Novel treatment (new drug/intervention; established drug/procedure in new situation)

Cervical pedicle screw fixation in traumatic cervical subluxation after laminectomy using the pedicle axis view technique under fluoroscopy

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Summary

Cervical pedicle screw (CPS) fixation has recently been performed in patients in need of cervical reconstruction. We report the case of a 50-year-old man who was operated for traumatic cervical vertebra subluxation using CPS fixation, in whom laminectomy had been performed in the past. We performed CPS fixation using the pedicle axis view technique under fluoroscopy. The four pedicle screws were accurately inserted within the pedicles without perforating the bone cortex of the pedicles. A navigation system is useful for cervical spine surgery because it enables a surgeon to perform relatively safe and accurate surgery during transpedicular screw fixation. However, attachment of the stereotactic reference arc to the spinous process is impossible, and the application of a navigation system is limited in cases in which laminectomy has been performed in the past. We have been using the pedicle axis view technique under fluoroscopy and have found that if we take care of the entry point accurately, we can safely insert the pedicle screw in cases with fewer landmarks.

BACKGROUND

The concept of pedicle screw fixation for mid-cervical and lower cervical spine reconstruction was introduced by Abumi *et al*,¹ who along with others have reported good clinical results and relatively low rates of complications from this procedure.^{2–4} The introduction of the cervical pedicle screw (CPS) has made it possible to perform posterior-only short-segment reconstructions. However, because it has the potential to seriously injure the spinal cord, nerve roots or vertebral arteries, CPS fixation has generally been considered a risky surgery.² For cases in which posterior wiring or lateral mass plating cannot be applied, transpedicular fixation may provide optimal stabilisation for an unstable motion segment.⁵ Therefore, when the safety of the procedure is ensured, CPS fixation could become an effective procedure for reconstructing the cervical spine.

Because of the lack of landmarks and an accurate entrance to the cervical pedicles, direct exposure of the pedicle cavity,¹ foramino-laminotomies⁶ and the use of expensive stereotactic image-guided systems or CT⁷ have been suggested as the ways to improve the accuracy of screw placement. We developed a pedicle axis view technique to accurately insert the posterior cervical pedicle screw and have used it in more than 200 cases.^{3,4,8}

We report a case with traumatic cervical subluxation after laminectomy, for which CPS fixation was performed. We used three-dimensional fluoroscopy (pedicle axis view technique) to perform the surgery.

CASE PRESENTATION

A 50-year-old man with pre-existing condition of von Recklinghausen's disease was complaining of neck pain and numbness in the upper two extremities.

Laminectomy due to spinal cord tumour had been performed at 25 years of age (C1–3, C6 and C7). The patient was injured when he fell down the stairs at home (a height of 3 m). He began experiencing neck pain and numbness in his upper two extremities; plain radiographs demonstrated subluxation of the third vertebra, and he was referred to our hospital for a consultation (figures 1A,B). The patient demonstrated increased tendon reflexes in the lower limbs. He did not demonstrate any decrease in muscle strength or any sensory deficit. Following confirmation by myelography and CT angiography, the patient was operated on.

TREATMENT

A C3/4 CPS fixation operation was planned using three-dimensional fluoroscopy. Under general anaesthesia, the patient was placed in a Mayfield head holder in a prone position (figure 2). We confirmed that the pedicle axis view was obtained under preoperative fluoroscopy (pedicle axis view technique). A multiplanar fluoroscope was rotated so that an approximate circular portion of the pedicle cortex wall could be visualised in the transverse plane of the vertebral body, and the axis of rotation was set to the cervical longitudinal axis (figure 2). The screw insertion point was located at the centre of the circle on the cervical lateral mass (figure 3A). After identifying the entry point under oblique fluoroscopy, we probed further under lateral fluoroscopy (figure 3B,C). After inserting a guide pin and reconfirming the trajectory using the pedicle axis view under fluoroscopy, tapping was performed to insert the screw. We concluded the surgery with an iliac-tip bone graft to the C3/4 intervertebral facet joint. The instruments used were a screw and rod system (OASYS; Stryker, USA). The surgery lasted 109 min and the total blood loss was 40 ml.

Figure 1. (A) Preoperative plain x-ray images (anteroposterior view). (B) Preoperative plain x-ray images (lateral view). The laminae of C1–C3, C6 and C7 have been removed; the third vertebra has been subluxated. (C) Postoperative plain x-ray images (anteroposterior view). (D) Postoperative plain x-ray images (lateral view). Subluxation has been reduced and favourable alignment has been achieved postoperatively.

OUTCOME AND FOLLOW-UP

The day after the surgery, the patient was fitted with a Philadelphia cervical collar and became ambulatory. Postoperative neck pain and numbness were reduced. Plain radiographs taken 2 weeks after surgery demonstrated that the positioning and alignment of the screw were both favourable, and the patient was discharged (figures 1C,D). In a CT taken 3 months after the surgery, the position of the screw was favourable, and the fusion was achieved (figure 4).

DISCUSSION

CPS achieved the strongest biomechanical internal fixation and made it possible to reconstruct unstable cervical spines, which conventional methods like halo vest fixation, wire fixation, anterior plate fixation and lateral mass screw fixation were unable to address.¹ Especially in cases of revision surgery after laminectomy, the use of a wire or hook system for destroyed posterior elements

presents with difficulties, and conventional methods are also weak in terms of fixation performance.

In general, the surgical results of anterior cervical spine surgeries are perceived to be favourable.^{9–10} However, the difficulties in reduction and in securing rigid fixation are the main drawbacks. Jhonson *et al*¹¹ reported 87 unilateral and bilateral facet fracture subluxations stabilised with anterior cervical discectomy, fusion and plating. Loss of postoperative alignment occurred in 13% of the subjects.

CPSs are strong structural elements that act as rigid anchorage for instrumentation. Hence, a screw through the pedicle, in which normal anatomical structures remain, is reliable and has the potential to replace conventional methods of reconstruction.^{12–13} However, screw implantation is an extremely difficult procedure and carries the risk of neurovascular injuries. When the surgery has been performed in the past, deformation of the posterior elements due to scar tissue formation often resulted in increased surgical difficulty compared to primary first-time surgery cases.¹⁴ In cases of revision cervical spine surgery, when a bone grafting has been performed in a previous operation and new bone and scar formations have been observed, the normal anatomical structure is lost. When a pedicle screw is implanted, the local anatomy, which the surgeon uses as a guide, is altered; this renders the screw implantation significantly more difficult.

A navigation system has been introduced to increase the precision of CPS implantation. The use of this navigation system has been reported to significantly lower the rate of perforation of the CPS and further improve safety.^{7–15–16} The navigation system can be either CT-based or fluoroscopy-based. However, image information cannot be updated intraoperatively when CT is used, and it is unsuitable in patients who need reduction due to trauma. On the contrary, a drawback to the use of image fluoroscopy is that three-dimensional image information cannot be obtained. Furthermore, owing to their high cost and user unfriendliness, these systems are not installed in most hospitals.

CPS implantation using the navigation system is a challenge in patients undergoing revision surgeries such as laminectomy, because it is difficult to establish the reference arc.^{15–16} Seichi *et al*¹⁷ have reported that when the reference arc was set up at non-relevant vertebrae, half the

Figure 2. Preoperative image. Illustrative setting of patients and fluoroscopy in order to obtain the appropriate pedicle axis view.

Figure 3. Intraoperative images. (A) Oblique radiograph shows the cortical circles of left C4–T1 pedicles. Left C6 pedicle is seen as a round circle just below the upper endplate and this is the pedicle axis view (arrow). (B and C) The pedicle axis view at the surgical level was confirmed intraoperatively under fluoroscopy (arrow).

screws deviated. Accurate navigation is difficult to achieve in cases with fracture of the spinous process, hypoplasia or laminectomy, where the surgeon is forced to set up the reference arc at the adjacent spinous process.

Anatomically, the cervical pedicle diameter is smaller than the thoracolumbar pedicle, and the pedicle axis is largely inclined in the transverse plane. Successful placement of pedicle screws requires an accurate identification of the pedicle axis. If an accurate entry point that coincided with the correct trajectory angle is determined during surgery, it would improve the accuracy of screw placement. In the conventional technique, the screw entry point was determined through a small hole, which was made with a high-speed burr, to locate the inner wall of the pedicle;¹ however, a larger hole was sometimes necessary to accomplish this task, but a larger hole could create a cortical defect in the lateral mass and result in decreased screw stability within the pedicle.

Fluoroscopic lateral imaging was recommended in a study describing the conventional technique¹ but this method only provides information regarding the vertical plane and not the horizontal plane. Furthermore, the location of the pedicle entrance is unique to each level of the cervical vertebra and large variations are found among individuals even at the same vertebral level.

The fluoroscopy-assisted pedicle axis view technique helped to determine the appropriate entry point that coincided with the correct trajectory angle for each cervical

vertebra in both sagittal and transverse planes. The strength of this technique is indicating both inserting point and trajectory angle of screws at the same time. If each of them is not correct, pedicle perforation is likely to occur.

If the pedicle axis view is accurately verified by three-dimensional fluoroscopy and careful attention is paid to the CPS implantation point and angle, a CPS can be safely implanted even in cases with a poor anatomical index like the present one. We believe, as do surgeons with extensive clinical experience, that the best tool for providing safe and accurate pedicle screw placement is the spinal surgeons' intimate knowledge of cervical anatomy. Owing to the possibilities of serious risks, this procedure should not be performed easily. Surgeons must select better procedure for each patient with cervical trauma, evaluating risks and benefits of each procedure.

Learning points

- Cervical pedicle screw (CPS) fixation surgery using three-dimensional fluoroscopy is useful for cervical subluxation following laminectomy. Hence, using the fluoroscopy-assisted pedicle axis view technique for determining the appropriate pedicle screw entry point that coincides with the correct trajectory angle should improve the accuracy and safety in CPS placement.

Figure 4. Postoperative CT images (axial view). (A) C3 level and (B) C4 level. The left screw has been implanted slightly inward at the C3 level, but has been accurately implanted into the pedicle at the C4 level.

Competing interests None.

Patient consent Obtained.

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Please cite this article as follows (you will need to access the article online to obtain the date of publication).

Machino M, Yukawa Y, Ito K, Nakashima H, Kanbara S

Morita D, Kato F. Cervical pedicle screw fixation in traumatic cervical subluxation after laminectomy using the pedicle axis view technique under fluoroscopy.

BMJ Case Reports 2012;10.1136/bcr-2012-006545, Published XXX

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