CERVICAL SPINE INJURIES ASSOCIATED WITH LATERAL MASS AND FACET JOINT FRACTURES: NEW CLASSIFICATION AND SURGICAL TREATMENT WITH PEDICLE SCREW FIXATION

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Abstract

OBJECTIVE: To clarify the initial spinal instability and the degree of discoligamentous injuries in cervical lateral mass and facet joint fractures, we retrospectively analyzed the initial fracture patterns, spinal instability and discoligamentous abnormalities on MR imaging. The surgical results using cervical pedicle screw fixation (CPS) for these injuries were retrospectively evaluated in terms of neurological outcome

Summary of Background data. There have been no report precisely analyzing fracture patterns and discoligamentous involvements in cervical lateral mass and facet joint fractures.

Methods. Thirty-one patients received surgical treatments using a cervical pedicle screw. The lateral mass fractures were divided into following four subtypes of separation, comminution, split, and traumatic spondylolysis. The sagittal and frontal alignments were evaluated at both mainly injured and adjacent spinal segments on radiographs. The initial discoligamentous injuries were investigated in terms of their frequencies, subtype of injuries, and spinal levels. The surgical outcome and complications were also reviewed.

Results. The anterior translation of fractured vertebra was demonstrated in 77% of lateral mass fractures, while 24% of anterior translation was observed even in cephalad-adjacent vertebrae. On magnetic resonance imaging, the signal changes in anterior longitudinal ligament (ALL) and intervertebral disc were demonstrated in 76% and 25% of caudal and cephalad segments adjacent to fractured vertebra, respectively. In the facet joint fractures,

the frequency of translation deformity and discoligamentous abnormality was lower than those in lateral mass fractures. The CPS provided the fusion rate of 100% and excellent capability of deformity correction. The average numbers of stabilized segments were minimized to 1.6 and 1.1 in lateral mass and facet joint fractures, respectively.

Conclusions. The evaluation of initial spinal instability and the assessment of soft tissue injury on MRI provide detailed information for these injuries, serving for accurate diagnosis and determination of treatment strategy. In separation fractures or fractures with mild comminution cases, we successfully saved the stabilized segments using CPS. The exclusive posterior stabilization with CPS provides a short fusion as well as a normal spinal alignment even in the lateral mass fractures with severe spinal instability.

Running Head: Cervical lateral mass fracture

Key words: Cervical lateral mass fracture, Facet joint fracture, Discoligamentous injury, Magnetic resonance imaging, Cervical pedicle screw

Mini Abstract

The evaluation of initial spinal instability and the assessment of soft tissue injury serve for accurate diagnosis and determination of treatment strategy for cervical lateral mass and facet

joint fractures. The exclusive posterior stabilization with cervical pedicle screw provides shorter fusion as well as a normal spinal alignment even in the lateral mass fractures with spinal instability.

Key Points

- The anterior translation of fractured vertebra was demonstrated in 77% of lateral mass fractures, while 24% of anterior translation was observed even in cephalad-adjacent vertebrae.
- On magnetic resonance imaging, the signal changes in anterior longitudinal ligament (ALL) and intervertebral disc were demonstrated in 76% and 25% of caudal and cephalad segments adjacent to fractured vertebra, respectively.
- In separation fractures or fractures with mild comminution cases, CPS successfully saved the stabilized segments. The exclusive posterior stabilization with CPS provides shorter fusion as well as a normal spinal alignment even in the lateral mass fractures with severe spinal instability.

Introduction

With the recent progression of medical imaging technologies, the increasing number of lateral mass and facet joint fractures were clinically detected in the cervical spine. These often require the conservative treatment, however, the surgical treatment is indicated when there is a neurologic disturbance or definite segmental spinal instability at the injured segment.[1,2,3,4,5] Due to a limited number of clinical reports, these fractures remain unclear in terms of fracture patterns, injury mechanism, frequency of initial sagittal and coronal deformity, and the degree of associated soft tissue injuries.[3,5] These data are required for the accurate diagnosis and the determination of initial treatment strategies.

In turn, there were several surgical procedures for lateral mass and facet joint fractures. Jeanneret et al. reported the osteosynthesis of the fractured lateral mass for the fracture-separation of lateral mass without sacrificing the motion segment.[4] Other procedures include posterior spinous process wiring, [6] lateral mass screw-plate fixation,[1,2,5,7,8,9] and the combined anterior and posterior stabilization.[10] We have utilized a cervical pedicle screw fixation (CPS) over 300 cases of several cervical spine disorders since 1990, demonstrating the excellent clinical outcome.[11,12,13]

The objectives of this study were twofold: first to retrospectively analyze the initial injury patterns, injury mechanism, spinal instability and discoligamentous abnormalities of

lateral mass and facet joint fractures and clarify the surgical indication and treatment strategies for these injuries; and secondary, to assure the efficacy of cervical pedicle screw fixation in the surgical treatment of these injuries.

Materials and Methods

Patient Demographics

From January 1991 to December 1999, thirty-one patients including twenty-three lateral mass fractures and eight facets joint fractures received surgical treatments in our institution. Twenty-six patients were male and five were female. The average age at surgery was 46 years old (18 – 63 years old). The injuries were caused by a traffic accident in 20, fall in six, a heavy weight object in two, and others in two. The days from injury to surgery were thirty-two days in average (0 to 257 days). Most patients were treated in other hospitals initially, and subsequently transferred to our institution due to residual deformity or neurological disturbance. The spinal fracture levels were C6 in fourteen, C5 in eight, C7 in six, C4 in two, and C3 in one. One patient suffered from a superior articular process fracture of C4 in combination with inferior articular process fracture of C3. The injury types were classified by evaluating injury x-rays according to Allen's classification.[14] There were 27 compressive-extension injuries, three lateral flexion injuries, and one distractive-flexion injury. The neurological disturbance at surgery was a persistent radiculopathy in 21 patients, while five patients had a myelopathy with various degree of Frankel grade from B to D.[15] The associated injury was recorded in one patient with a cerebral contusion treated conservatively.

Radiographic analyses of fracture patterns and associated soft tissue injury

From x-rays and MRI analyses, the fractures were classified into subtypes. The translation of fractured and adjacent vertebrae in the sagittal and coronal planes, uncovertebral joint subluxation, and the degree of vertebral body destruction were evaluated preoperatively and at follow-up. The signal changes and the rupture of the intervertebral disc and spinal ligaments (Anterior longitudinal ligament: ALL; Posterior longitudinal ligament: PLL; Supraspinous and interspinous ligaments; SSL&ISL) were examined at both a mainly injured spinal segment and adjacent segments on initial MRI films. These changes were classified into partial or complete change, subsequently. The associated bony bruise was also evaluated on MRI films. The occurrence of these parameters was compared between the lateral mass fracture group and the articular process fracture group as well as between each fracture subtype to examine whether the severity of injury corresponded to these changes.

Surgical Procedures

Thirty patients underwent posterior reduction and stabilization with cervical pedicle screw system. The simultaneous posterior neural decompression was conducted in eight patients: foraminotomy in six and multiple level laminectomies for developmental narrow canal in two. Four patients received additional anterior decompression and fusion for the release of

rigid deformity or requirement of additional anterior column support. The osteosynthesis for the separation fracture of lateral mass was performed in one patient with a titanium cannulated screw. In early series of transpedicular screw fixation, scale-downed VSP screw (Depuy AcroMed, Raynham, MA) was used in eight patients. In subsequent cases, the cervical transpedicular screw system was used with different screw diameters of 3.5, 4.0, and 4.5 mm. The bone graft was conducted with the locally harvested bone from spinous processes and was properly placed under cervical pedicle screw plate bilaterally.

Assessment of surgical outcome and functional recovery

At a final follow-up, the fusion status and spinal alignment were evaluated using functional x-rays and CT scans. The number of stabilized segments was compared among fracture subtypes to assess whether the short fusion was achieved in specific fracture subtypes. The neurologic recovery was evaluated using a Frankel grade for myelopathy, and the pain, motor, and sensory changes were descriptively recorded for radiculopathy cases. The early and late complications were recorded in terms of infections, pseudoarthrosis, implant failures, and neurologic deterioration

Results

All cases were followed until a final follow-up (average 5.2 years, 2 to 10 years and 1 month).

Radiographic analyses of fracture patterns and associated soft tissue injury

The lateral mass fractures were divided into following four subtypes: separation fracture in eleven, comminution type in four, split type in five, and traumatic spondylolysis in two **(Figure 1)**. The separation fracture was defined as two fracture lines of unilateral lamina and pedicle, thereby isolating and separating the unilateral entire articular mass.[4,5,16] The comminution type showed multiple fracture lines in the lateral mass with significant fragmentations, frequently accompanying with the lateral wedging deformity in a coronal plane. The split type fracture had a vertical fracture line on a coronal plane in the unilateral lateral mass, creating an anterior-posterior separation with the invagination of superior articular process of caudal adjacent vertebra. The traumatic spondylolysis showed bilateral horizontal fracture lines at pars interarticularis, leading to a separation between anterior and posterior spinal elements. The superior and inferior articular process fractures, and combination of both fractures at consecutive vertebrae were seen in six, one, and one patient, respectively.

In terms of spinal alignment on initial radiographs, the anterior translation of fractured vertebra was demonstrated in 77% of whole lateral mass fractures, while 24% and 10% of anterior translation were observed even in cephalad and caudal adjacent vertebrae, respectively **(Table 1)**. The alignment change in coronal plane was detected in 33% of lateral mass fractures. In turn, articular process fractures demonstrated the anterior translation of upper adjacent vertebra in 50%, while 33% and 0% of anterior translation were observed in fractured and caudal adjacent vertebrae, respectively. The alignment change in coronal plane was not detected in any articular process fractures.

The subtype analysis in lateral mass fractures demonstrated that the separation fracture, split type and traumatic spondylolysis showed high rates of anterior translation in 91%, 80%, and 100%, respectively. The anterior translation of the adjacent vertebra was 20%, 50%, 0%, and 50% in separation, comminution type, split type, and traumatic spondylolysis, respectively. However, there was no statistical difference between groups due to a small number of patients in each group. The comminution and split type demonstrated higher rates of coronal malalignment in 25% and 40%, respectively, when compared to that of separation fracture (3%) ($P<0.05$).

In terms of vertebral body destruction, both groups of lateral mass fractures and articular process fractures showed 33% of vertebral body destruction rate. However, in the

subgroups of lateral mass fracture, the separation fracture demonstrated significantly lower rate of 1% than that of other subtypes (50-60%) ($P<0.05$).

On MRI, the main injured segment was the caudal segment adjacent to the fractured vertebra in the lateral mass fractures. The signal changes of ALL and disc in lateral mass fractures were demonstrated in 76% and 24-29% of caudal and cephalad segments adjacent to the fractured vertebra, respectively **(Table 2)**. The PLL and SISL changes at the main injured segment were 35% and 12%, respectively in the lateral mass fractures. The adjacent PLL or SISL change was minimum (0-6%) in lateral mass fractures. Meanwhile, the signal changes of ALL and disc in articular process fractures were demonstrated in 40% and 80% at the cephalad segment adjacent to the fractured vertebra, respectively. The signal changes of PLL and SISL were not detected in both cephalad and caudal segments. Additionally, the caudal adjacent segment did not show any signal change of ALL and disc in articular process fractures.

The subtype analyses in lateral mass fractures demonstrated that each subtype showed the same trend as that in whole lateral mass fracture group. There were no significant differences among fracture subtypes in terms of frequency of signal changes.

Surgical outcome and functional recovery

The arthrodesis was successfully achieved in all cases. Although the average number of injured segments was 1.7, 1.5 spinal segments were surgically stabilized in average, demonstrating the tendency of short segment fusion in a whole group. The average number of stabilized segments in either lateral mass fracture or articular process fracture group was 1.6 and 1.1 segments, respectively. In separation type, we successfully saved fixed segments in about a half of cases by fusing the segment just below the fractured vertebra, exclusively (average fixed segment: 1.4). The average number of fixed segments in comminution, split, and traumatic spondylolysis types were 1.6, 2, and 2 segments, respectively. The more comminuted type of injury often requires two-level fixation.

The postoperative radiographic analysis demonstrated that there were six cases of mild anterior translation deformity at follow-up. Among them, three cases showed the anterior translation of fractured vertebra due to incomplete reduction during operation. However, no correction loss after postoperative periods was seen in all cases. Other three cases of cephalad vertebra translation occurred due to short-segment fusion. A case of C6 separation fracture was treated with osteosynthesis of unilateral fracture site using a cannulated screw. The reduction of fractured lateral mass was successfully achieved, however, the translation of vertebra remained to some degree. Other two cases of C5 separation and C6 comminution type fractures showed the anterior translation of fractured and cephalad vertebrae, however, because of a lack in soft tissue injury at the adjacent segment on MRI, the main injured

segment was stabilized exclusively. Even though the mild deformity seen in six cases above, no problem relating neurologic symptom or pain was demonstrated at follow-up.

In terms of neurologic symptoms, there were five cases of cervical myelopathy, and 21 cases of radiculopathy, preoperatively. Based on Frankel grading system, there were B in one, C in three, and D in two cases, preoperatively, however, there were no B, C in one case, D in two, and E in three cases. The neurologic improvement more than one grade was seen in all myelopathy cases. All radiculopathy cases recovered well in terms of radicular pain, numbness, and weakness in upper extremities, except three cases of persisting motor weakness between good and fair level.

Complications

There was one deep infection in C5-7 lateral flexion injury case, which was treated with C5-7 pedicle screw fixation. The continuous irrigation without implant removal successfully resulted in the settlement of infection. There were four cases of screw thread exposure from the pedicle wall detected in postoperative x-ray and CTs. No neurologic injury was observed in those cases, however, one case of vertebral artery injury was demonstrated. In this case, the screw was inserted into a fractured pedicle in separation fracture of lateral mass. The bleeding stopped with bone wax and the patient had no circulatory and neurologic symptoms, consequently.[11] The patient who complained of a pain due to skin irritation of screw head required a hardware removal after completion of arthrodesis.

Case Presentations

Case1 (Figure 2)

A 43-year-old male suffered from a separation fracture of left C5 lateral mass due to a traffic accident. The initial neurologic presentation was incomplete Brown-Sequard syndrome with motor and sensory deficits. The imaging studies showed a typical horizontalization and fracture-separation of left C5 lateral mass as well as ruptured ALL and disc injury at C5-6 on sagittal MRI imaging. The posterior fixation and fusion was conducted using cervical pedicle screw system. After four years postoperatively, the arthrodesis was complete and no adjacent segment change was demonstrated.

Case 2 (Figure 3)

A 33-year-old male sustained a C6 separation fracture of left lateral mass with C6 radiculopathy. The CT scan demonstrated a typical floating lateral mass of C6. The osteosynthesis of fractured pedicle was carried out using a cannulated titanium screw. At five years postoperatively, the successful bony fusion was obtained at the fracture site, however, a slight anterior slippage of C6 vertebra remained without any symptoms.

Case 3 (Figure 4)

A 60-year-old male injured a comminution type of C5 lateral mass fracture with spinal cord injury of Frankel C grade. The supposed injury mechanism was C5-6 compressive-extension injury according to Allen's classification. The comminuted right lateral mass displaced posteriorly, demonstrating two-level instability. Two-level posterior fixation and fusion was carried out with cervical pedicle screw system followed by C4-7 laminoplasty. The successful arthrodesis was achieved at one year postoperatively.

Discussion

Several authors have pointed out a low accuracy in the initial diagnosis of lateral mass and articular process fractures.[5,17,18,19,20] These fractures often involved in the lower cervical spine and initial plain radiographs did not demonstrate the abnormality in many cases. The oblique x-rays are recommended for better visualization of fracture sites, however, in patients who suffered from multiple trauma or neurological injury, it is sometimes difficult to take those views initially. Halliday et al. reported that only 6 of 24 cervical plain radiographs (25%) detected an initial abnormality in the emergency department.[3] Levine et al. reported that standard roentgenograms were effective in making the definitive diagnosis in only nine of twenty-four cases (38%).[5] The use of CT or multidirectional tomography is recommended for better visualization of fracture and neural involvement. [20,21]

Fractures of the lateral mass and articular process were generally accepted as being produced by hyperextension or hyperextension combined with rotational injury mechanism. [18,21,22] In our series, most injury types were classified into compressive-extension injuries followed by lateral flexion injuries according to Allen's classification.[14] In lateral flexion injuries, the lateral mass fractures were more comminuted and associated with the asymmetrical vertebral body fracture.

In this series of lateral mass fracture, we newly divided the fractures into following four subtypes: separation, comminution, split, and traumatic spondylolysis. In these subtypes, comminution and split type fractures were new entities. The comminution type fracture consisted of multiple fracture lines in the lateral mass with significant fragmentations, frequently accompanying with the lateral wedging deformity in a coronal plane. The split type fracture was previously reported by Sim and Yetkin et al.[21,23] Sim reported five cases of these injuries and described that the segmental stability was likely to be adequate and surgical indication was limited.[23] We experienced five cases of this injury type, all presenting an anterior translation, axial rotational deformity, and local lateral wedging deformity in a coronal plane. Although the invagination of superior articular process into the fractured rostal lateral mass possibly prevents the gross initial instability, the significant three-dimensional deformity should be corrected and stabilized to prevent the subsequent persistent severe neck pain.

The analysis of spinal alignment abnormality at initial injury demonstrated the higher incidence of anterior translation or frontal plane deformity in lateral mass fractures than that in articular process fractures. In lateral mass fractures, the anterior translation of vertebra was detected in 77% of fractured vertebra, while in 24% of upper adjacent vertebra as well as the frontal plane deformity in 33%. Levine et al. reported an incidence of anterior vertebral translation in twenty-four cases of lateral mass fracture separation.[5] The anterior

translation of fractured vertebra was observed in 79% of fractured vertebra, as well as in 21% of cephalad-adjacent vertebra. These data were almost equivalent to that in the present study. In turn, fracture subtype analysis demonstrated that the split and comminution type showed significantly higher rates of coronal malalignment and vertebral body destruction when compared to the separation fracture. This indicated that higher injury energy seemed to be provided to those two types of injuries.

This serves as the first study to precisely evaluate the initial intervertebral disc or ligamentous injuries at both fractured and adjacent spinal segments in cervical lateral mass and facet joint fractures. Overall, 76% of ALL and disc, 35% of PLL, and 12% of SSL and ISL were injured on MRI at the main injured segment of lateral mass fractures. Halliday et al. reported 50% of ALL, 29% of PLL, and 75% of ISL injuries in twenty-four cases of lateral mass and facet fractures.[3] Considering the main injury mechanism of compressive-extension in Allen's classification, it is reasonable to observe the higher frequency of ALL and disc injuries than that of SSL or ISL injury. The associated lamina fractures often demonstrate the T2 high signal intensity change around ISL resembling SSL and ISL injuries, however, this signal change has to be carefully examined with T1-weighted image in terms of the continuity of SSL black line. Another possible explanation to this contrast is that our series may include more severely injured cases when compared to their series requiring surgeries in only 50% of whole cases. In turn, 24 to 29% of ALL and disc signal changes at the

cephalad-adjacent segment were demonstrated in this study, serving as the important data for diagnosis of injury type and subsequent treatment strategy.

The initial treatment strategy for lateral mass or articular process fracture is determined mainly based on the neurologic disturbance and segmental spinal instability. The suggested simple algorithm for the initial treatment strategy is shown in Figure 5. When the patients have the apparent neurologic disturbance with anterior or lateral vertebral subluxation, the surgical treatment is recommended. When there is neurologic disturbance without anterior or lateral vertebral subluxation, the further investigation has to be performed using CT and MRI in terms of fracture type and soft tissue damage analysis. The multiple discoligamentous damage or comminuted lateral mass fractures with supposed spinal instability require the surgical treatment. In case of adequate spinal stability preserved, the conservative treatment with collar can be selected. In turn, even when the patients are neurologically normal, the spinal instability based on multiple discoligamentous damage or comminuted lateral mass fractures require the surgical intervention. Although the practical decision-making in clinic is not sometimes simple like this algorithm due to severity of neural damage or socioeconomic status, this algorithm is useful in simplifying the principal initial management strategy.

In terms of surgical management, we utilized a cervical pedicle screw fixation with a high fusion rate and patient satisfaction. In separation fracture cases, the osteosynthesis

using a single screw is another choice for surgical treatment (Figure 3).[4] However, our case demonstrated a residual anterior translation of repaired vertebra due to the injured intervertebral disc below. As the moderate or severe disc injury is mostly associated with the separation fracture, the osteosynthesis is only indicated for separation fracture with a minimum disc damage shown on MRI. In turn, the cervical pedicle screw fixation was reported to offer the superior three-dimensional biomechanical stability and pullout strength [24,25]. Kotani et al. demonstrated the clear advantage of cervical pedicle screw fixation over that of combined anterior and posterior fixation using Bohlman's triple wiring or posterior lateral mass screw fixation even in the severe discoligamentous injury model [25]. This stabilizing capacity clinically provides the excellent correction of fractured vertebra as well as a high fusion rate. Consequently, we successfully saved the stabilized segments in separation fractures or fractures with mild comminution based on the adjacent disc and ligaments evaluation. However, severely comminuted lateral mass fractures with coronal plane malalignment required two-level posterior fixation. Regarding the clinical risk of CPS, the previous studies showed no increased neurovascular complications using CPS over that of other posterior fixation techniques [11]. Finally, the exclusive posterior stabilization with cervical pedicle screw system provides a short fusion as well as a normal spinal alignment even in the lateral mass fractures with severe spinal instability.

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Table 1.

Translation of fractured and adjacent vertebrae on sagittal and frontal plane
(Frequency shown as percentage in each fracture type)

Fracture Type	Anterior Translation		Frontal Translation	
	Upp. Adj.	Fractured	Low. Adj.	Fractured
Lateral Mass	24%	77%	10%	33%
Articular Proc.	50%	33%	0%	0%

Lateral Mass: Lateral Mass Fracture, Articular Proc.: Articular Process Fracture, Upp. Adj.: Upper Adjacent Vertebrae, Fractured: Fractured Vertebra, Low. Adj.: Lower Adjacent Vertebra

Table 2.

Invertebral Disc and Ligamentous Injuries on Initial Magnetic Resonance Imaging
(Frequency shown as percentage in each fracture type)

Fracture Type	Main Injured Segment				Adj. Segment	
	ALL	Disc	PLL	SISL	ALL	Disc
Lateral Mass	76%	76%	35%	12%	24%	29%
Articular Proc.	40%	80%	0%	0%	0%	0%

All signal changes of lateral mass fracture at adjacent segment were observed in cephalad-adjacent segments to fractured vertebrae.

Lateral Mass: Lateral Mass Fracture, Articular Proc.: Articular Process Fracture,
Adj. Segment: Adjacent segment to main injured segment, ALL: Anterior Longitudinal Ligament, Disc: Intervertebral Disc, PLL: Posterior Longitudinal ligament, SISL: Supraspinous and Interspinous Ligaments

Figure Legend

Figure 1: Fracture subtypes of lateral mass fracture.

A: Separation fracture. The separation fracture was defined as two fracture lines of unilateral lamina and pedicle, thereby isolating and separating the unilateral entire articular mass

B: Comminution type. There are multiple fracture lines in the lateral mass with significant fragmentations, frequently accompanying with the lateral wedging deformity in a coronal plane.

C: Split type. There is vertical fracture line on a coronal plane in the unilateral lateral mass, creating an anterior-posterior separation with the invagination of superior articular process of caudal adjacent vertebra.

D: Traumatic Spondylolysis. There are bilateral horizontal fracture lines at pars interarticularis, leading to a separation between anterior and posterior spinal elements

Figure 2

A: A 43-year-old male injured a C5 separation fracture of lateral mass with incomplete Brown-Sequard

syndrome. A-P radiograph showed a typical horizontalization of left C5 lateral mass.

B: MRI showed the ALL and disc injury at C5/6 level.

C: CT scan demonstrated a typical floating lateral mass on the left side.

D.E: Single segment posterior fixation and fusion was conducted with cervical pedicle screw system. After four years postoperatively, the arthrodesis was complete and no adjacent segment change was demonstrated.

Figure 3

A, B: A 33-year-old male sustained C6 separation fracture of left lateral mass with C6 radiculopathy.

C, D: The osteosynthesis of fractured pedicle was carried out using a cannulated titanium screw. At five years postoperatively, the successful bony fusion was obtained at the fracture site, however, a slight anterior slippage of C6 vertebra remained without any symptom.

Figure 4

A,B: A 60-year-old male injured a comminution type of C5 lateral mass fracture with spinal cord injury of Frankel C grade. The supposed injury mechanism was C5-6 compressive-extension injury according to Allen's classification.

C,D: The comminuted right lateral mass displaced posteriorly, demonstrating two-level instability.

E,F,G: Two-level posterior fixation and fusion was carried out with cervical pedicle screw system followed by C4-7 laminoplasty. The successful arthrodesis was shown at one year postoperatively. The oblique x-ray demonstrated the accurate screw purchases.

Figure 5: Suggested algorism of treatment strategy for cervical lateral mass or articular process fracture. The algorism was simplified mainly based on the presence of neurologic abnormality and anterior or lateral vertebral subluxation for the emergency use.

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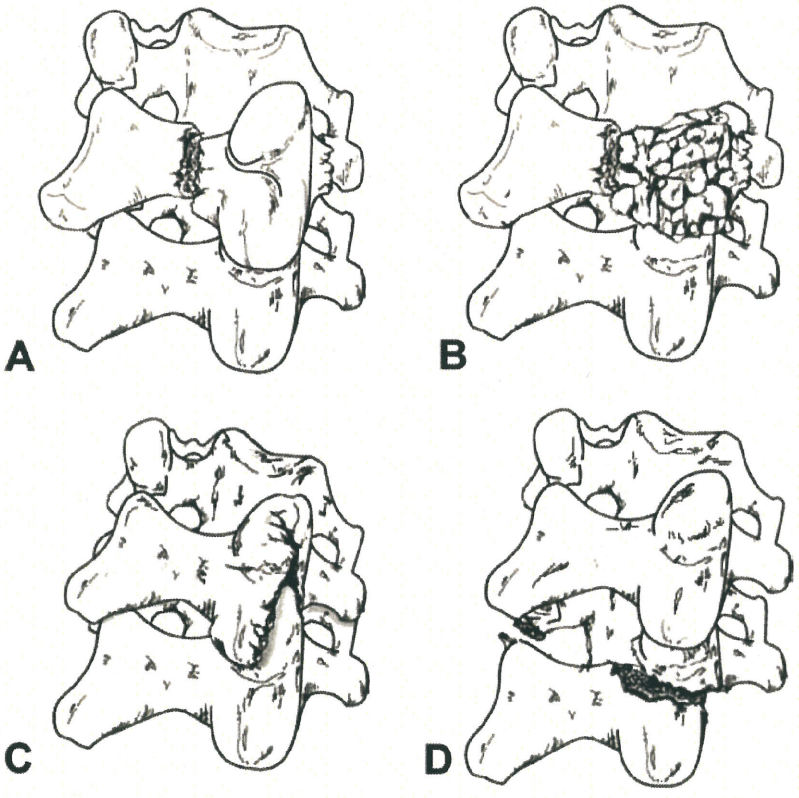
E,F,G: Two-level posterior fixation and fusion was carried out with cervical pedicle screw system followed by C4-7 laminoplasty. The successful arthrodesis was shown at one year postoperatively. The oblique x-ray demonstrated the accurate screw purchases.

Figure 5: Suggested algorism of treatment strategy for cervical lateral mass or articular process fracture. The algorism was simplified mainly based on the presence of neurologic abnormality and anterior or lateral vertebral subluxation for the emergency use.


A
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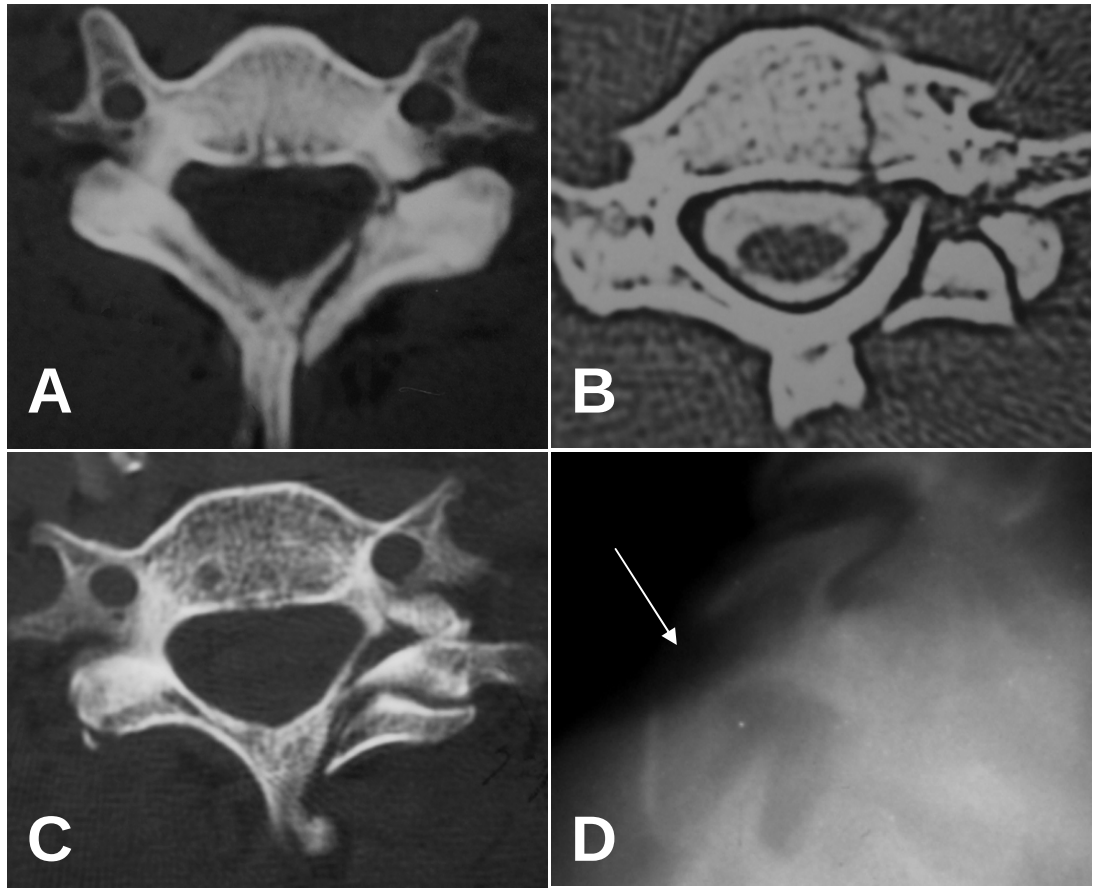
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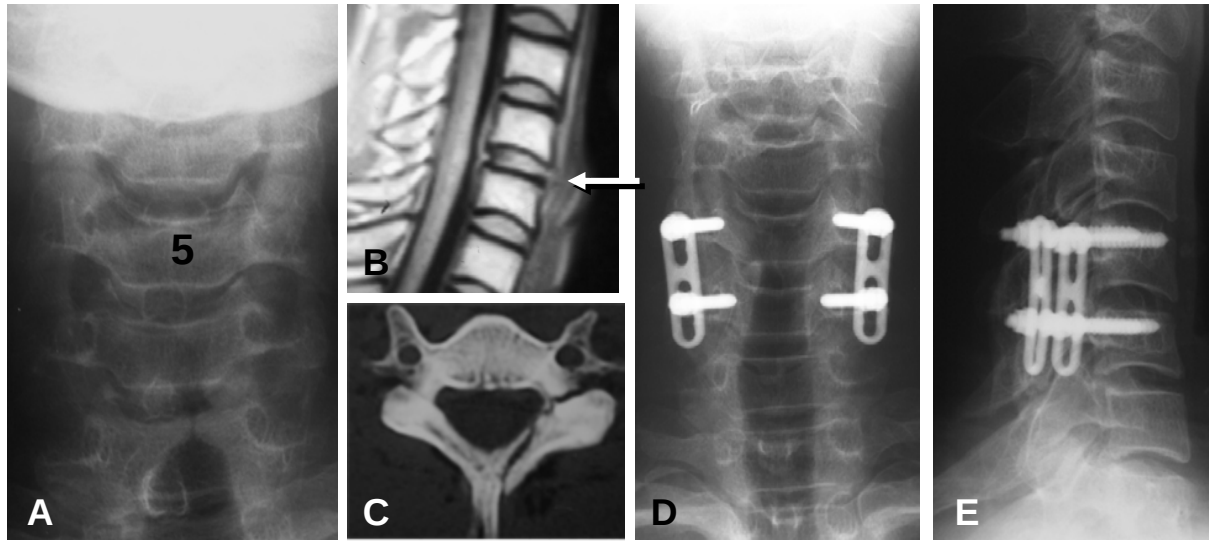
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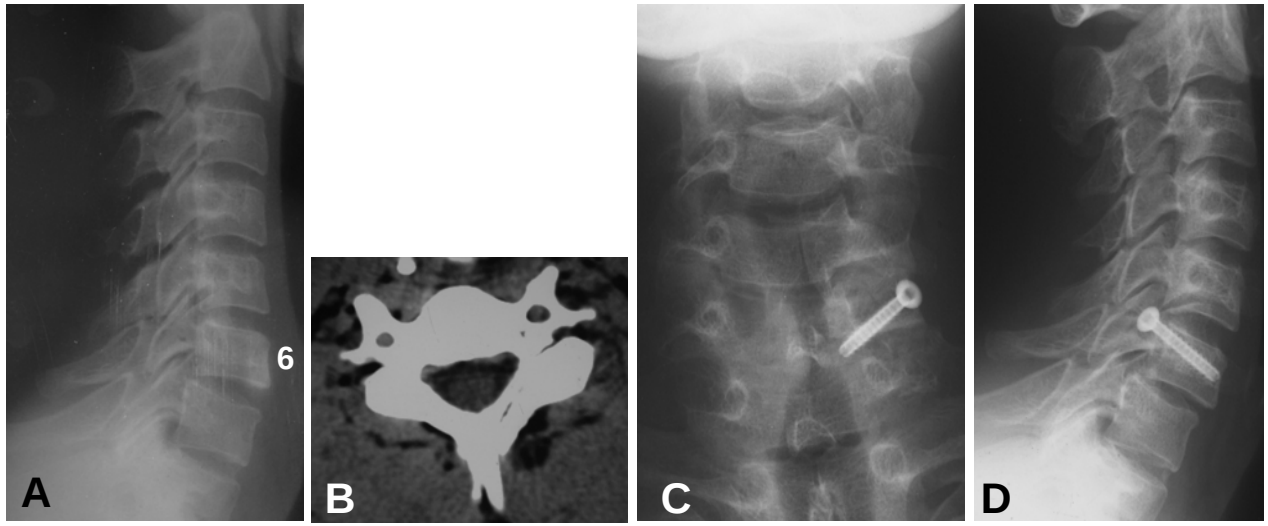
6
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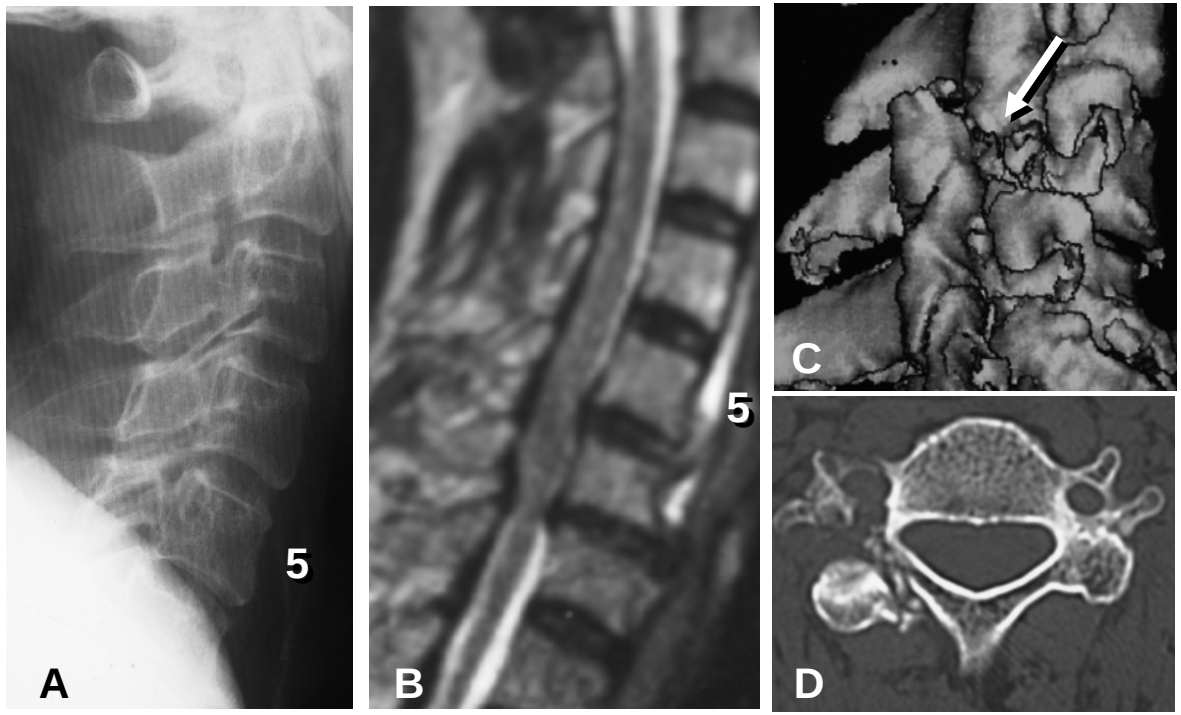
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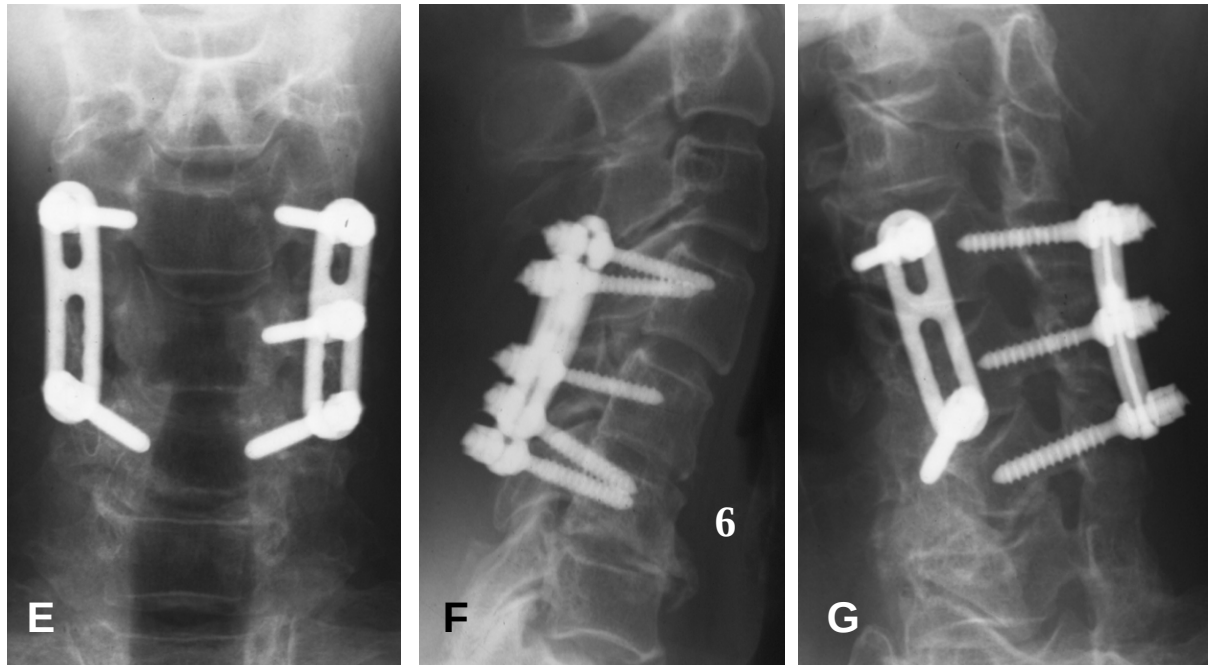
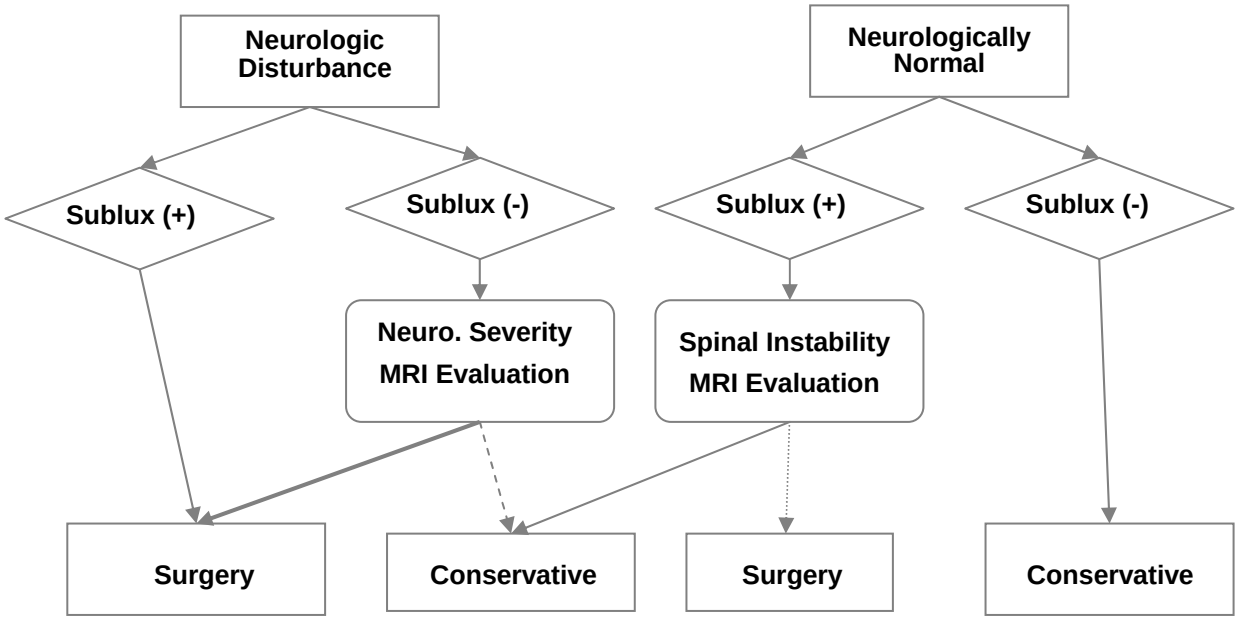

E
F
6
G


Neurologic Disturbance
Neurologically Normal
Sublux (+)
Sublux (-)
Sublux (+)
Sublux (-)
Neuro. Severity MRI Evaluation
Spinal Instability MRI Evaluation
Surgery
Conservative
Surgery
Conservative