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ORIGINAL ARTICLE

Anterior surgery in selective patients with massive ossification of posterior longitudinal ligament of cervical spine: technical note

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Abstract
Study design The study includes case series, technical note and review of literature.
Objective The objective of this study was to assess the validity of the radiographic indicator and the result of anterior operation for massive ossification of posterior longitudinal ligament (MOPLL, ossification of posterior longitudinal ligament with an occupying ratio exceeding 50%).
Summary of background data Anterior decompression yielded a better outcome than posterior approach in patients with MOPLL of cervical spine. But anterior surgery has the problem of technically demanding and was associated with a high incidence of surgery-related complications. Many ways for reducing the risk of anterior surgery have been reported, including floating method, employing microscopes or burrs, and laser-assisted corpectomy.
Materials and methods A case series of selective patients with MOPLL of cervical spine undergoing anterior surgery is reported. All patients were strictly selected based on CT images with the appearance of *open-base*. 29 cases with more than 12 months follow-up (average, 31.0 ± 10.0 m) were reviewed. Average age at operation was 59.3 ± 8.2 years (43–73 years). Anterior decompression was done only for one or two vertebrae.
Results One corpectomy was done in 13 cases, two corpectomies in 3 cases, and one corpectomy and one discectomy in 13 cases. Three levels were fused in 16 cases and two levels in 13 cases. No permanent neurological deterioration was observed. Neurological improvement was observed in every patients with an average improvement rate of 64 ± 23%. Mesh migration was observed in one case. A fusion rate of 100% was achieved.
Conclusion Anterior surgery using our technique may be a relatively simple and safe procedure in selective patients with massive ossification of posterior longitudinal ligament of cervical spine.

Keywords Ossification of posterior longitudinal ligament · Surgery · Anterior · Cervical

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Introduction

Massive ossification of posterior longitudinal ligament of cervical spine (MOPLL), ossification of posterior longitudinal ligament (OPLL) with an occupying ratio (OR) exceeding 50%, poses a significant challenge for spinal surgery. The occupying ratio is usually defined as the maximum thickness of OPLL divided by the anterior–posterior diameter of the bony spinal canal on lateral X-ray or axial CT image [3, 12]. As OR grows, the ossified foci indents the spinal cord deeper, and the incidence of dural ossification rises, which results in a high rate of iatrogenic neurological deterioration and cerebrospinal fluid leakage [5, 7]. Although some of these surgical complications are transient, others may be permanent. Serious iatrogenic spinal injury and infection happen rarely, but the consequence is ruinous.

Both anterior and posterior decompression can be applied in the treatment of OPLL. Most reports on surgical results of OPLL described patients with varying degree of OPLL, from subtle to massive ones. Studies focus on

prognosis of MOPLL drew a consistent conclusion that anterior decompression yielded better outcome than posterior approach [11, 16, 23]. But the authors also admitted that the anterior procedure is technically demanding and the skill of the surgeon must be taken into consideration when making the strategy of treatment. Many techniques for reducing complication of anterior surgery have been reported in the literature, including floating method, employing microscopes or diamond-tip burrs, and laser-assisted corpectomy [9, 14, 23]. We selected some patients with special patterns on CT scan, which may be more ideal for anterior decompression, to optimize the surgical result in a relatively safe and simple way. Here we documented a series of 29 patients with the *open-base* appearance on CT axial image, who underwent anterior surgery, using our decompressing techniques.

Case series

Indications for anterior decompression for MOPLL are as follows: (1) maximum OR exceeding 50%, (2) *open-base* appearance on axial CT image. The *open-base* has been defined as both lateral margin of ossified foci is within the posterior cortex of vertebral body and do not reach the pedicle (Fig. 1). (3) Corpectomy was needed in one or two vertebrae. Considering the high rate of non-fusion of three or more level corpectomy, anterior decompression was done only for one or two vertebrae.

From 2002 to 2007, data of 29 selective patients undergoing anterior decompression and fusion, with at least 12 months follow-up were collected and reviewed (Table 1). Lateral roentgenography, CT scan and MRI were taken before and after the operation in each case. OR was measured and calculated based on CT axial image. Neurological function was evaluated by JOA scores pre- and post-operatively. Improvement rate (IR) was defined as, $IR = (\text{postoperative JOA scores} - \text{preoperative JOA scores})/(17 - \text{preoperative JOA scores}) \times 100\%$ [8]. The type of OPLL according to Hirabayashi classification, ossified vertebrae levels and fused levels were also recorded. Fusion was considered with the bridging trabeculae on postoperative CT scan or X-ray image.

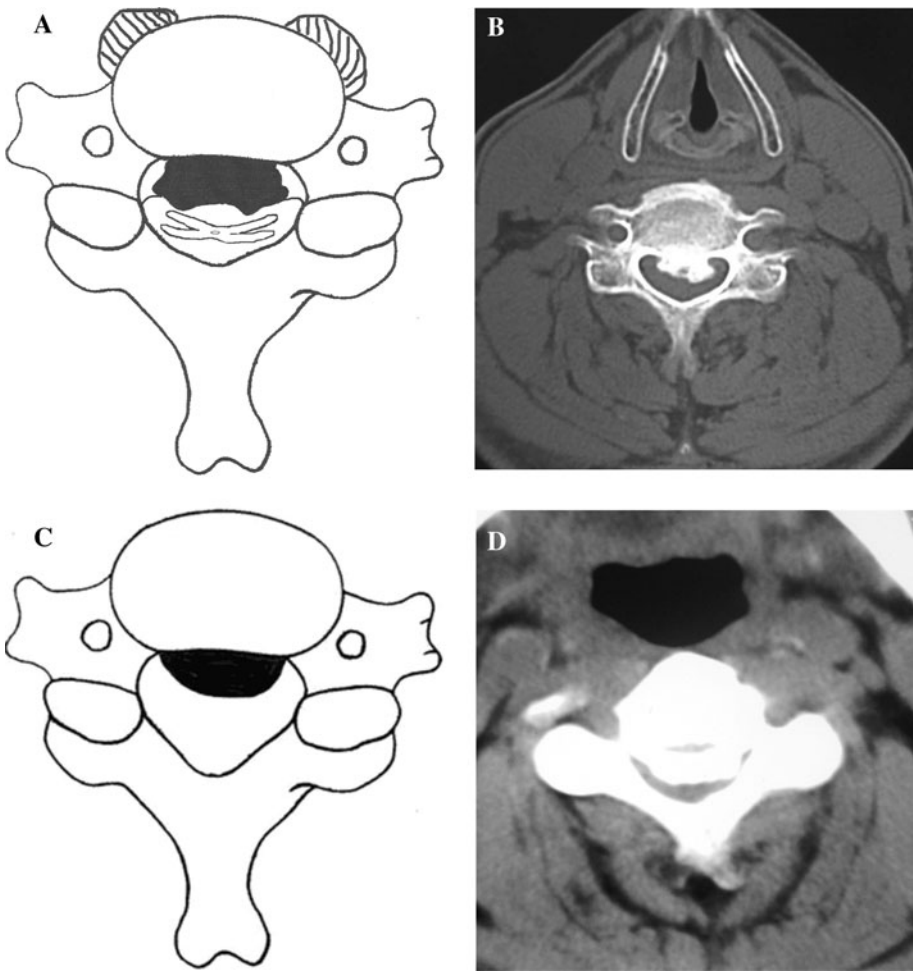

Fig. 1 **a** An illustrative drawing of *open-base* **b** CT appearance of *open-base* OPLL. **c**, **d** The illustrative drawing and CT image of non *open-base* OPLL

Table 1 Case series of patients of MOPLL undergoing anterior decompression and fusion

Cases	Sex	Age	Hirabayashi classification	Combined morbidity	Follow-up period (months)	Preoperative OR (%)	Postoperative OR (%)	Preoperative JOA score	Postoperative JOA	IR (%)	Decompression levels	Number of fused levels
1	m	65	Continuous		36	67	17	9	15	75	C4,C5	3
2	m	55	Mixed		36	54	15	8	16	89	C4,C5/6	3
3	m	70	Segmental		36	83	9	11	16	83	C6,C4/5	3
4	f	50	Other	DM	24	57	0	8	11	33	C6	2
5	m	62	Segmental	DM	30	75	15	6	14	73	C7,C5/6	3
6	m	48	Continuous		42	66	14	8	14	67	C4,C5	3
7	m	73	Segmental		30	65	10	8	13	56	C5	2
8	f	44	Other		12	85	0	12	17	100	C5	2
9	f	47	Mixed		24	58	0	6	11	45	C6,C4/5	3
10	f	60	Mixed		30	80	8	6	13	64	C6,C4/5	3
11	m	65	Segmental		32	71	9	7	15	80	C6	2
12	f	68	Continuous		36	59	12	7	11	40	C5,C3/4	3
13	m	68	Continuous		32	78	13	7	15	80	C5,C6/7	3
14	f	55	Other		48	73	14	11	12	17	C5	2
15	m	56	Segmental		24	60	10	9	13	50	C6	2
16	m	62	Other	HP	36	75	13	12	13	20	C4	2
17	f	52	Mixed		12	56	5	9	12	38	C5,C3/4	3
18	m	57	Other		18	56	0	12	16	80	C5	2
19	m	43	Continuous	DM	30	50	17	5	10	42	C5,C3/4	3
20	m	67	Other		18	52	15	7	16	90	C5	2
21	m	72	Continuous	HP	30	80	14	8	16	89	C5,C6	3
22	m	59	Mixed		48	78	7	8	16	89	C6,C4/5	3
23	m	67	Continuous		24	53	15	7	16	90	C6,C4/5	3
24	m	58	Segmental		36	77	12	10	14	57	C6	2
25	m	59	Continuous		48	74	15	9	14	63	C5,C3/4	3
26	m	66	Segmental		24	68	8	10	15	71	C5	2
27	m	58	Other		24	64	12	5	13	67	C4	2
28	m	62	Continuous		30	59	13	6	14	73	C6, C3/4	3
29	f	53	Other		48	79	5	10	12	29	C6	2

C4, *C5*, *C6*, and *C7* means a corpectomy at the corresponding level, respectively; while *C3/4*, *C4/5*, *C5/6* and *C6/7* means a discectomy at the corresponding level, respectively. One corpectomy was done in 13 cases, two corpectomy in 3 cases, and one corpectomy and one discectomy in 13 cases

DM diabetes mellitus, *HP* hypertension

Operative technique

A standard approach with a vertical or transverse incision was used. After discectomies at the appropriate levels, corpectomy was performed by the extent of neurological involvement and CT reconstruction image. Transverse decompression width was larger than the width of OPLL base, while not offending the vertebral artery. The rongeur or burr was used to slightly thin the posterior vertebral wall and the ossified mass to facilitate further decompression. A special 90° angled micro dissector was inserted through disc level to confirm the position of the lateral margin of OPLL (Fig. 2a). Then a 1 mm Kerrison rongeur was used to divide OPLL at lateral margin joining with the posterior cortex of the cervical vertebrae (Fig. 2b). When dividing OPLL at the other lateral margin, the micro dissector was used to hold the partly floated ossified mass to prevent it from turning over, causing unintended hurt of spinal cord (Fig. 2c). In rare condition that the ossified mass slightly adhere to the dura, the ossified foci could be lifted and removed as a whole after releasing from dura using the micro dissector. In most cases, the ossified mass was

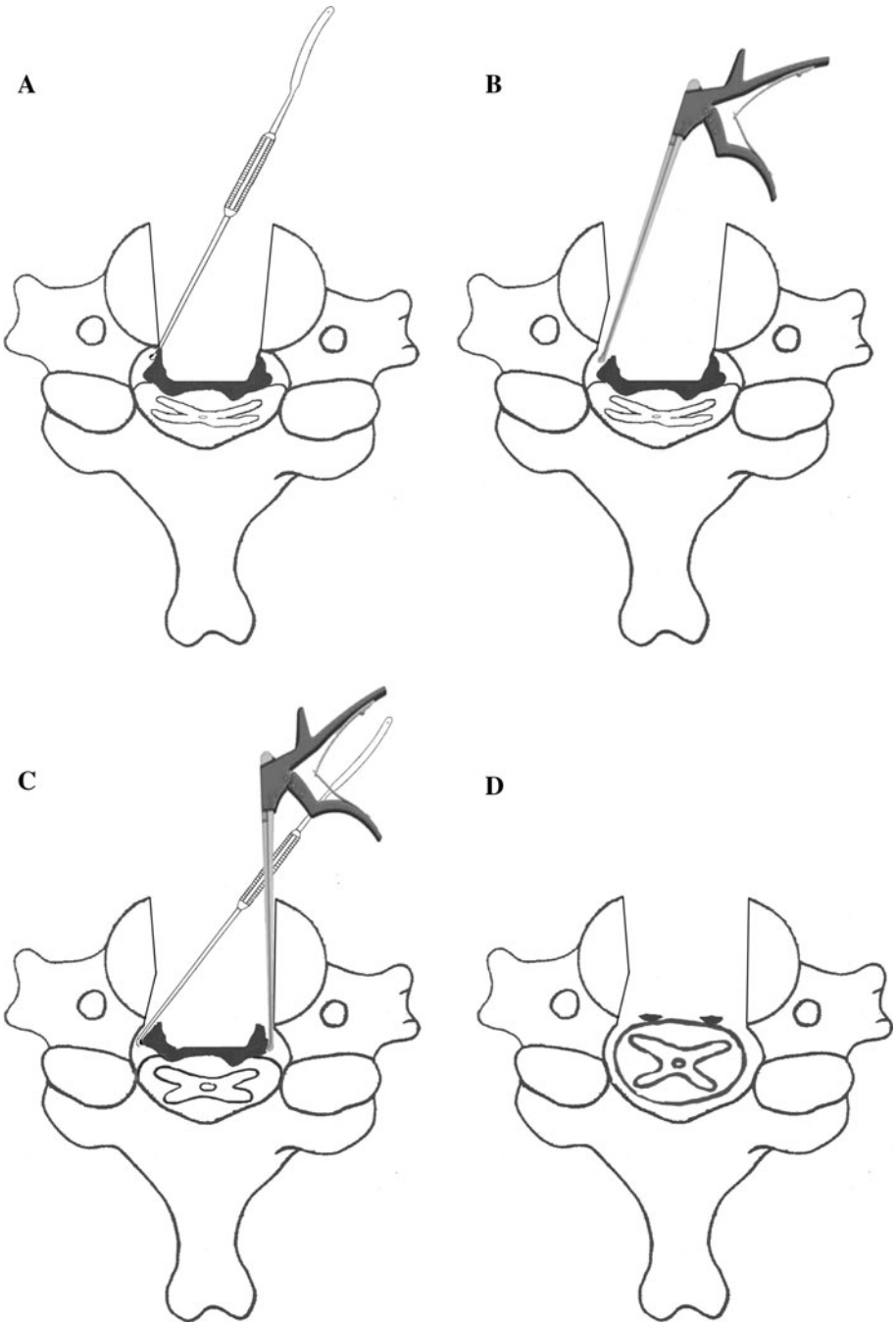

Fig. 2 Micro dissector was inserted at disc level to confirm the position of the margin of OPLL (**a**), then OPLL was separated from the posterior cortex of the vertebrae by Kerrison rongeur (**b**). Micro dissector was used to hold the partly floating bony mass while removing it piece by piece (**c**). Bone islands were left when there were strong adherence or the dura is ossified (**d**)

removed piece by piece, in a lateral–medial direction, using a 1 mm Kerrison rongeur. Micro dissector was always used to hold the partly floating bony mass on the other side. As the ossified mass partly floated, more space was provided for the use of instruments. If part of ossified mass strongly adhered to the dura or the dura itself was ossified, bony island was left (Fig. 2d). Cage or tricortical iliac crest was used for arthrodesis. Anterior constrained plate was generously used.

The patients were allowed to walk with a Philadelphia collar next day after surgery. The hard collar was used for 6–8 weeks, depending on the patient's general condition and the surgeon's experience.

Results

In this series, there were 8 females and 21 males (Table 1). Average age at operation was 59.3 ± 8.2 years, ranged from 43 to 73 years. Type of OPLL was distributed as follows: continuous (9 cases, 31%), segmental (8 cases, 28%), mixed (5 cases, 17%), and others (7 cases, 24%). Combined morbidity included diabetes mellitus in 3 cases and hypertension in 2 cases. A mean follow-up period of 31 months (31.0 ± 10.0 months, ranging from 12 to 48 months) was obtained. All patients in this series got neurological improvement. Mean JOA score increased significantly after operation (8.3 ± 2.1 to 13.9 ± 1.9). The average IR was 64 ± 23%. Meanwhile, OR decreased from 67.3 ± 10.6% to 10.2 ± 5.3% (Table 2, Fig. 3). One corpectomy was done in 13 cases, two corpectomies in 3 cases, and one corpectomy and one discectomy in 13 cases. Three levels were fused in 16 cases and two levels in 13 cases. The mean of fused levels was 2.6 (Table 1). Five complications (17%) were observed. Four complications were minor. There were 2 cases (7%) of slight cerebrospinal fluid leakage that cured in 2 weeks without additional treatment. Transient minor neurological deterioration happened in two cases (7%) with diabetes mellitus, which presented soon after operation and diminished within 3 days. One case (3%) presented dyspnea and neurological deterioration caused by subcutaneous and epidural bleeding, which was cured by reopening the incision, later closure and intensive care, without any residual complication. Migration of a mesh-cage in one patient with a 2-level corpectomy reconstruction was recognized on a routine radiograph at 2 months follow-up (Figs. 4, 5). However, the patient did not reveal symptoms and as there were no signs of gross construct instability, the patient was observed and finally fusion was achieved (Fig. 6). No patients received second operation during the entire follow-up period. A fusion rate of 100% was achieved.

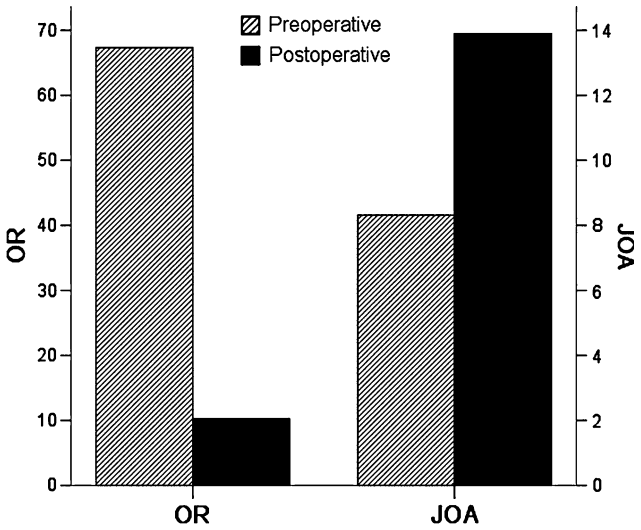

Fig. 3 Postoperative OR decreased significantly, while JOA score increased with statistical means

Discussion

There are still some controversies over the treatment of OPLL. Due to relatively simple procedure, simple technique demanding and low complication rate, posterior approach was preferred by most of the surgeons [10, 17]. Anterior approach has the advantage of better outcome and long-term benefit, especially in MOPLL [1, 15, 22, 23, 26]. A recent study reported that maximum improvement rate of anterior decompression was 64% and final follow-up improvement rate was 54% in patient with MOPLL, while maximum improvement rate of laminoplasty was only 34% and final follow-up improvement rate was 14% [11]. Other authors reported a similar mean improvement rate after decompression and fusion for MOPLL, 58–68.4% in anterior group and 13–52.5% in posterior group [16, 23]. These results may explain why many authors recommended anterior approach to laminoplasty or laminectomy, even with higher incidence of surgery-related complications.

Table 2 Average OR, JOA score and IR (Mean ± SD)

	Occupying rate (%)	JOA score	Improvement rate
Before operation (range)	67.3 ± 10.6 (50–85)	8.3 ± 2.1 (5−12)	–
12 m follow-up (range)	10.2 ± 5.3* (0–17)	13.9 ± 1.9* (10–17)	64 ± 23% (17–100%)

* $P < 0.01$, compared with the data before operation using the student t test

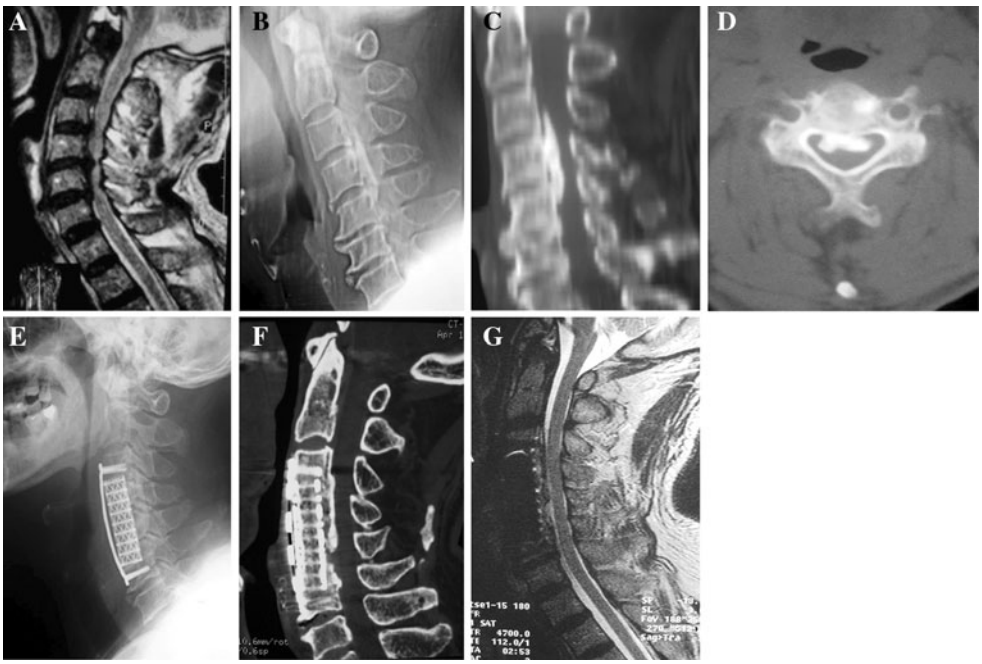

Fig. 4 A 65-year-old male suffered from severe paresis and numbness in extremities. JOA score was 9 before surgery. Preoperative MRI showed severe spinal cord compression at C3–C6 (**a**). The preoperative X-ray and 3-D CT reconstructive image showed a massive OPLL with an occupying rate of 67% (**b**, **c**). Axial CT image demonstrated *open-base* ossification (**d**). The patient underwent an anterior decompression with 2 level corpectomy and fusion with a mesh (**e**). Tomogram 3 years after operation shows ossified mass had been removed, and solid fusion was achieved (**f**). No compression of spinal cord was noted on MRI T2 midsagittal image (**g**). JOA score after operation was 15

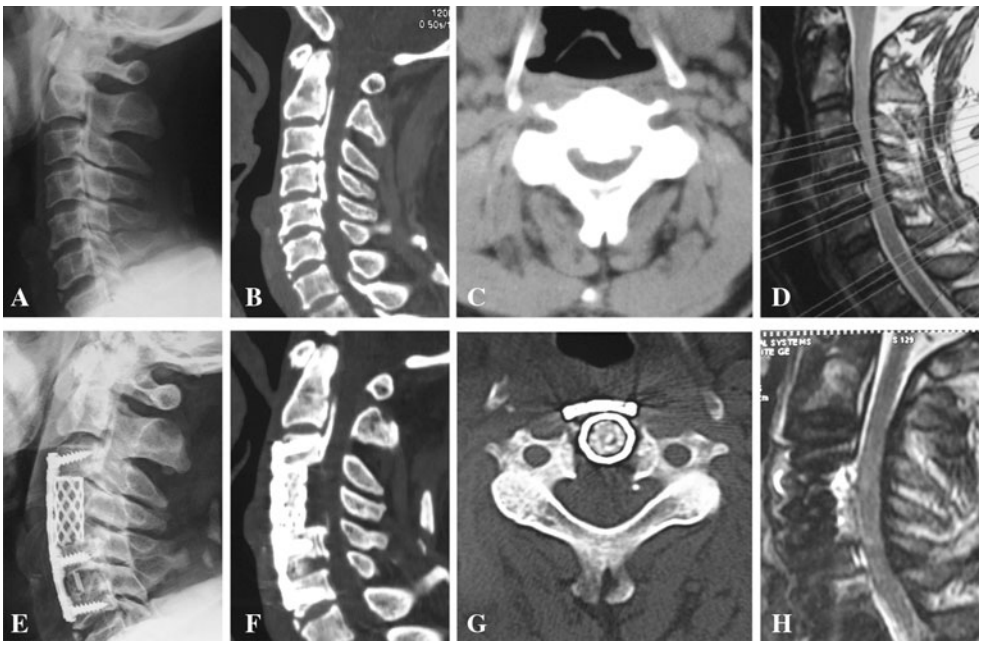

Fig. 5 A 55-year-old male patient complained of numbness in extremities and trunk with rapid progression of paresis in extremities. Plain radiological examination and preoperative 3-D CT image showed OPLL of mixed type from C2 to C6 with an OR of 54% (**a**–**c**). MRI demonstrated spinal cord compression at C3/4, C4/5, and C5/6 (**d**). Corpectomy at C4 and discectomy at C5/6 were performed (**e**, **f**). OR was 15% postoperative (**g**). No compression of spinal cord was noted on MRI after operation (**h**). JOA score was 8 preoperative and 16 1 year after operation

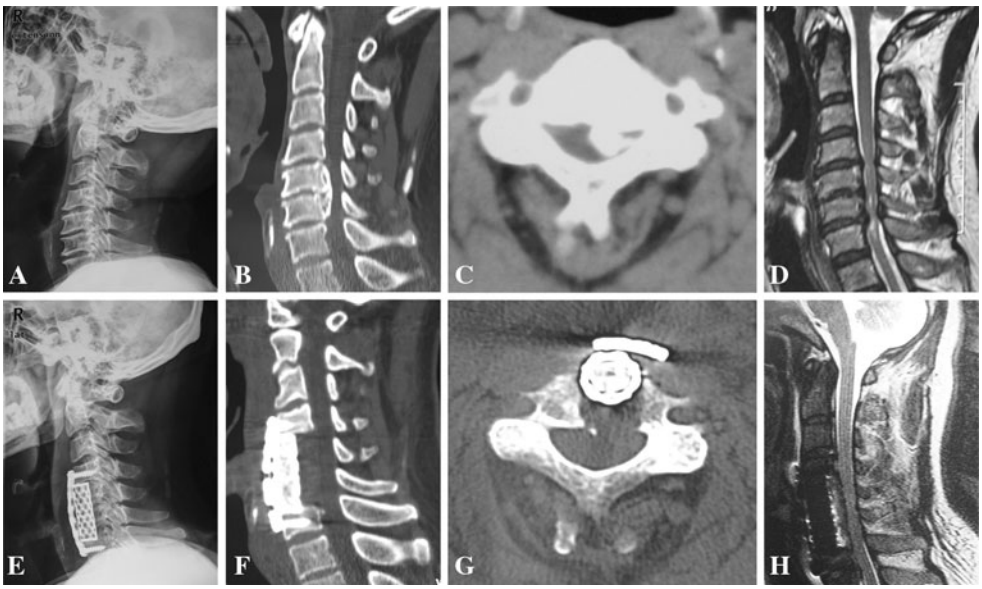

Fig. 6 A 72-year-old male patient presented incomplete paralysis after a slight fall. 3-D CT image showed a big bony mass at C5 and C6. OR was 80% (**a**, **b**, **c**). Corpectomy of two vertebrae was done. X-ray examination 2 months after operation demonstrated the mesh located at anterior part of vertebrae (**e**). The patient was closely followed-up and no further movement of the mesh was observed. CT scan showed fusion 1 year after operation (**f**). Showed OR was 14% after operation (**g**). Preoperative MRI (**d**) and postoperative MRI (**h**) demonstrated that spinal cord compression was relieved

Among all the complications relating to cervical anterior decompression and fusion, iatrogenic neurological deterioration is prominent in patients with OPLL. The early reports of anterior decompression for OPLL have suggested that the procedure was fraught with severe iatrogenic deterioration of neurological state [18, 21, 27]. Studies suggested a reduction in neurological deterioration in different operative techniques [19, 23], employing microscope and diamond-tip burrs [9, 23], or using laser-assisted equipment [14]. Recent studies reported case series undergoing anterior decompression and fusion with no neurologic complication in OPLL of all degrees [4, 13], and neurological deterioration rate of 0–7% in anterior procedure for MOPLL [2, 11, 23]. In this series, decompression in selective patients of *open-base* MOPLL did not further reduce the incidence of neurological deterioration. However, all cases of neurological deterioration were minor and transient.

Though good result of anterior surgery for MOPLL has been accomplished in recent studies, it is repeatedly emphasized in these reports that skill of surgeons must be taken into consideration. As the experience and skill of surgeons could not be duplicated, we looked for the type of MOPLL which may be more ideal for anterior procedure with corresponding surgical technique. The anatomical nature of *open-base* OPLL provided a space for instrument entrance for cutting ossified foci without further compressing the already compromised spinal cord, promising a real no-touch technique. In classic floating method for cervical anterior decompression, thinning ossified mass is the most dangerous and skillful part, which asks for precisely even and extremely thinning without perforation [9]. While utilizing the character of *open-base* OPLL in our way, such a skillful thinning part was not needed. Maneuvers of our technique are same to ordinary decompression in cervical spondylosis which are familiar to spine surgeons.

As a technique, our way of decompression could be combined into any strategy for OPLL containing anterior procedure in indicated patients. In our practice, anterior decompression extent was made based on neurological involvement and radiographic examinations. Corpectomy was limited in one or two vertebrae if possible, for postoperative stability of corpectomy is poor and the instability grows when more segments are evolved, even when anterior plate was used [6, 20, 24]. Anterior corpectomy of three- or four-vertebrae was also performed using this technique in few cases which needed. It was not concluded for incomplete data. Experience for corpectomy of long extent is needed to be accumulated in further practice.

Conclusion

MOPLL poses a significant challenge for spinal surgery. While anterior decompression and fusion demonstrated a great benefit in neurological recovery in MOPLL, every effort should be made to facilitate its application and reduce the morbidity associated with the procedure. In our series, decompression in selective patients of *open-base*

MOPLL did not further reduce the incidence of neurological deterioration. However, all cases of neurological deterioration were minor and transient. As the procedure of our technique is simple and familiar to spine surgeons, it may help to win good results in indicated cases of MOPLL with low risk.

Conflict of interest None of the authors has any potential conflict of interest.

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