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Technical Note

Anterior pedicle screw fixation for multilevel cervical corpectomy and spinal fusion

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Summary

Background. Prevention of graft dislodgement in multilevel cervical corpectomy and fusion has been an unresolved problem. Anterior plate fixation has a significant failure rate. External support with a halo-vest is uncomfortable for patients. In the present study, we report a new surgical technique of anterior pedicle screw (APS) fixation for multilevel cervical corpectomy and spinal fusion, and describe the safety and utility of the system.

Method. After cervical corpectomy, the pedicles on the right side were visualised under oblique fluoroscopy. Guide wires were inserted into the pedicles from the inner wall of the excavated vertebral body until they were hidden in the pedicles. After a fibula autograft was placed, the graft was penetrated in the reverse direction by the guide wires. After drilling and tapping, cannulated screws were inserted into the pedicles through the grafted fibula along the guide wires.

Findings. In 9 patients with cervical myelopathy, the surgery was accomplished with a fibula autograft using APS fixation. A total of 22 APSs were inserted, and 21 screws were placed precisely in the pedicles. There were no neurovascular complications. Patients were allowed to ambulate without a halo-vest on the second day after the surgery. Post-operatively, no dislodgement of the grated fibula occurred, and all patients improved neurologically.

Conclusions. The insertion of APSs is feasible and safe. APS fixation enables us to obtain rigid fixation anteriorly, and we propose that APS fixation is an attractive option for multilevel cervical corpectomy and fusion.

Keywords: Pedicle screw; anterior surgery; cervical spine; corpectomy; vertebral artery.

Introduction

Previous reports have shown that surgical outcomes of multilevel cervical corpectomy with spinal fusion are superior to those of laminoplasty in patients with cervical myelopathy, especially when the alignment of the cervical spine is kyphotic, and the spinal cord is severely compressed anteriorly [16, 20, 25, 26, 29].

Previous studies have shown that such problems as post-operative neck pain and stiffness, are less prominent after multilevel cervical corpectomy with spinal fusion when compared with those after laminoplasty [8, 15, 28].

Despite pre-operative information showing good surgical outcomes associated with anterior surgery, many patients (especially elderly patients) have selected posterior surgery [20]. The major reason for this selection is that the post-operative course of anterior surgery is often complicated. In particular, prevention of graft dislodgement in multilevel cervical corpectomy with spinal fusion has been an unresolved problem. Anterior plate fixation has a significant failure rate [5, 23, 27]. External

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support with a halo-vest decreases the dislodgement of the grafted bone, but application of the support is uncomfortable for patients [20]. Anterior and posterior plate fixation increases the stability of the constructs [6, 24], but requires a longer anaesthesia and is very laborious, including a change of the patient's surgical position.

We previously reported data showing the safety of anterior pedicle screw (APS) insertion in the cervical spine in an experimental study using cadavers (presented at the 19th annual meeting of the Cervical Spine Research Society-European Section, 2004). Based on those results, we began investigating the clinical application of APS fixation for multilevel cervical corpectomy with spinal fusion. In the present study, we describe the operative technique of APS fixation and report on its outcome.

Materials and methods

Patient population

From June 2004 to June 2006, 9 patients with cervical compression myelopathy underwent multilevel cervical corpectomy and spinal fusion with an autologous fibula graft using APSs (Table 1). The patients included 7 males and 2 females (average age at time of surgery = 56.3 years; range, 40–71 years). The average follow-up period was 16 months (range, 6–25 months). The cause of myelopathy were classified as ossification of the posterior longitudinal ligament (OPLL) in 4 patients, cervical spondylotic amyotrophy in 2, multilevel cervical disc herniation in 2, and cervical disc herniation accompanied by canal stenosis in the other patient. The fusion level was C3–C7 in 4 patients, C4–C7 in 3, C3–C6 in 1, and C5-T1 in 1.

Surgical technique of anterior pedicle screw fixation

As a representative example, we describe the surgical procedures for a patient (Number 3, Table 1), who underwent corpectomy of C5 and C6 and a fibula autograft fixed with APSs through the right C5 and C6 pedicles. The patient was placed in the supine position, and the patient's head was fixed with Mayfield's three pin system. With the patient in this position, we could obtain enough working space for surgery at the patient's nuchal area. Draping was performed so that the anterior and posterior aspects of the patient's neck were contained to the operative field.

Pre-operatively, we set the fluoroscopy angle at approximately 45° oblique to the floor and along the axis of the pedicles of C5 and C6. With such oblique fluoroscopy, we could detect the round-shaped cortex of the C5 and C6 pedicles on the right side of the cervical spine clearly.

A transverse collar incision of approximately 8 cm was made at the left side of the neck. The surgical approach extended along the esophagus and left carotid sheath, and the anterior aspect of the cervical vertebrae was exposed. After discectomy of C4/5, C5/6 and C6/7, cervical corpectomy of C5 and C6 was performed. Decompression of the spinal cord was confirmed by intraoperative spinal ultrasonography.

At the caudal aspect of C4 and the cranial aspect of C7, the endplate was removed by an air drill, and a graft bed for the strut fibula was prepared. The length required for the strut bone was measured. A piece of the left fibula was harvested from the patient's leg and prepared as a free strut graft to the site of corpectomy.

The right C6 pedicle was visualsed under oblique fluoroscopy. A guide wire, with both ends sharpened, was inserted into the pedicle from the inner wall of

Table 1. *Summary of data for 9 patients who underwent surgery with anterior pedicle screw fixation*

Case no.	Age (y)/ gender	Diagnosis	Fusion level	APS level	Follow-up period (mo)	JOA score		Solid graft union/period (mo)
						Before surgery	At follow-up	
1	44/M	OPLL	C4–C7	C5, C6	25	7.5	15	yes (12)
2	50/F	CDH&CS	C3–C6	C4, C5	24	12	16.5	yes (9)
3	64/M	CSAM	C4–C7	C5, C6	24	14.5	15.5	yes (14)
4	48/M	OPLL	C3–C7	C4, C5*, C6	18	1	7.5	yes (15)
5	40/M	MCDH	C4–C7	C5, C6	18	n.d.	n.d.	yes (12)
6	71/F	MCDH	C5–Th1	C6, C7	12	6	12	yes (12)
7	57/M	CSAM	C3–C7	C4, C5, C6	12	13	17	not yet
8	66/M	OPLL	C3–C7	C4, C5, C6	9	8	13.5	not yet
9	67/M	OPLL	C3–C7	C4, C5, C6	6	13	15	not yet

APS Anterior pedicle screw, *JOA* Japanese Orthopaedic Association, *OPLL* ossification of the posterior longitudinal ligament, *CDH&CS* cervical disc herniation and canal stenosis, *CSAM* cervical spondylotic amyotrophy, *MCDH* multilevel cervical disc herniation, *n.d.* not detected.

* The screw penetrated the lateral wall of the pedicle.

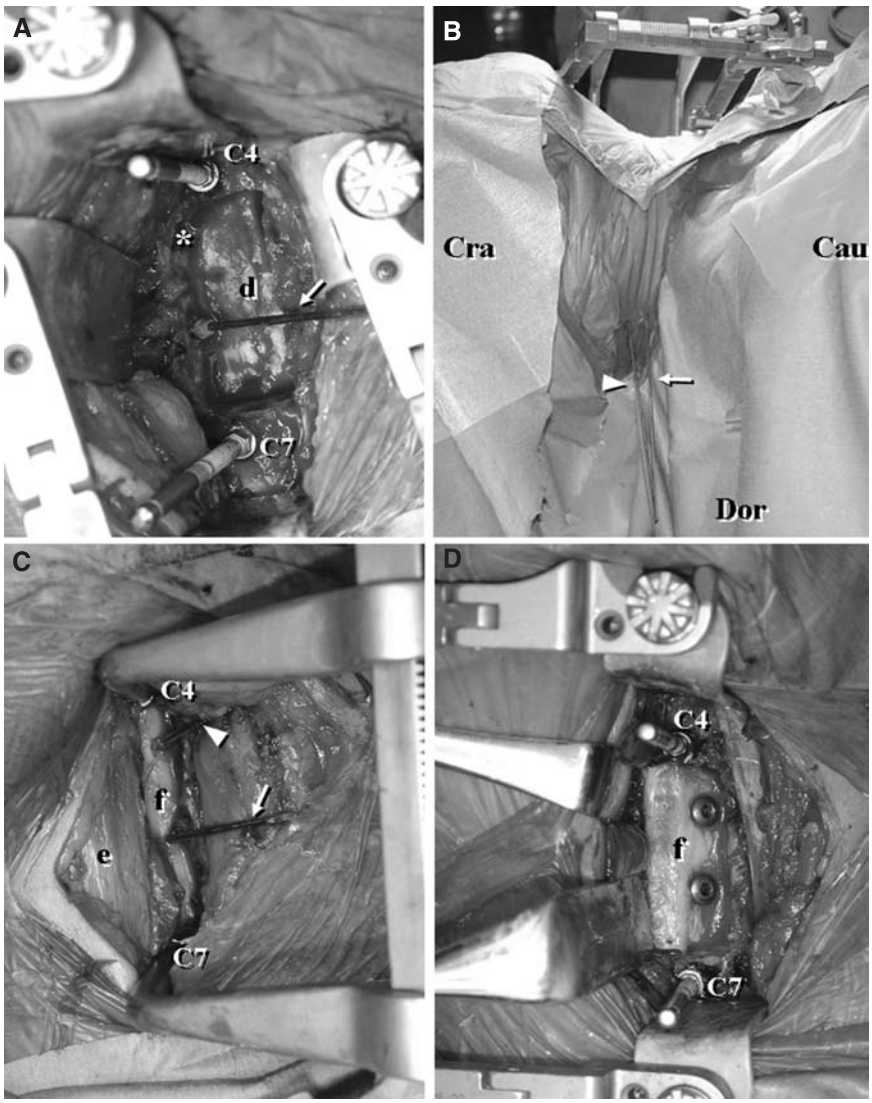

Fig. 1. Intra-operative photographs showing the process of anterior pedicle screw fixation for C5–C6 corpectomy and C4–C7 spinal fusion in a patient with cervical myelopathy (Patient 3). After corpectomy of C5 and C6, the right C6 pedicle was visualized under oblique fluoroscopy. (A) A guide wire (*arrow*) was inserted into the right C6 pedicle from the inner wall of the excavated vertebral body. The asterisk indicates the insertion point of the C5 pedicle screw. *d* Dura mater. (B) Guide wires were inserted deeply until they were hidden completely in the C5 and C6 pedicles. At this stage, the guide wires pass through the C5 pedicle (*arrowhead*) and the C6 pedicle (*arrow*) perforated the skin at the posterolateral area of the neck. The cranial side (*Cra*), caudal side (*Cau*) and dorsal side (*Dor*) of the patient are indicated. (C) After a fibula autograft (*f*) was placed, the graft was penetrated in the reverse direction by the guide wires through the C5 pedicle (*arrowhead*) and the C6 pedicle (*arrow*). *e* Esophagus. (D) After drilling and tapping, cannulated screws were inserted into the C5 and C6 pedicles through the grafted fibula (*f*) along the guide wires

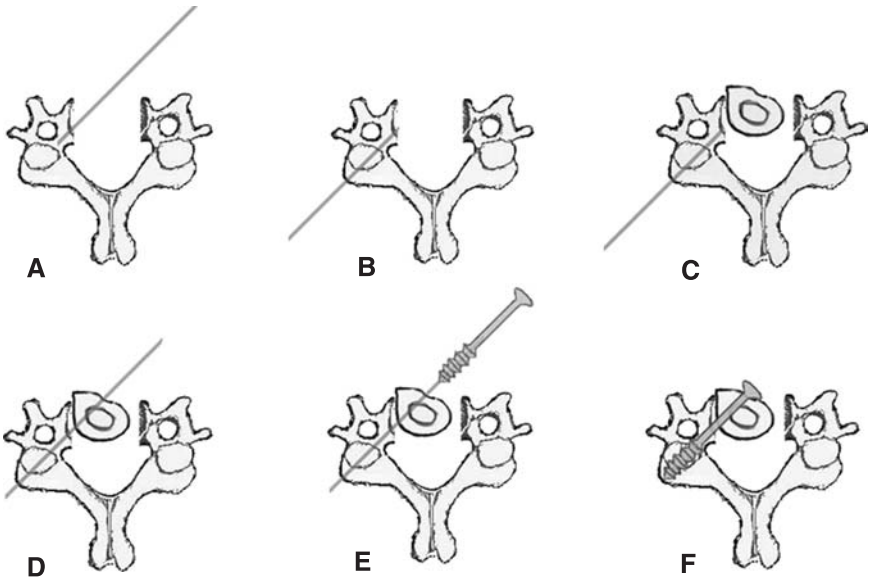

Fig. 2. Schematic drawings (A–F) showing the process of anterior pedicle screw fixation for multilevel cervical corpectomy and fusion

the excavated vertebral body under fluoroscopic guidance (Figs. 1A and 2A). It was inserted deeply, until it was hidden completely in the pedicle (Fig. 2B). At this stage, the guide wire perforated the skin at the posterolateral area of the neck (Fig. 1B). Another guide wire was placed similarly at the right C5 pedicle. The fibular autograft was tapped gently into place without interference by the guide wires (Fig. 2C). The graft was penetrated in the reverse direction by the guide wires (Figs. 1C and 2D). After drilling and tapping, a cannulated screw was inserted into the C6 pedicle through the graft along the guide wire (Fig. 2E, F). The length of the screw was determined pre-operatively by measuring the axial CT images. Similarly a screw was inserted at C5 (Fig. 1D).

On the second day after surgery, the patient was allowed to ambulate with a Philadelphia collar. At 6 weeks after surgery, a soft collar was used instead of the Philadelphia collar, and at 8 weeks after surgery, the soft collar was removed.

Clinical assessment

The Japanese Orthopaedic Association (JOA) scoring system was used to evaluate the severity of cervical myelopathy [20]. In 8 patients, the JOA scores before surgery and at the final follow-up after surgery were evaluated, and the recovery rate calculated. In patient 5, it was difficult to evaluate sensory and motor loss precisely, because the patient was mentally retarded.

Radiographic assessment

Accuracy of the insertion of the APSs was evaluated with CT reconstruction images. We determined that

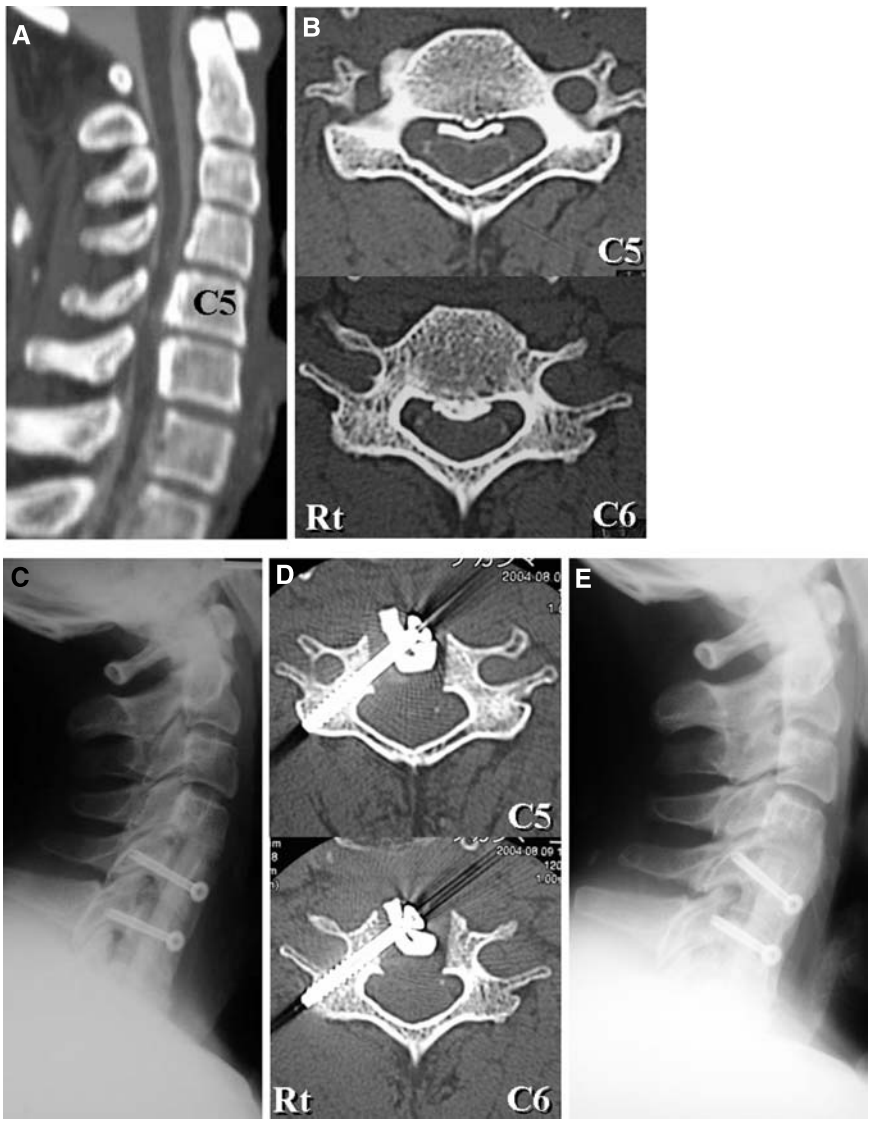

Fig. 3. Pre-operative midsagittal reconstruction image (A) and axial images at the C5 and C6 pedicles (B) of a CT myelogram of a 44-year-old man (Patient 1) showing OPLL at C4–C6 with compression of the spinal cord anteriorly at C5–C6. Post-operative lateral radiographic image (C) and axial views of CT (D) two weeks after surgery, indicating that the screws were inserted accurately through the grafted fibula autograft and the C5 and C6 pedicles. A lateral radiographic image two years after surgery (E), showing complete spinal fusion at C4–C7

the graft union was complete when intersegmental mobility within the fused segment was absent. A solid fusion was defined as ≤ 1 mm of change between flexion and extension radiographs in the interspinous distance across a grafted segment and by continuous osseous trabeculation at the site of the arthrodesis.

Results

A total of 22 APSs was inserted in this series. Among them, 21 screws were inserted precisely in the pedicles, and 1 screw perforated the lateral wall of the pedicle (C5 of patient 4). Thus, the pedicle perforation rate in this series was 4.5%. There were no neurovascular complications.

All 9 patients improved neurologically. The mean JOA score was 9.4 points before surgery and 14.0 points at the final follow-up, and the mean recovery rate was 64.4%.

There was no loosening or dislodgement of screws. No displacement of the grafted fibula occurred. Among 7 patients who were followed for more than 1 year after surgery, solid spinal fusion was detected in 6. The mean time to solid spinal fusion was 12.3 months (range, 9–15 months) after surgery.

Clinical presentations

Patient 1

A 44-year-old man presented with bilateral numbness in his upper and lower extremities and a spastic gait. The pre-operative JOA score was 7.5/17 points. Radiological examinations with CT myelogram and MR images showed C4–C6 OPLL associated with compression of the spinal cord anteriorly at C5–C6 (Fig. 3A, B).

At surgery, we first performed corpectomy of C5 and C6, extirpated the OPLL, and decompressed the spinal cord. We then harvested the fibula from his left leg and grafted it between C4 and C7. We inserted two APSs through the grafted fibula and the right C5 and C6 pedicles. Post-operative radiographs and CT images confirmed that the screws were inserted accurately through the pedicles (Fig. 3C, D), and no dislodgement of the grafted fibula was seen. At the final follow-up of 25 months, the patient's JOA score was 15/17 points (recovery rate: 79%), and complete spinal fusion was confirmed (Fig. 3E).

Patient 2

A 50-year-old woman presented with bilateral numbness and clumsiness in her hands. Her pre-operative JOA score was 12/17 points. Radiological examination with CT myelogram and MR images showed a central-type soft disc herniation at C4/5 and disc bulging at C5/6, which compressed the spinal cord anteriorly (Fig. 4A). She also had canal stenosis at the cervical spine; the anterior–posterior diameter of the spinal canal was 13 mm at C3, 12 mm at C4, 11.5 mm at C5, 13 mm at C6 and 13.5 mm at C7.

At operation, we first performed corpectomy of C4 and C5, extirpated the herniated discs, and decom-

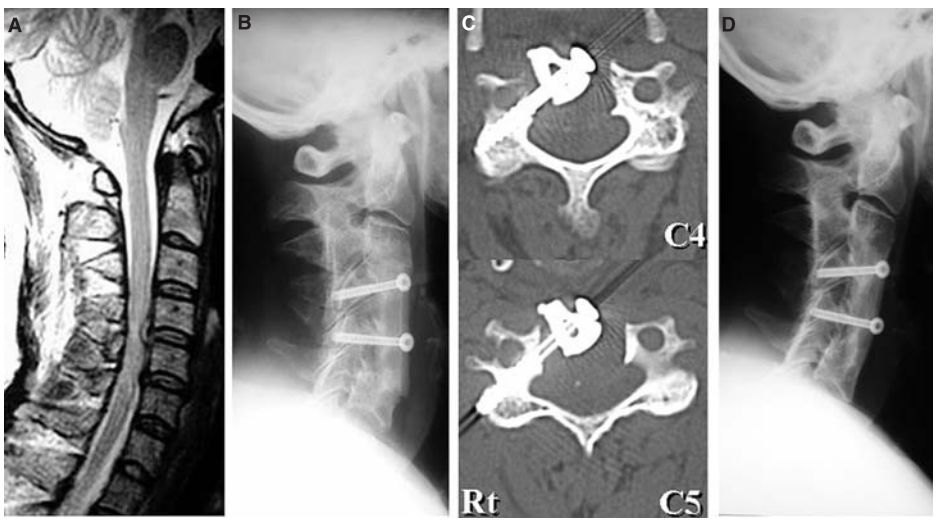

Fig. 4. Pre-operative T2-weighted MRI at the midsagittal plane (A) of a 50-year-old woman (patient 2) showing soft disc herniation at C4/5 and disc bulging at C5/6, which compressed the spinal cord anteriorly. Post-operative lateral radiographic image (B) and axial views of CT (C) two weeks after surgery, indicating that the screws were inserted accurately through the grafted fibula autograft and at the C4 and C5 pedicles. A lateral radiographic image two years after surgery (D), indicating that spinal fusion with the fibula autograft was complete at C3–C6

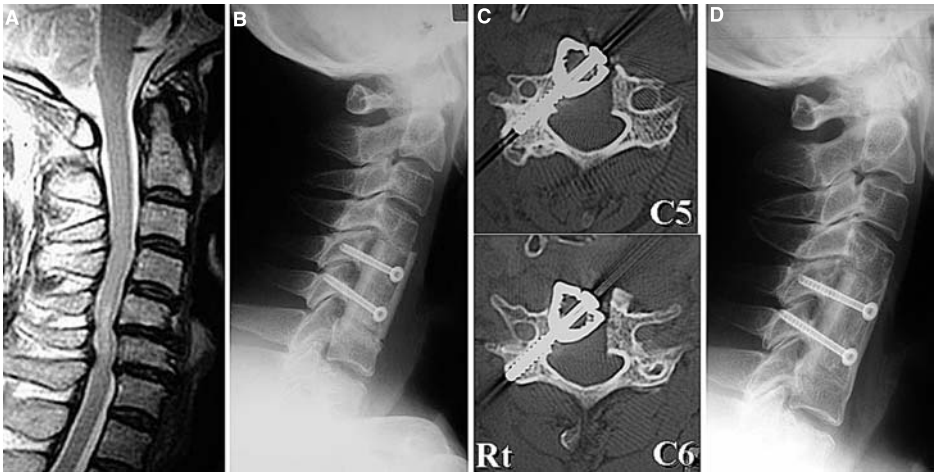

Fig. 5. Pre-operative T2-weighted MRI at the midsagittal plane (A) of a 64-year-old man (Case 3) showing osteophytes at C5/6 and C6/7, which compressed the spinal cord anteriorly. Post-operative lateral radiographic image (B) and axial views of CT (C) two weeks after surgery, indicating that the screws were inserted accurately through the grafted fibula autograft and the C5 and C6 pedicles. A lateral radiographic image two years after surgery (D), indicating that spinal fusion with the fibula autograft was complete at C4–C7

pressed the spinal cord. We then harvested the fibula from the left leg and grafted it between C3 and C6. We inserted two APSs through the grafted fibula and the right C4 and C5 pedicles. Post-operative radiographs and CT images confirmed that the screws were inserted accurately through the fibula autograft and the pedicles (Fig. 4B, C). At the final follow-up of 24 months, the patient's JOA score was 16.5/17 points (recovery rate: 90%), and complete spinal fusion was completed with an adequate alignment of the cervical spine (Fig. 4D).

Patient 3

A 64 year old man presented with muscle weakness and dysaesthesiae of his right upper extremity. His pre-operative JOA score was 14.5/17 points. Radiological examination with CT myelogram and MR images showed instability at C4/5 and osteophytes at C5/6 and C6/7, which compressed the spinal cord anteriorly (Fig. 5A).

At surgery, we first performed corpectomy of C5 and C6, extirpated the osteophytes and decompressed the spinal cord. We then harvested the fibula from his left leg and grafted it between C4 and C7. We inserted two APSs through the grafted fibula and the right C5 and C6 pedicles. Post-operative radiographs and CT images confirmed that the screws were inserted accurately through the pedicles (Fig. 5B, C). At the final follow-up of 24 months, the patient's JOA score was 15.5/17 points (recovery rate: 40%), and complete spinal fusion was confirmed without any dislodgement of the grafted fibula (Fig. 5D).

Discussion

Pedicle screws are useful tools for posterior fixation of the cervical spine [1–3]. The insertion of pedicle screws, however, has the potential risk of screw misplacement that causes damage to the spinal cord, nerve roots, or vertebral artery [4]. Previous studies have shown that the ratio of correct placement of ordinary posterior pedicle screws at the cervical spine ranges from 12.5 to 97% [4, 12–14, 18, 19, 21, 22]. Abumi *et al*. reported that the misplacement ratio of cervical posterior pedicle screws was 6.7% in their series (45 of 669 screws) [4]. Neo *et al*. inserted 86 pedicle screws in degenerative cervical vertebrae from the posterior direction, and 25 of them (29%) breached the pedicle walls [21].

In our APS fixation method, the vertebral artery is located at the lateral aspect of the entrance point, and the dura is directly visible in the surgical field. In addition, the ideal anterior entrance point of the APS can be identified using oblique fluoroscopy, which enables us to insert the APS into the pedicle accurately. When we compare the procedure for the placement of the APS with that of the posterior pedicle screw, the entrance point of the APS is closer to the pedicle (Fig. 6). Thus, the safety area at the insertion of the APS was larger than that of posterior pedicle screws. In fact, in the present series, 21 of 22 APSs were placed correctly in the pedicles, even though they were inserted into degenerative vertebrae. In this series, therefore, the misplacement ratio of APSs was 4.5%, which is principally lower than that of previously reported posterior pedicle screws [4, 21].

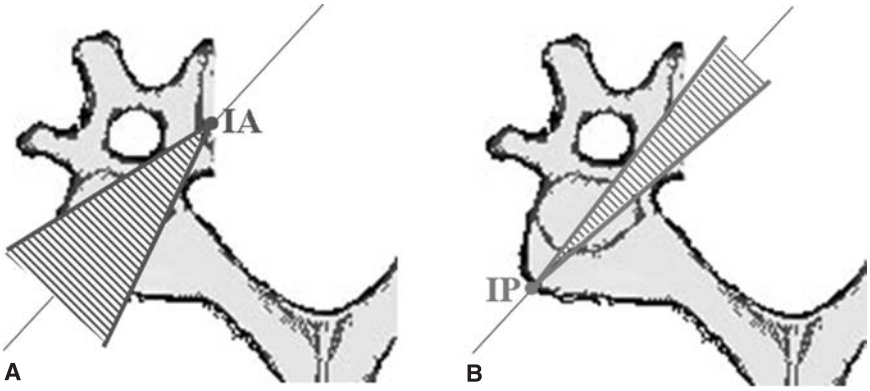

Fig. 6. Schematic drawings comparing the screw insertion points and the safety areas of the trajectory of an anterior pedicle screw (A) and a posterior pedicle screw (B). The safety area at the insertion of the anterior pedicle screw is larger than that of the posterior pedicle screw. The insertion points of the anterior (*IA*) and posterior (*IP*) pedicle screws are indicated

Fixation with an anterior plate and screws has several problems. The screws of the anterior construct are short and inserted monocortically to a vertebral body, which is sometimes made of fragile cancellous bone. Thus, anterior plating alone excessively loads the graft even with small degrees of motion, which may promote piston movement and failure of the anterior plate construct [7]. In particular, graft sinking is a major risk factor, which causes the failure of the anterior plate construct.

In contrast, fixation with APSs has several advantages. First, the pedicle is a strong anchor, even in osteoporotic patients [2]. Previous reports have proved biomechanical superiority of pedicle screws to conventional anterior and/or posterior cervical instrumentation methods [11, 17]. Another advantage is that the APS method does not fix the junction between the grafted bone and the vertebral body. This suggests that graft sinking does not reduce the stability of the construct.

Based on the considerations described above, we have begun clinical application of APS fixation. The present results showed that the insertion of APSs was safe, and no technical difficulty existed. Although a halo-vest was not applied post-operatively in this series, no dislodgement of the grafted fibula occurred. Graft sinking occurred to some extent during the follow-up period; however, bone union at the junction between the grafted fibula and the vertebral body progressed successfully. In this series, solid spinal fusion was detected 9–15 (mean 12.3) months after surgery. Previous reports showed that when multilevel cervical anterior fusion was performed with a fibular strut graft and post-operative halo-vest fixation, graft union was achieved at an average of 12 months after surgery [9, 10]. In the present series, the period for obtaining solid spinal fusion was almost the same as that in those previous reports. Thus, APS fixation can provide a rigid anterior fibula graft with minimum post-operative external support.

In conclusion, the present data demonstrates that insertion of APSs is feasible and safe. APS fixation could become a useful tool for obtaining rigid fixation of the grafted bone anteriorly when performing multilevel cervical corpectomy and spinal fusion.

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Comment

Aramomi *et al*. have analyzed a small series of patients who underwent anterior pedicle screw fixation for multilevel cervical corpectomy and spinal fusion. The anterior insertion of screws into the pedicles has been introduced as feasible and safe. The new anterior surgical approach was expected to increase stability and lower the risk of failures by using conventional anterior fixation methods. Even though the outcome in this small series was quite good, long-term results of much larger series will have to confirm this assumption. Nevertheless, this technical note is a nice introduction into a new fixation method performed from anteriorly. We agree that Halo-vests are very uncomfortable for patients who underwent cervical corpectomies and should be used only in special cases with significant morbidity. In fact, even Philadelphia collars can be avoided in most cases and a soft collar should be sufficient, provided intraoperative stability and screw firmness are confirmed. Although we would prefer iliac bone grafts instead of fibular grafts, this certainly would not change the overall idea of this paper. We are looking forward to see the reports of larger series from other groups using this elegant anterior fixation method.

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