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Total decompression of the spinal cord for combined ossification of posterior longitudinal ligament and yellow ligament in the thoracic spine

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Summary. One of the causes of hyperostosis in the spinal canal, ossification of the posterior longitudinal ligament (OPLL) combined with ossification of the yellow ligament (OYL) in the thoracic spine, can result in serious myelopathy, leading to sandwich-type compression of the spinal cord from anterior and posterior. For such cases we devised a treatment of total decompression of the spinal cord and intervertebral body fusion. This operation consists of two steps. The first step is designed for posterior and lateral decompression of the spinal cord by removal of the OYL following wide laminectomy. The second step is removal of the OPLL anteriorly for anterior decompression, followed by interbody fusion. As the final procedure of the first step, two deep parallel gutters, covering the extent of the OPLL to be removed anteriorly, are drilled down from the rear into the vertebral body along both sides of the dura. This pretreatment makes removal of the OPLL anteriorly during the second stage much easier, faster, and safer. This operation is lengthy and demanding. However, based on our experience so far, it appears to be a promising surgical procedure.

Zusammenfassung. Die Verknöcherung des Ligamentum longitudinale posterius (OPLL) in Kombination mit der Verknöcherung des Ligamentum flavum (OYL) am Brustwirbel, die als eine Erkrankung der Wirbelkanalhyperostose genannt wird, kann schwere Myelopathie verursachen, die zur Sandwich-Abdrückung des Rückenmarks von der Vorder- und Rückseite aus kommt. Für diesen Fall haben wir uns eine totale Druckentlastungstechnik des Rückenmarks und eine Spondylosynthese (spinal fusion) des Wirbelkörpers ausgedacht. Diese Operationstechnik besteht aus zwei Stufen. Die erste Stufe zielt auf die vordere und laterale Druckentlastung des Rückenmarks, die mit Entfernung des OYL nach der umfangreichen Laminektomie erreicht werden kann. Die zweite Stufe ist die vordere Entfernung des OPLL für vordere Druckentlastung, die durch die Spondylosynthese des Wirbelkörpers erreicht werden kann. Als letztes Verfahren der ersten Stufe werden zwei parallele tiefe Furchen, die bis an den Bereich des OPLL reichen, mit dem Drillbohrer von der Rückseite in den Wirbelkörper entlang den beiden Seiten des dura mater spinalis gebohrt. Diese Vorbehandlung macht die Entfernung des OPLL von stirnseitiger Richtung aus bei der zweiten Stufe noch leichter, schneller und sicherer. Diese Operation nimmt viel Zeit in Anspruch. Jedoch scheint es uns nach unseren vorliegenden Erfahrungen, daß diese Operation ein vielversprechendes Verfahren sei.

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Ossification of the posterior longitudinal ligament (OPLL) and ossification of the yellow ligament (OYL) are the two main causes of spinal hyperostosis, which leads to compressive myelopathy.

In the cervical spine, OPLL is frequently seen and the surgical treatment (posterior decompression and expansive laminoplasty) has been shown to improve neurological deficits [7].

In the thoracic spine, OPLL and OYL are seen separately but occasionally, cases of combined OPLL and OYL also occur. There is no divergence of opinion on the merits of posterior decompression for thoracic OYL, i.e., removal of the ossified tissue following wide laminectomy. On the other hand, the surgical treatment for thoracic OPLL has been controversial, and there is disagreement as to the technique which should be employed: posterior indirect decompression by laminectomy or anterior direct decompression by removal of the ossified ligament. Our experience leads us to support anterior direct decompression.

Severe thoracic myelopathy occurs when OPLL is combined with OYL, sandwiching the spinal cord both anteriorly and posteriorly. There are two opposing opinions on the best treatment for this condition, posterior decompression by removal of the OYL [4] or anterior decompression by removal of the OPLL [5]. However, the results of surgery by either of these procedures alone have not been satisfactory, because the spinal cord is de-

compressed from only one side, leaving ossified tissue on the other side.

Based on our experience with cases of thoracic OPLL or OYL, we felt that total decompression should be performed for combined OPLL and OYL. Here we report on our surgical technique and the clinical results for combined OPLL and OYL in the thoracic spine.

Materials and methods

Materials

Eleven patients with combined OPLL and OYL have been operated on for decompression of the spinal cord during the past 6 years (Table 1). They were four men and seven women, ranging in age from 43 to 67 years (average 55 years). Among these patients the earliest cases (cases 1–4) were treated using posterior decompression (laminectomy) alone. From 1983 on, total decompression has been employed and seven patients have been operated on to date using this technique (cases 5–11). These patients were examined with regard to neurological changes according to our evaluation system during January 1988. The follow-up period was 1–6 years (average 3.2 years).

Evaluation system for thoracic myelopathy

The evaluation system for cervical myelopathy (Table 2) was established by the Japanese Orthopedic Association (JOA) in 1976. To evaluate thoracic myelopathy, this system was modified by excluding the category of the upper extremity (sections I, III-A), so that a full score becomes 11 points.

Surgical technique of total decompression

Preoperative preparation involves first measures to counteract excessive bleeding:

- Prepare cross-match of 3000 ml of blood in case of massive bleeding;
- Place an arterial pressure monitor in the radial artery;
- Intraoperative autotransfusion (blood recovery system).

Then we set up intraoperative spinal cord monitoring (spinal cord evoked potentials: SCEP [1]). The third step is to adjust the surgical microscope.

The surgical procedure consists of two steps, posterior decompression and then anterior decompression.

First step: Posterior decompression with wide laminectomy. The extent of laminectomy includes all the lamina showing symptoms or signs of OYL. In addition, it should include one vertebra above and below the area affected by OPLL. This gives enough room behind the spinal cord to prevent pinching by the remaining lamina edge when the cord, which is still compressed by OPLL, shifts backward following posterior decompression.

The procedure for wide laminectomy is the double-leafed hinged laminectomy that is commonly employed for OYL [4] (Fig. 1a). All the lamina to be removed is erased first with a steel burr and then with a diamond burr, particularly medially, and laterally, until the lamina becomes thin enough to enable the surgeon to see through the affected OYL. OYL is usually located on both sides of the spinal canal, and the median often leaves a slight space. Both median edges of the thinned lamina can be hooked up and aside, and the ossified yellow ligament is carefully dissected from the dura. When the OYL adheres to the dura, the separation should be done under a surgical microscope. This decompression should be performed not only on the posterior side of the dura but also laterally (Fig. 1b).

The next procedure is undertaken as a pretreatment for safe removal of the OPLL anteriorly. This is one of the keys to the

Table 1. Cases of combined OPLL and OYL in the thoracic spine

Case no./age (years)/sex	Levels	Op. (extent)	JOA score		Recovery rate	Follow-up (years)
			Pre-op.	Post-op.		
Posterior Decompression (Laminectomy)						
1. 56/f	OPLL (T11–L2) OYL (T11–L2)	Laminec. T10–L2	3 (1011)	5 (2012)	25%	6.0
2. 62/m	OPLL (C3–T5) OYL (T2–7)	Laminec. C3–T8	2 (0011)	–	–	Died
3. 51/f	OPLL (T2–6) OYL (T7–8)	Laminec. T6–8	4 (1111)	7 (2122)	43	5.5
4. 48/m	OPLL (T5–12) OYL (T11–12)	Laminec. T11–12	7 (2122)	8 (3122)	50	4.5
Total Decompression (Post. & Ant. Decompression)						
5. 43/m	OPLL (T7–8) OYL (T2–12)	Ant. dec. T7–8 Laminec. T6–8	5 (2012)	9 (3123)	67	4.0
6. 51/m	OPLL (T6–7) OYL (T6–7)	Ant. dec. T6–7 Laminec. T6–8	4 (1111)	10 (3223)	86	3.5
7. 59/f	OPLL (T7–9) OYL (T7–12)	Ant. dec. T6–10 Laminec. T7–12	2 (0011)	8 (2123)	67	2.5
8. 53/f	OPLL (T2–10) OYL (T2–12)	Ant. dec. T3–6 Laminec. T2–8	3 (1011)	10 (3223)	87.6	2.0
9. 67/f	OPLL (T10–L1) OYL (T10–12)	Ant. dec. T10–12 Laminec. T9–L2)	2 (0011)	9 (2223)	77.8	2.0
10. 56/f	OPLL (T5–12) OYL (T6–L2)	Ant. dec. T8–12 Laminec. T5–12	5 (2111)	10 (3223)	87.6	1.0
11. 58/f	OPLL (T2–L1) OYL (T5–L1)	Ant. dec. T8–L1 Laminec. T8–L1	2 (0011)	0 (0000)	0	0.5

Table 2. Evaluation system for thoracic myelopathy (only underlined sections are scored)[a]

Section	Score (point)
I. *Upper extremity function*	
Impossible to eat with either chopsticks or spoon	
Possible to eat with spoon, but not with chopsticks	
Possible to eat with chopsticks, but inadequate	
Possible to eat with chopsticks, but awkward	
Normal	
II. *Lower extremity function*	
Impossible to walk	0
Need cane or aid on flat ground	1
Need cane or aid on stairs	2
Possible to walk without cane or aids, but slow	3
Normal	4
III. *Sensory*	
A. Upper extremity	
Apparent sensory loss	
Minimal sensory loss	
Normal	
B. Lower extremity	
Apparent sensory loss	0
Minimal sensory loss	1
Normal	2
C. Trunk	
Apparent sensory loss	0
Minimal sensory loss	1
Normal	2
IV. *Bladder function*	
Urinary retention or incontinence	0
Severe dysuria (sense of retention, straining)	1
Slight dysuria (pollakiuria, retardation)	2
Normal	3

Normal condition = II (4) + III-B (2) + III-C (2) + IV (3) = 11 points

[a] Evaluation of the upper extremity is excluded from the system for evaluating cervical myelopathy, established by the Japanese Orthopedic Association

whole procedure (for reasons given below). Corresponding to the area of OPLL to be removed, the inner part of the intervertebral joints and the pedicles (the lateral side of the dura) are drilled down a further 1 cm into the vertebral body with a diamond burr. Thus, two parallel, deep gutter lines are made on both sides of the dura (Fig. 1c). The lateral edge of OPLL and the dura should be separated as carefully as possible.

This first step of the operation occasionally causes persistent bleeding from the intraspinal vertebral venous plexuses. For hemostasis, careful bipolar coagulation and covering of the gutters and the area of the dura with Oxycel cotton and thrombin are necessary before closing the wound. This first stage of the operation usually takes about 3–4 h and results in blood loss of 1000–1500 ml.

Second step: Anterior decompression and intervertebral body fusion. In collaboration with the anesthesiologists, the patient is rolled and placed in lateral decubitus. Thoracotomy by a transthoracic approach [2] is made at the rib level of the main OPLL. As the posterior third of the vertebral bodies is drilled out with an air burr (Fig. 1d), the two gutters marked in the first step are revealed. These gutters show the width and the extent of OPLL to be removed. As the vertebral bodies are drilled as close as possible to the OPLL, the OPLL whose lateral margin has already been released during the first step becomes movable. This ossified tissue sometimes adheres to the dura, in which case it should be removed under a surgical microscope (Fig. 1e). As the spinal cord is decompressed, it shifts forward due to thoracic convexity. Intradural pulsation becomes visible.

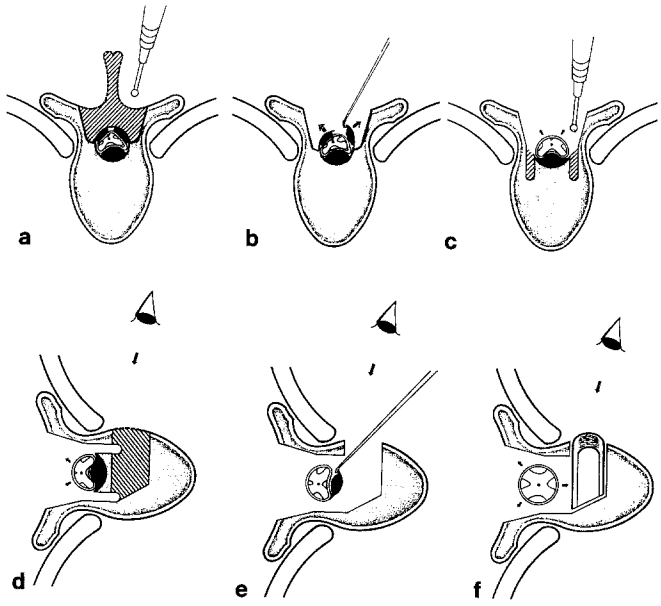

Fig. 1a–f. Total decompression for thoracic myelopathy due to combined OPLL and OYL. **a–c** First step: posterior decompression – wide laminectomy (**a**); resection of OYL to achieve posterior and lateral decompression (**b**); gutter drilling as a pretreatment for OPLL removal (**c**). **d–f** Second step: anterior decompression – partial vertebrectomy (**d**); removal of OPLL to achieve anterior decompression (**e**); anterior interbody fusion (**f**)

SCEP are repeatedly monitored on removal of OPLL. If the amplitude decreases by 30%, the surgeon should be particularly careful to be atraumatic in handling the spinal cord.

A bed for the bone graft is prepared in the vertebra, and a full-thickness, corticocancellous iliac graft is placed and impacted with a tamper to obtain anterior interbody fixation (Fig. 1f). This second stage of the operation usually takes 4 h, and the blood loss is 1000–1500 ml.

The length of time needed for the entire operation is clearly a matter of concern, particularly in view of the delicate surgery required, and at Kanazawa we use different teams for the two steps of the operation.

The patient is allowed to sit or walk with a plastic spinal orthosis 6 weeks after surgery, and this orthosis is discontinued at 3 months, when bone fusion is recognized on the roentgenograms.

Results

When laminectomy alone was used in cases of combined OPLL and OYL, the recovery rates were as low as 25%–50%. These results were below our expectations.

For the past 4 years, we have performed total decompression on seven patients. The maximum extent of decompression was eight laminectomies, followed by five partial vertebrectomies. The recovery rates following total decompression rose to between 67% and 87.6%. In most patients neurological recovery was remarkable, and they were able to walk without a cane within a year.

Case reports

Case 8. A 53-year-old woman had suffered from paresthesia and spastic palsy of both legs for a year (Fig. 2). She visited our hospi-

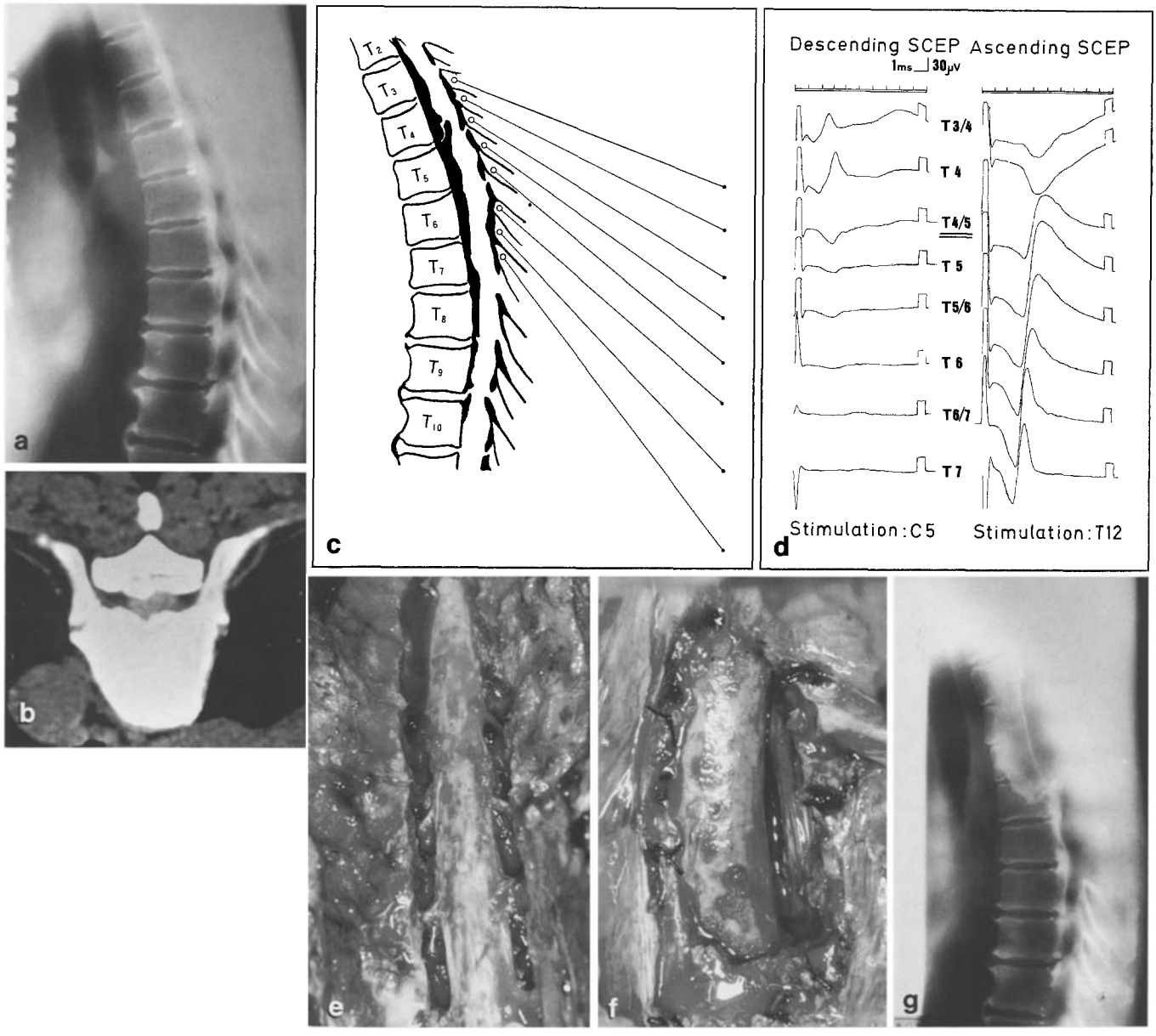

Fig. 2a–g. Case 8, female, 67 years. **a** Tomogram of thoracic spine; **b** CT scan at the level of T4; **c** scheme of OPLL (T2–10) and OYL (T2–12); **d** preoperative SCEP mapping. SCEP showing killed and potential at levels of T4, T5; **e** first step: wide laminectomy and guttar drilling; **f** second step: removal of OPLL and intervertebral body fusion; **g** postoperative tomogram (OPLL of T3–6 was removed and iliac bone was grafted)

tal because she had become incapable of walking and standing, and because dysuria had appeared 4 months previously. The score for thoracic myelopathy on admission was 3/11 points (1 + 0 + 1 + 1) by the JOA score system. The examination revealed that the spinal cord was compressed by OPLL at the level of T2–10 and by OYL at T2–12. It was concluded by SCEP examination that the lesions at T4–5 were primarily responsible for myelopathy. First laminectomy was carried out on the T2–8 vertebrae, and then a deep gutter was drilled in the T3–6 vertebrae. As a second step, OPLL at T3–6 was removed using thoracotomy to decompress the cord anteriorly. The day after the operation, sensation and motion in both legs dramatically improved and the spastic palsy disappeared. One month after the operation, the patient started standing exercises, and she left the hospital walking without any support 3 months after the operation. The JOA score improved from 3 to 10 points during 2 years' follow-up study.

Case 9. The patient was a 67-year-old woman who had suffered from paraplegia for a month (Fig. 3). She had suffered from sensory disturbance affecting both legs for 4 years. Roentgenographic examination revealed OPLL at the level of T10–L2 and OYL at T9–11. Laminectomy of T9–L2 and removal of OPLL affecting T10–12 were carried out. The patient showed remarkable recovery, with the JOA score improving from 2 to 9 points within a year.

In an earlier case of laminectomy alone (case 2), the patient's blood pressure suddenly decreased during the operation. This was due to massive hemorrhage from the intraspinal vertebral venous plexuses during removal of the OYL. The operation was stopped; however, the patient died of cardiac infarction after a few days. Since this case, we have taken particular care to counteract excessive bleeding with the measures described above.

In another patient (case 11) with elongated, multi-level OPLL and OYL of 12 vertebrae, the edge of the untreated OPLL recom-

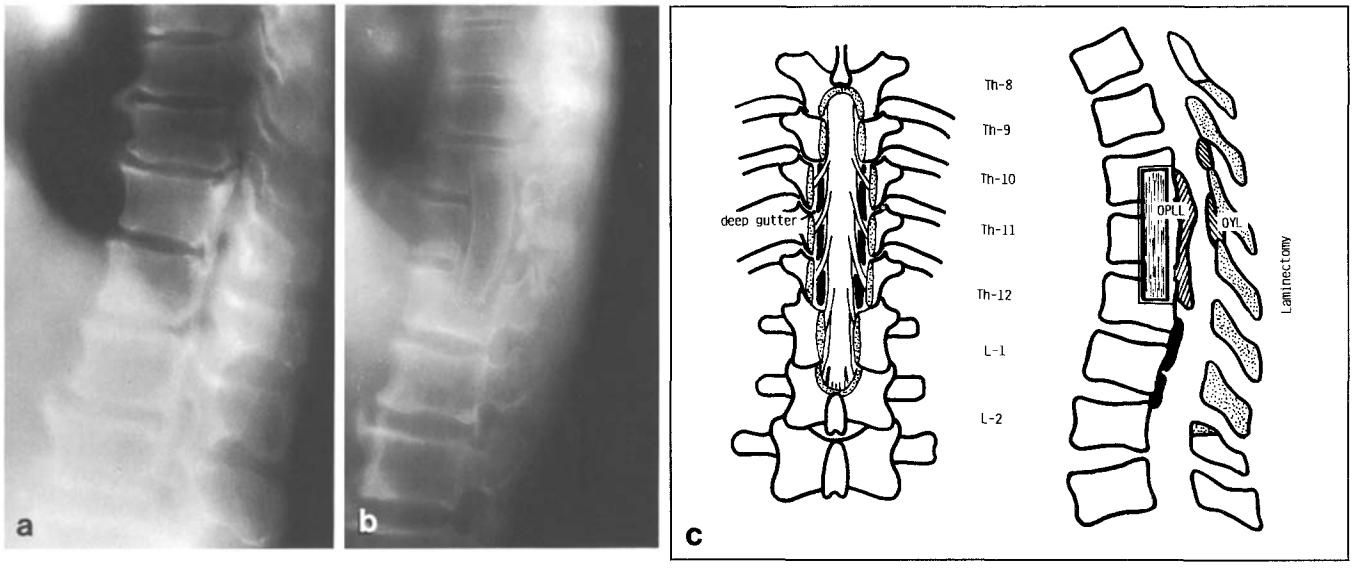

Fig. 3a–c. Case 9, female, 53 years. **a** Tomogram (before operation); **b** tomogram (after operation); **c** scheme of operation

pressed the spinal cord (part of OPLL had to be left untreated, since it is inadvisable to operate on more than six vertebrae because of the danger of irretrievably weakening the spinal column). The patient's neurological deficit became worse, and she is under rehabilitation for paraplegia.

Discussion

It is normal in patients with either OPLL or OYL in the thoracic spine to remove the cause of compression of the spinal cord. OYL can be easily removed by careful, wide laminectomy. OPLL is quite difficult to remove anteriorly and without trauma to the spinal cord, and disagreement exists as to the best procedure. We are of the opinion that anterior decompression is still preferable to posterior decompression, because satisfactory decompression cannot be obtained by performing posterior laminectomy, due to the natural thoracic kyphosis.

In patients suffering from combined OPLL and OYL, spinal cord decompression becomes more difficult. Satisfactory results are not obtained by either posterior or anterior decompression alone, since the part of the spinal cord not operated on will continue to be compressed. In fact, it has been generally accepted that the chance of recovery from this condition is slight [6]. However, there have been several papers discussing potential solutions to this problem. Wide laminectomy to remove OYL alone has been tried [3, 4]. However, this operation revealed two problems. The neurological deficit may partially improve but is unlikely to do so substantially, and it was stressed that the main purpose of this operation was only to prevent further deterioration.

On the other hand, many doctors agree that in cases of combined OPLL and OYL, OPLL on the concave side of the spinal cord appears to be the main cause of neurological disorders. Anterior decompression by removal of the defined extent of OPLL [5] has been performed. The most difficult point of this operation is to approach and to remove the OPLL completely. Sometimes it is technically impossible. Furthermore, if OYL on the other side of the cord is significant, no remarkable recovery will be obtained.

Based on our experience of separate occurrences of OPLL and OYL in the thoracic spine, we assumed that in the instance of combined OPLL and OYL, complete removal of the ossified tissues from both the anterior and posterior sides might theoretically result in as satisfactory a recovery as in cases of either OPLL or OYL alone. We considered that such a procedure would ultimately provide the most atraumatic total decompression for the spinal cord. Thus, posterior decompression was performed as the first step, followed by anterior decompression as the second step.

The major problem of this operation for both the patient and the operating staff is the length of time it takes. One solution may be to divide the operation into two stages, with several days' interval between the two steps. We have not yet tried this, since we are afraid that the spinal cord might be recompressed during this interval.

Another great problem is how easily, safely and completely the OPLL can be removed. Surgeons who have tried to remove OPLL anteriorly will know how difficult this is, due both to the difficulty of estimating the exact extent of OPLL (the surgeon's view is abstructed by the vertebrae) and to the danger of injuring the spinal cord. Unless total decompression is carried out successfully, the spinal cord will continue to be affected by remnants of OPLL.

In an attempt to solve these problems, we drilled a deep gutter from posterior into the vertebral body prior to finishing the first step of the operation (as detailed above). This served two important purposes: the extent of OPLL to be removed was revealed, and the gutters assisted the removal of OPLL later in the operation, since its rim had already been released from the dura.

Conclusion

Total decompression in cases of combined OPLL and OYL has brought greater recovery from neurological deficit in most cases than we had experienced using anterior or posterior decompression alone. This is by no means easy to perform, but we believe it is a radical and potentially rewarding surgical procedure.

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