)	16.8±3.9	17.1±4.6	0.334	0.740
Cause of disease (n)			0.409	0.815
Multilevel cervical disc herniation	26	23		
ligamentum flavum hypertrophy combined with cervical disc herniation	11	13		
calcification of posterior longitudinal ligament	8	9		

Note: LLFDF: Limited laminectomy and foraminal decompression with fixation; NLF: Normal laminectomy with fixation; BMI: Body Mass Index.

It included motor functions of upper the extremities, motor functions of the lower limbs, sense and bladder functions. A higher score indicated that the cervical neurological function was better.

Incidence rate of C5 palsy was compared between two groups [18]. The judgement criteria of C5 palsy was as follows: After surgery there was a new occurrence of paralysis of the deltoid or biceps brachii, or disturbance of sensation in the C5 dermatome region or intractable pain. It was calculated according to the following formula: Incidence rate of C5 palsy = (number of cases with C5 palsy/total number of patients)* 100%.

VAS was used to score the preoperative and postoperative cervical pain before and after surgery [19]. VAS scores ranged from 0 to 10. The higher scores indicated that the pain was worse.

Statistical analysis

All clinical data were analyzed using the SPSS software, version 22.0. Measurement data were expressed as mean ± standard deviation, and the independent sample t-test was used for the comparison between two groups. Paired t test was used for the comparison between before and after surgery in the same group. Enumeration data were presented as percentages, and the chi-square test was applied for the comparison between both groups. P<0.05 indicated significant statistical differences.

Results

Comparison of basic information

There were no significant differences in the basic information concerning gender, age, BMI, course of disease, pathogenic factors, and underlying diseases between the LLFDF group and NLF group (all P>0.05), as shown in **Table 1**. They were comparable. All surgeries in this study were finished successfully, as seen in **Figures 1** and **2**.

Intraoperative indicators

No significant difference was found in terms of intraoperative blood loss (324.8±60.4 mL vs 305.7±57.7 mL, t=1.534, P=0.129) and operative time (160.4±31.2 min vs 152.7±28.3 min, t=1.225, P=0.223) between the groups. Compared with those in the NLF group, the laminectomy width (17.1±3.1 mm vs 22.2±3.5 mm t=7.317, P<0.001) in the LLFDF group significantly less, as shown in **Figure 3**.

JOA score

Compared to the preoperative scores, the patients' JOA scores in both groups at 6 months after surgery were significantly higher (P< 0.001). JOA scores at 6 months after operation in the LLFDF group were significantly higher than that in the NLF group (17.2±2.8 vs 14.8±2.3, t=4.443, P<0.001). There was no significant difference in JOA scores before surgery between two groups (7.5±1.9 vs 7.9±2.1, t=0.948, P=0.346), as seen in **Figure 4**.

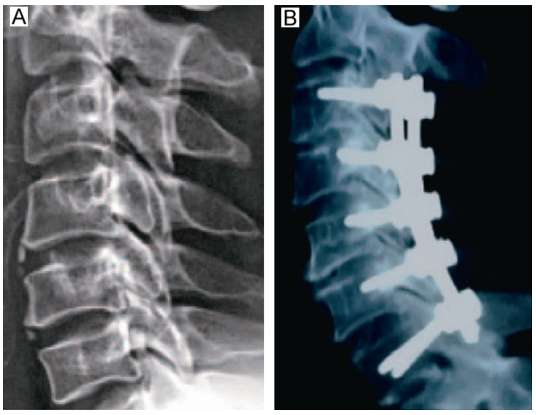

Figure 1. Patients with multi-segment cervical spondylotic myelopathy who underwent limited laminectomy and foraminal decompression with fixation. A: Preoperative X-ray image; B: Postoperative X-ray image.

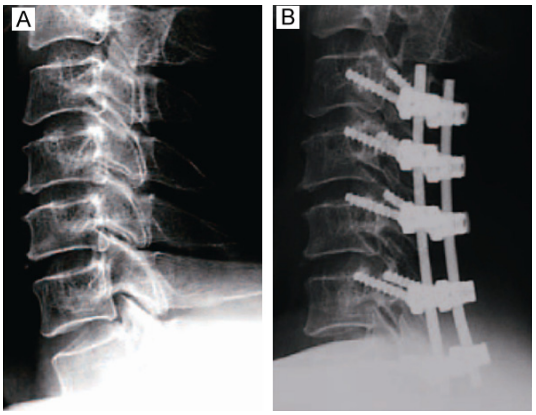

Figure 2. Patients with multi-segment cervical spondylotic myelopathy who underwent normal laminectomy fixation. A: Preoperative X-ray image; B: Postoperative X-ray image.

Cervical curvature index

As shown in **Figure 5**, there was no significant difference in CCI before surgery between two groups (12.4±2.5 vs 12.7±2.9, t=0.526, P=0.601). Compared to the preoperative scores, patients' CCI in both groups at 6 months after surgery were significantly higher (P<0.001). A significant difference was not found in CCI at 6 months after operation between the LLFDF group and NLF group (17.1±4.1 vs 17.6±4.4, t=0.558, P=0.579).

Incidence rate of C5 palsy

The occurrence rate of C5 palsy in the LLFDF group was 4.4% (2/45), while the occurrence rate in the NLF group was 26.7% (12/45). There was a statistically significant difference between the two groups (χ^2=8.459, P=0.004), Shown in **Figure 6**.

Spinal cord drift distance

Compared with that in the NLF group, the spinal cord drift distance in the LLFDF group was remarkably lower, and there was a statistically significant difference (2.4±0.5 mm vs 3.7±0.8 mm, t=9.244, P<0.001), as shown in **Figure 7**.

VAS scores and length of stay

As shown in **Table 2**, compared to the preoperative scores, the VAS scores in both groups at 6 months after surgery were significantly lower (P<0.001). There was no significant difference in VAS before surgery and at 6 months after surgery between the two groups, The length of stay in the LLFDF group was significantly shorter than that in NLF group (P<0.001).

Discussion

Multi-segment cervical spondylotic myelopathy is the most serious type of cervical spondylosis. It is a degenerative cervical disease and the incidence of this disease is rising annually. Currently, cervical laminectomy is an effective technique for treating multi-segment cervical spondylotic myelopathy, and this method has been accepted by most orthopedic surgeons. This operation can relieves the spinal cord compression and promote the recovery of neurological function through an increase in the diameter and volume of the spinal canal. Nevertheless, many studies suggest that normal laminectomy still has disadvantages such as spinal instability, cervical kyposis, and occurrence of C5 palsy, which seriously affect the prognosis of these patients. As a result, the technique is becoming harder to accept among patients in recent years. Limited laminectomy is a newly-developed surgery. It may be able to overcome the above disadvantages and minimize secondary damage to the posterior column structures of the spine [20]. Limited laminectomy is a preferred technique for patients with multi-segment cervical spondylotic myelopathy. However, it is noted that limited laminectomy has a strict requirement for the surgeons to have a good understanding of the indi-

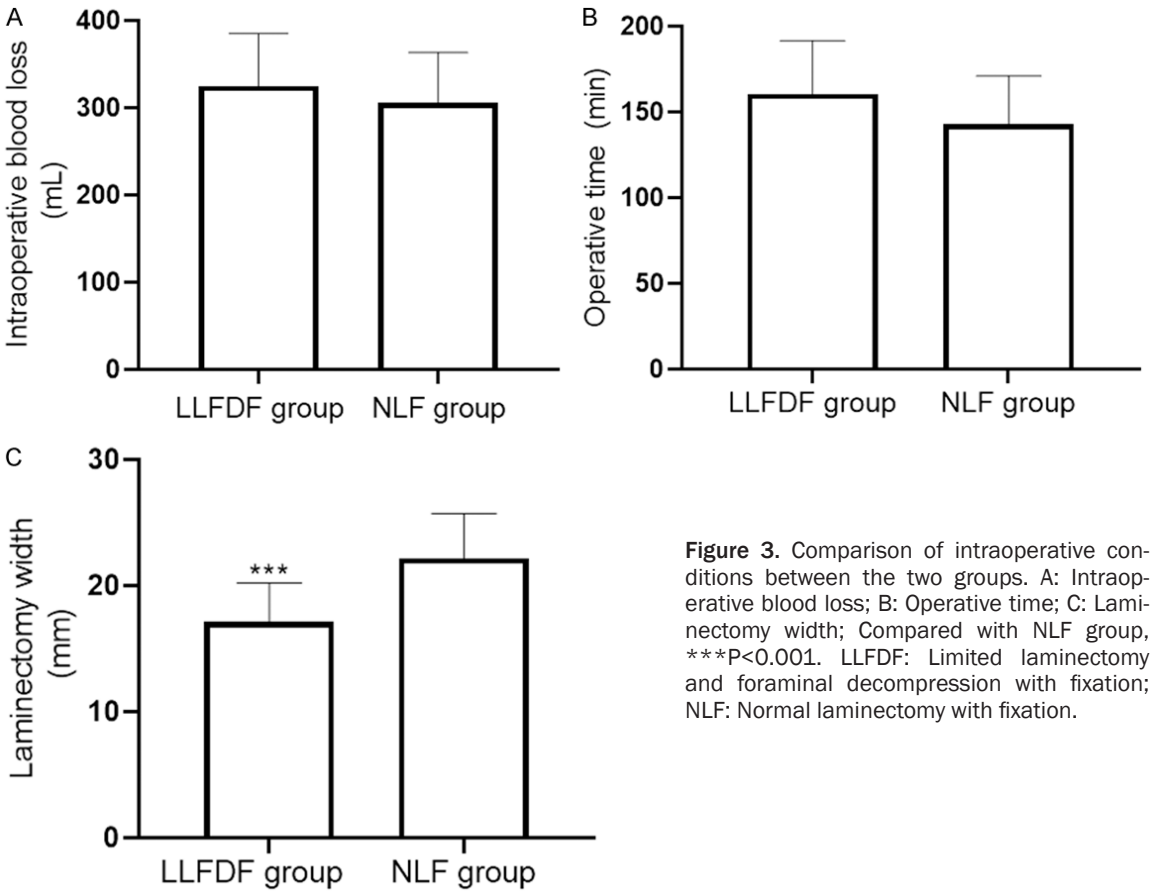

Figure 3. Comparison of intraoperative conditions between the two groups. A: Intraoperative blood loss; B: Operative time; C: Laminectomy width; Compared with NLF group, ***P<0.001. LLFDF: Limited laminectomy and foraminal decompression with fixation; NLF: Normal laminectomy with fixation.

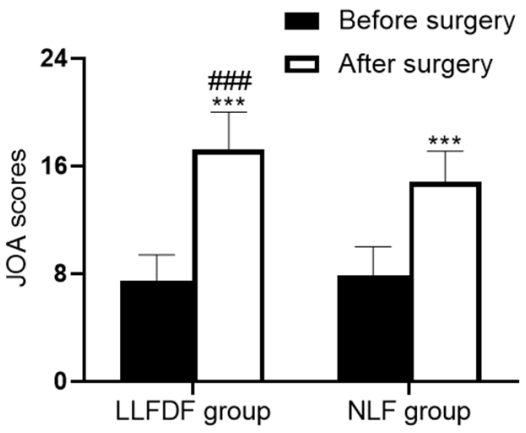

Figure 4. Comparison of JOA scores between two groups. Compared with before surgery in the same group, ***P<0.001; Compared with after surgery in NLF group, ###P<0.001. LLFDF: Limited laminectomy and foraminal decompression with fixation; NLF: Normal laminectomy with fixation; JOA: Japanese orthopaedic association.

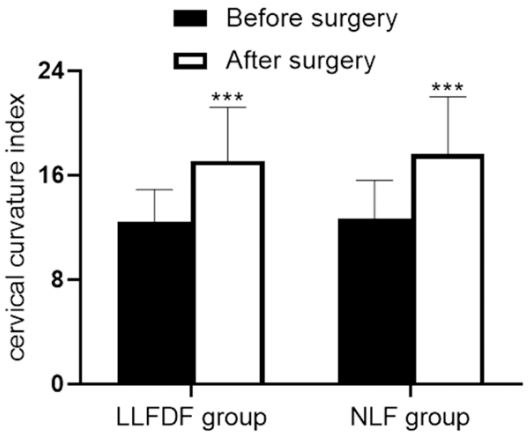

Figure 5. Comparison of cervical curvature index between the two groups. Compared with before surgery in the same group, ***P<0.001. LLFDF: Limited laminectomy and foraminal decompression with fixation; NLF: Normal laminectomy with fixation.

cations of treatment [12]. For the patients with multi-segment cervical spondylotic myelopathy, the proper surgical method based on their respective conditions should be chosen.

In this study, we recruited 90 patients with multi-segment cervical spondylotic myelopathy to compare the differences concerning the therapeutic effect between the LLFDF treatment group and the NLF group. All the patients

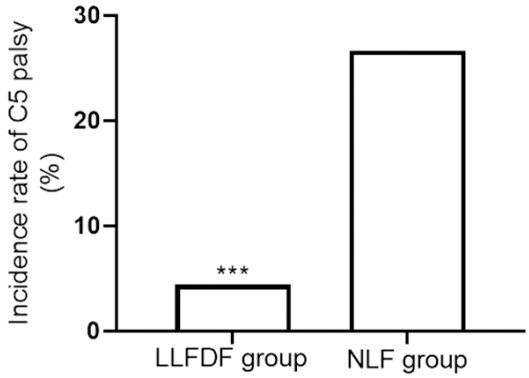

Figure 6. Comparison of incidence rate of C5 palsy between the two groups. Compared with NLF group, ***P<0.005. LLFDF: Limited laminectomy and foraminal decompression with fixation; NLF: Normal laminectomy with fixation.

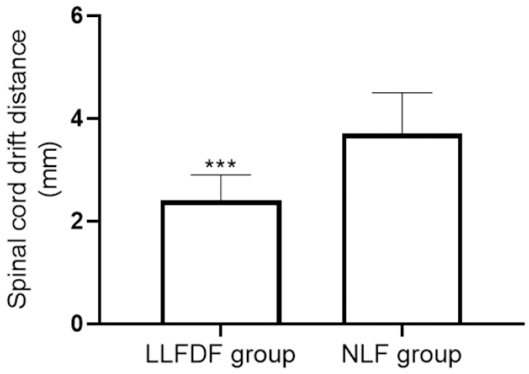

Figure 7. Comparison of spinal cord drift distance between the two groups. Compared with NLF group, ***P<0.001. LLFDF: Limited laminectomy and foraminal decompression with fixation; NLF: Normal laminectomy with fixation.

in both groups underwent pedicle screw fixation. The results of this study showed that compared with preoperative CCI, postoperative CCI in both groups was significantly improved and the cervical spinal curvature was well kept. No significant differences were found in the postoperative CCI between the two groups. It is indicated that postoperative CCI is not associated with differences in laminectomy ranges and it is related with pedicle screw fixation. This is because pedicle screw fixation is most effective for the therapy of cervical spondylotic myelopathy with correction of deformity and cervical instability [21]. Some studies reported that the stability in laminectomy with fixation was better than that in laminectomy or laminoplasty and CCI was remarkably increased from 8.4±2.5% preoperatively to 19.3±2.1% postoperatively by the method of pedicle screw fixation [4, 22]. In addition, the width of the laminectomy in the LLFDF group was less than that in the NLF group and there was a significant difference. There were no differences in operative time and intraoperative blood loss between the two groups. These results are according with Zhao et al.'s report [6].

There are a lot of factors affecting spinal cord drift. It is reported that spinal cord drift is associated with laminectomy extent and cervical spinal curvature [23]. Also that spinal cord backward drift may increase nerve root tension leading to the occurrence of C5 palsy under the effect of reperfusion injury, ischemia with anoxia of the nerve root, embolism and other factors [24, 25]. In this study, foraminal stenosis decompression was conducted in patients in the LLFDF group. The results showed that spinal cord drift distance and incidence rate of C5 palsy in the LLFDF group were less than those in the NLF group and there were significant differences. Some studies reported that when the cervical cord drifted 4 to 5 mm backward at the C5 level, segmental nerve root palsy usually occurred [26]. Other studies suggested that every 1 mm increase in the diameter of nerve canal root would lead to a 98% reduction in the nerve palsy incidence [18]. Thus, the decrease of nerve root palsy could be achieved by the enlargement of the nerve root canal and the limiting of the spinal cord excessive drift backwards.

JOA score is an important index for evaluating the recovery of neurological function in patients [27]. In this study, JOA score at 6 months after surgery in the LLFDF group was higher than that in the NLF group and there was a significant difference. It is indicated that compared with NLF surgery, LLFDF can yield a better satisfactory recovery of neurological function. Sangwan et al reported similar results [28]. Besides, according to the study results, the VAS score of patients who were in the LLFDF group was significantly less than that in the NLF group at 6 months after surgery (P<0.05) and the length of stay in the LLFDF group was shorter than that in the NLF group (P<0.001). This showed that LLFDF surgery had a better effect on treating multi-segment cervical spondylotic

Table 2. Comparison of VAS scores and length of stay between the two groups

Groups	VAS scores		T value	*P* value	length of stay (days)
	Before surgery	6 months after surgery			
LLFDF group	6.6±1.2	2.5±1.1	16.900	<0.001	10.5±1.9
NLF group	6.9±1.4	2.7±1.2	15.280	<0.001	15.4±2.2
T value	1.091	2.472			11.310
P value	0.278	0.015			<0.001

Note: LLFDF: Limited laminectomy and foraminal decompression with fixation; NLF: Normal laminectomy with fixation; VAS: Visual Analogue Scale.

myelopathy and relieving postoperative pain than NLF operation, which was generally consistent with the previous research results [29].

In conclusion, LLFDF and NLF operations were applied for clinical treatment of multi-segment cervical spondylotic myelopathy, however, the former was associated with less width of the laminectomy, better recovery of neurological functions, shorter spinal cord drift distance, lower incidence rate of C5 palsy, shorter length of stay and more significant effects on relieving postoperative pain in patients with multi-segment cervical spondylotic myelopathy. However, there are some limitations in this research, such as being a small sample size, a single center study, short follow-ups, and inability to confirm the long-term outcomes of the above surgical techniques in treatment of multi-segment cervical spondylotic myelopathy as well as unknown information about the optimal width of laminectomy. Additional studies are warranted for further validation.

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Disclosure of conflict of interest

None.

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