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ORIGINAL ARTICLE

Indirect posterior decompression with corrective fusion for ossification of the posterior longitudinal ligament of the thoracic spine: is it possible to predict the surgical results?

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Abstract To investigation of the outcomes of indirect posterior decompression with corrective fusion for myelopathy associated with thoracic ossification of the longitudinal ligament, and prognostic factors. Conservative treatment for myelopathy associated with thoracic ossification of the longitudinal ligament (OPLL) is mostly ineffective, and treatment is necessary. However, many authors have reported poor surgical outcomes, and no standard surgical procedure has been established. We have been performing indirect spinal cord decompression by posterior laminectomy and simultaneous corrective fusion of the thoracic kyphosis. Twenty patients underwent indirect posterior decompression with corrective fusion, and were included in this study. The follow-up period was minimum 2 years and averaged 2 years and 9 months (2–5 years 6 months). Operative results were examined using JOA scoring system (full marks: 11 points) and Hirabayashi's recovery rate, as excellent (100–75%), good (74–50%), fair (49–25%), unchanged (24–0%) and deteriorated (i.e., decrease in score less than 0%). Cases in which the spinal cord is floating from OPLL on intraoperative ultrasonography were defined as the floating (+) group, and those without floating as the floating (−) group. In addition, we used compound muscle action potentials (CMAP) as intraoperative spinal cord monitoring and the cases were divided into three groups: Group A, no change in potential; Group B, potential decreased, and Group C, potential improved. The mean pre- and postoperative JOA scores were 6.2 and 8.9 points, respectively, and the recovery rate was 56%. The outcome was rated excellent in three, good in eight, fair in six, unchanged in two, and deteriorated in one. The mean preoperative thoracic kyphosis measured 58°, and was corrected to 51° after surgery. On intraoperative ultrasonography, 12 cases were included in the floating (+) and 8 in the floating (−) groups; the recovery rates were 58 and 52%, respectively, showing no significant difference between the recovery rates of the two groups. Regarding intraoperative CMAP, the outcome was excellent in one, good in seven, fair in four, and unchanged in one in Group A; fair in one, unchanged in one, and deteriorated in one in Group B, and excellent in two and good in one in Group C. The recovery rates were 50, 48 and 68.3% in Groups A, B and C, respectively, showing that the postoperative outcome was significantly poorer in Group B. Although indirect posterior decompression with corrective fusion using instruments obtained satisfactory outcomes, not all cases achieved good outcomes using this procedure. We consider that additional application of anterior decompressive fusion is preferable when improvement of symptoms occurs not satisfactory after indirect posterior decompression with corrective fusion using instruments. Intraoperative spinal cord monitoring of CMAP demonstrated that the spinal cord was already impaired during the laminectomy via the posterior approach. Concomitant intraoperative monitoring of CMAP to avoid impairment of the vulnerable spinal cord and corrective posterior spinal fusion with indirect spinal cord decompression is recommendable as a method capable of preventing postoperative neurological aggravation.

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Introduction

Conservative treatment for myelopathy associated with thoracic ossification of the longitudinal ligament (OPLL) is mostly ineffective, and surgical treatment is necessary. However, many authors have reported poor surgical outcomes, and no standard surgical procedure has been established. Many cases of aggravation following laminectomy have been reported, and we have earlier also reported five aggravated cases [3]. There are two types, the flat type and beak type, for which surgery is difficult, in thoracic OPLL [3, 5]. We have been performing indirect spinal cord decompression by primary wide laminoplastic decompression and correction of kyphosis using instruments via a posterior approach for the beak type and flat type accompanied by ossification of the ligamentum flavum and facet destruction in posterior decompression since 1999 [7]. The objective of this study was to investigate the outcomes of indirect posterior decompression with corrective fusion, and prognostic factors in cases with poor outcomes.

Materials and methods

Of 37 patients with thoracic OPLL who underwent surgery between March 1985 and July 2006, 20 patients who underwent indirect posterior decompression with corrective fusion using instruments after 1999 were included. The average age was 58 years (37–67 years), and the follow-up period was minimum 2 years, and averaged 2 years and 9 months (2–5 years 6 months). Operative results were examined at 6 months after the surgery using Japanese Orthopaedic Association Scoring System (JOA score). This has a total of 17 points, consisting of four points for motor dysfunction of the upper and lower extremities, respectively; two points for sensory dysfunction of the upper and lower extremities and trunk, respectively; and three points for bladder dysfunction. The results of thoracic spine disease were evaluated using the same score excluding evaluation of upper-limb function (maximum 11 points). Postoperative recovery rate was determined by Hirabayashi's method as follows: recovery rate = (postoperative JOA score − preoperative JOA score) × 100/(full score − preoperative JOA score).

Based on Hirabayashi's recovery rate, we defined as excellent (100–75%), good (74–50%), fair (49–25%), unchanged (24–0%) and deteriorated (i.e., decrease in score; ≤0%). The investigated points were the JOA score, recovery rate, fusion range, pre- and postoperative Cobb angle of thoracic kyphosis, intra- and postoperative blood losses, operative time, intraoperative ultrasonography findings, intraoperative spinal cord monitoring (CMAP), and complications. The basic fusion area was three vertebrae above and below the OPLL lesion. Cases in which the spinal cord free from OPLL on intraoperative ultrasonography were defined as the floating (+) group, and those without as the floating (−) group. Regarding CMAP, the cases were divided into three groups: Group A: no change in potential, Group B: potential decreased, and Group C: potential improved.

The unpaired *t* test, Mann–Whitney *U* tests, or Fisher's exact probability test was used for statistical analysis. A *P* value of less than 0.05 was considered to indicate statistical significance.

Ethical consideration

Surgery was performed after the natural course of the disease without surgery and the possibility of surgical complications: (1) palsy, (2) infection, (3) transfusion, etc., were explained to the patients, and an informed consent was obtained.

Results

The average pre- and postoperative JOA scores were 6.2 (3–8) and 8.9 (3–10), respectively, and the recovery rate was 56%. The clinical outcome was excellent in three, good in eight, fair in six, unchanged in two, and deteriorated in one case (Table 1). The fusion area was T1–T4 in one, T1–T6 in one, T1–T9 in two, T2–T10 in three, T2–T11 in three, T3–T9 in three, T3–T10 in one, T4–T11 in three, and T6–T12 in three. Cervical laminoplasty was performed in 14 cases simultaneously. The preoperative thoracic kyphosis averaged 58° (48–72), and corrected to 51° (43–65) after surgery. The mean operative time was 7 h and 30 min (5 h 50 min–8 h 45 min), and the blood loss was 926 ml (670–1,135 ml) (Table 2).

Table 1 Clinical results

JOA score	
Preoperative 6.2 (3–8)	
Postoperative 8.9 (3–10)	
Recovery rate 56%	
Excellent	3 cases
Good	8 cases
Fair	6 cases
Poor	2 cases
Deteriorate	1 cases

Table 2 Operative results

Thoracic kyphosis	Preoperative 58° (48–72)
	Postoperative 51° (43–65)
Operative time	7 h 30 min (5 h 50 min–8 h 45 min)
Bleeding	926 ml (670–1,135 ml)

On intraoperative ultrasonography, 12 cases were included in the floating (+) and 8 in the floating (−) groups, and the recovery rates were 58 and 52%, respectively, showing no significant difference between the recovery rates of the two groups (Fig. 1). Regarding intraoperative CMAP, the derivation rate before decompression was 99%. In only one patient, the monitoring of spinal cord was impossible just prior to surgery and immediately thereafter; 13, 3 and 3 patients were included in the Groups A, B and C, respectively. In Group B, the potential was improved by 10 min arrest of decompression procedure in one case, the potential decreased immediately after laminectomy and recovered by correction of kyphosis with instruments in one case, and the operative procedure proceeded with overlooking of decreased spinal cord potential in one case.

In all three patients of Group C, the spinal cord potential did not change following the decompression procedure alone, but improved immediately subsequent to the correction of kyphosis with instruments (Table 3). The clinical outcome was excellent in one, good in seven, fair in four, and unchanged in one in Group A, fair in one, unchanged in one, and deteriorated in one in Group B, and excellent in two and good in one in Group C. The pre- and postoperative JOA scores of Groups A, B and C were 6.8 and 8.9, 6.0 and 8.4 and 5.8 and 9.4, respectively; the recovery rate was 50% in Group A, 48% in Group B and 68.3% in Group C, respectively, indicating that the postoperative outcome was significantly poorer in Group B (Table 4).

Table 3 Detail of group B and C

Group B
Case 1: amplitude getting down while laminectomy procedure after 10 min rest, amplitude was recovered
Case 2: just after laminectomy, wave was disappeared after correction of kyphosis, wave was appeared
Case 3: just after laminectomy, wave was disappeared after correction of kyphosis, wave was not appeared
Group C
3 Cases: while laminectomy, no wave change, after correction of kyphosis, amplitude of the wave improved

Regarding intra- and postoperative complications, cerebrospinal fluid leakage was noted in ten cases with adhesion between the dura and ossified ligamentum flavum or ossification of the dura, but it was treatable with postoperative lumbar drainage using autologous fibrin glue.

Typical case: Group B

The patient was a 53-year-old male with the chief complaint of gait disturbance. Stenosis from C3 to C7 and beak-type OPLL of T4–T5 and T5–T6 were noted. OYL of T4–T5 was also present, and the spinal cord was severely compressed (Fig. 2a). Laminoplasty from C3 to T2 was performed for cervical canal stenosis, followed by laminectomy of T3–T5. As the potential of CMAP began to

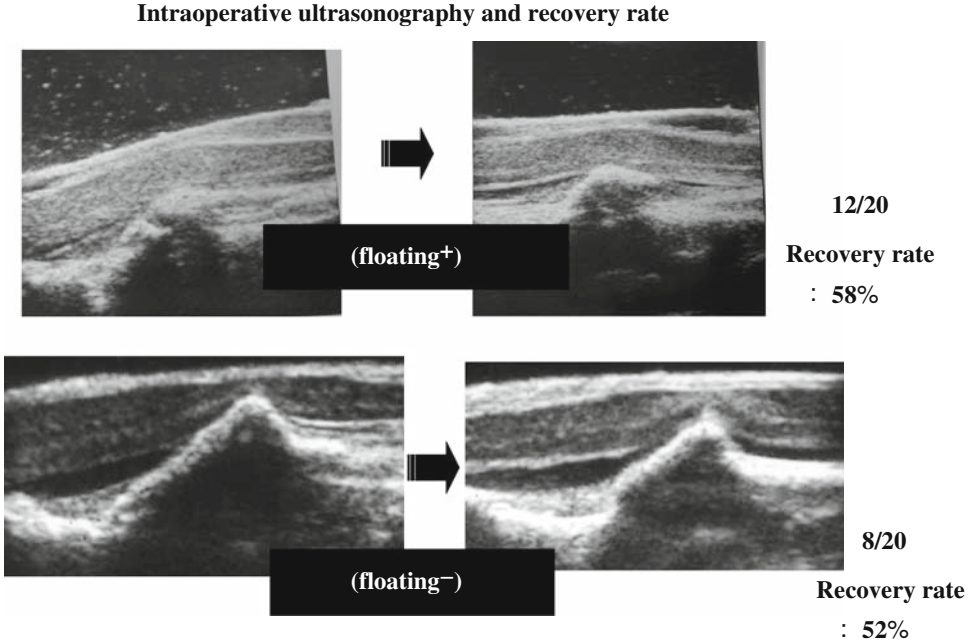

Fig. 1 Intraoperative ultrasonography and recovery rate. In the floating (+) group, 12 of the 20 patients were included and the JOA recovery rate was 58%. In the floating (−) group, 8 of the 20 patients were included and the JOA recovery rate was 52%. There was no significant difference between the recovery rates of two groups

Table 4 Clinical results of three groups

Group	A	B	C
Excellent	1		2
Good	7		1
Fair	4	1	
Poor	1	1	
Deteriorate		1	
Preoperative JOA	6.8	6.0	5.8
Postoperative JOA	8.9	8.4	9.4
Recovery rate (%)	50	48	68

decrease immediately following laminectomy of T3–T5, intraoperative ultrasonography was performed immediately. The compression of the spinal cord by OPLL from anteriorly was noticed. We applied pedicle screws at T3, T4, T7, and T8, and the kyphosis was corrected and fixed with cantilever and compression force with instruments (Fig. 2b). Intraoperative ultrasonography revealed that the compression of the spinal cord by OPLL decreased following the correction of kyphosis. CMAP recovered 1 min after correction of kyphosis (Fig. 2c). Neither neurological aggravation nor improvement occurred after the surgery.

Discussion

Conservative treatment for myelopathy associated with OPLL is mostly ineffective, and surgical treatment is necessary. However, many authors [1–3, 10–16] have

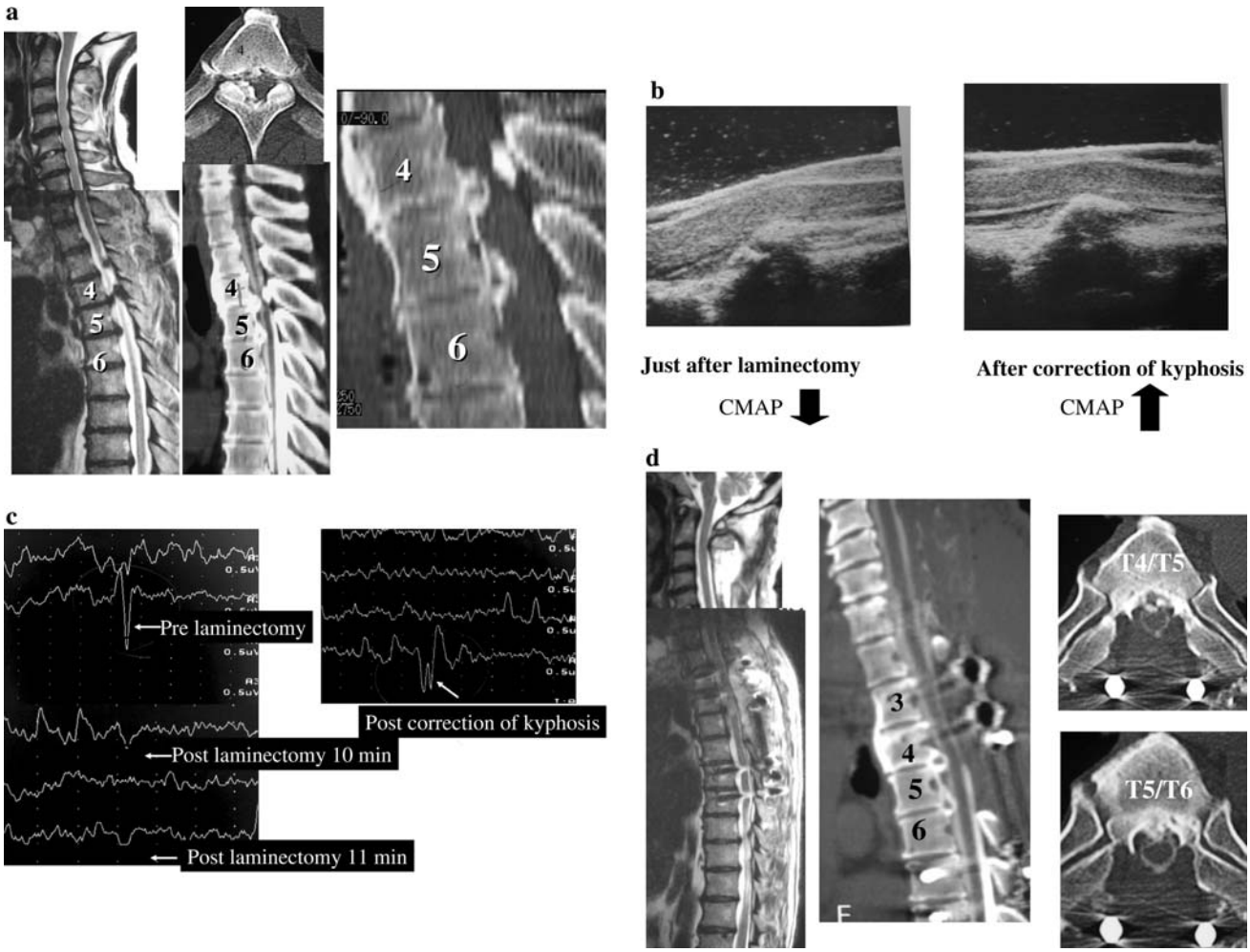

Fig. 2 **a** MRI and myelo CT. Cervical canal stenosis from C3 to C7 and beak-type OPLL of T4/T5 and T5/T6 were detected. Severe spinal compression by OYL and OPLL was noted at T4/T5. **b** Intraoperative ultrasonography after laminectomy and after correction of kyphosis. On ultrasonography immediately after laminectomy, the spinal cord was raised by OPLL in the anterior region. The spinal cord was free from OPLL after correction of kyphosis. **c** CMAP decreased 10 min after laminectomy. Since intraoperative ultrasonography detected that the spinal cord was pushed up by OPLL in the anterior region, kyphosis was corrected rapidly, and indirect spinal decompression was performed. The intraoperative CMAP recovered immediately after the decompression. **d** Spinal cord decompression was sufficient on MRI and myelo CT

reported poor surgical outcomes, and no standard surgical procedure has been established. Since physiological kyphosis is present in the thoracic spine, unlike the cervical and lumbar spine, spinal cord decompression through the posterior approach alone is difficult. Anterior decompression by the anterior approach is also technically difficult because of the presence of adhesion between the dura and ossified ligament, a narrow visual field requiring a longitudinal section of sternum in the upper thoracic area, and the necessity of an anterolateral approach by cost-transversectomy in the middle-lower thoracic region [1, 13, 14, 16]. Tsuzuki [14] reported pan-laminoplasty, namely, laminoplasty to a wide region from the cervical to the thoracic region via the posterior approach to decompress the thoracic spinal cord; Otsuka et al. [11] reported anterior decompression via the posterior approach by laminectomy with transpedicular resection of the OPLL, but postoperative neurological aggravation occurred in some cases with both procedures. We morphologically classified thoracic OPLL into the flat and beak types, and compared the postoperative outcome between the anterior and posterior approaches as well as anterior decompression through the posterior approach in each type. Neurological aggravation after surgery was found in four cases, and the common point was a localized beak shape of ossification [3, 5]. Yamasaki et al. [15] reported a neurological deteriorated case after laminectomy, and the neurological status improved upon stabilizing the fusion using instruments in a second operation.

As causes of neurological deterioration associated with the posterior approach, ossification and adhesion of the ligamentum flavum with the dura, the presence of severe compression of the spinal cord, impairment of the vulnerable spinal cord by laminectomy, and development of thoracic kyphosis by laminectomy, resulting in spinal cord injury, were considered. There are no reports of neurologically aggravated cases wherein the dangerous intraoperative procedure or the period of onset of neurological deterioration was closely investigated. We have been performing wide laminoplasty and correction of kyphosis using instruments via the posterior approach, regardless of the ossification morphology, to indirectly decompress the spinal cord [7]. To prevent damage of the vulnerable spinal cord, CMAP was measured continuously, and when and by what procedure the spinal cord potential was altered was closely investigated [4, 6, 8]. Furthermore, we attempted to predict the postoperative outcome from the condition of spinal cord decompression on intraoperative ultrasonography, but no significant difference was noted between the cases in which the spinal cord free and not free from the OPLL, unlike the findings reported by Tokuhashi et al.[12]. However, the recovery rate was significantly lower in group B in which the potential decreased during surgery. In one patient in group B, the spinal cord was compressed by OPLL in the anterior region on intraoperative ultrasonography, which decreased the spinal cord potential, but immediate decompression of the spinal cord by correction of kyphosis using instruments restored the potential. However, once the potential decreased, such as the decrease in group B, the recovery rate was low, and persistent decrease results in neurological aggravation, as in these patients. Monitoring of CMAP facilitates early check of impairment of the vulnerable spinal cord, and arrest of the decompression procedure until recovery of the potential when instruments for prevention of kyphosis have been placed, or correction of kyphosis acquires indirect spinal cord decompression that prevents permanent spinal cord palsy. Although indirect posterior decompression with corrective fusion using instruments obtained satisfactory outcomes in our study, not all cases achieved good outcomes by this procedure.

Kawahara et al. performed decompressive fusion via the posterior approach as the first step, and when spinal cord decompression on MRI was insufficient at 3 weeks after surgery, they performed anterior decompressive fusion as the second step regardless of the degree of improvement of symptoms, and reported that the outcome was better in the group also treated with anterior decompressive fusion, than in the group treated with posterior decompression with corrective fusion alone [2]. However, the improvement of symptoms was good after the posterior decompression with corrective fusion, designated as the first step by Kawahara et al., in the long-term follow-up in many patients; most patients were satisfied without the second step anterior decompression. We consider the additional application of anterior decompression when improvement of symptoms at 6 months after indirect posterior decompression with corrective fusion is not satisfactory. In any procedure, surgical treatment of thoracic OPLL is difficult. Intraoperative monitoring of CMAP clarified that the spinal cord was already impaired during laminectomy via the posterior approach. Concomitant intraoperative monitoring of CMAP [4, 6, 8, 9] to avoid impairment of the vulnerable spinal cord and corrective posterior spinal fusion with indirect spinal cord decompression is recommendable as a method capable of preventing postoperative neurological aggravation.

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