T he lateral mass screw fixation technique is commonly used for fixation of an unstable cervical spine caused by trauma, degenerative disorders, neoplasms, rheumatoid arthritis (RA), and destructive spondyloarthropathy (DSA). This technique was first described by Roy-Camille et al. in the 1960s. In that report, lateral mass screws were used as a component of an internal fixation system for cervical spine arthrodesis. Following this, application of lateral mass screw fixation has been broadened by Anderson, An, and Jeanneret and their colleagues. Based on the subsequent clinical experiences showing its effectiveness and safety, the advantage of this technique over other procedures has been widely accepted.

Although lateral mass fixation is regarded as a relatively safe procedure, there are several complications that may be encountered during screw insertion, such as vertebral artery and nerve root injuries, facet violation, and lateral mass fracture. Among these, lateral mass fracture is considered to be one of the minor complications that does not cause serious insult. However, this complication may impair fixation strength or compel the surgeon to extend the fixation level that can potentially affect the postoperative outcome (Fig. 1). In previous literature, a few clinical papers referred to this complication with an incidence of 1.6%–4%. Among these, lateral mass fracture is considered to be one of the minor complications that does not cause serious insult. However, this complication may impair fixation strength or compel the surgeon to extend the fixation level that can potentially affect the postoperative outcome (Fig. 1). In previous literature, a few clinical papers referred to this complication with an incidence of 1.6%–4%. In our current clinical practice, indications for cervical fixation have expanded to include patient populations with severe deformity and instability as well as bone fragility caused by chronic morbidities such as DSA, RA, and osteoporosis. In these situations, the incidence of lateral mass fracture may be even higher than previously reported.

The purpose of this study is to determine the inci-
Incidence and etiology of lateral mass fractures during cervical lateral mass screw fixation in our clinical practice. It was hypothesized that the incidence of lateral mass fracture is higher than reported in previous literature, and there are specific patient subgroups exhibiting increased risk of this complication.

Methods

Study Population

One hundred twenty patients (583 lateral masses) who underwent cervical lateral mass screw fixation between 1997 and 2010 were included in the study. Among these patients, 3 patients (16 screws) who underwent cervical lateral mass screw fixation via an exceptional type of instrumentation were excluded. Lateral mass screws inserted at the C-7 level (10 screws) were excluded from the analysis because of the difference in bone morphology. Screw insertion was not attempted in 2 lateral masses at the C-3 level because of inadequate bone stock or size based on the intraoperative assessment of the surgeon. Therefore, 117 patients (555 lateral masses) composed the base for this study. All screws were placed using a modified Magerl method. The average age at surgery was 57 years (range 15–86 years). There were 72 male and 45 female patients who underwent 98, 173, 177, and 107 screw insertions at the C-3, C-4, C-5, and C-6 levels, respectively. Preoperative diagnoses were traumatic lesion (trauma), cervical spondylotic myelopathy, RA, ossification of the posterior longitudinal ligament, DSA, cerebral palsy, and tumor and other lesions (Table 1). Diagnosis of DSA was based on the radiological findings exhibiting narrowing of the intervertebral disc space with presence of erosion and cysts in the adjacent vertebral plates associated with minimal osteophyte formation. The OASYS system (Stryker Spine) with 3.5-mm screws and the Olerud system (Anatomica) with 4.0-mm screws were used in 52 patients (249 lateral masses) and 65 patients (306 lateral masses), respectively (Table 2). Instrumentation type was selected arbitrarily for each patient. The surgical procedure is illustrated in Fig. 2.

Definition of Lateral Mass Fracture

The definition of intraoperative lateral mass fracture was based on perception of a crack in the lateral mass during screw placement (drilling, tapping, and screwing) by experienced spine surgeons. Data regarding screw pull-out and breakage detected initially by CT scanning in the early postoperative period were not included because it was impossible to determine whether the event occurred intraoperatively or in the early postoperative period.

Incidence and Analysis of Risk Factors of Intraoperative Lateral Mass Fracture

The incidence of intraoperative lateral mass fracture during lateral mass fixation among all cases was calculated. Thereafter, subgroup analyses were performed based on factors such as age, sex, side of fracture, cervical level,
**Intraoperative lateral mass fracture of lateral mass screw fixation**

**Results**

**Incidence of Lateral Mass Fractures**

Incidence of lateral mass fractures during cervical lateral mass fixation among all cases was 4.7% (26 lateral masses), or in other words, 20 patients (17.1%) had this complication (Table 3). In the subgroup analysis (Table 4), it was shown that the incidence was significantly higher in patients with DSA (18.8%, 12 lateral masses). As a result, we found that more than half of the patients with hemodialysis (63.6%, 7 patients) had this complication. There were 4 patients who had multiple broken lateral masses, 3 of whom had DSA (Fig. 3). Age, sex, and side of fracture showed no significant difference (p = 0.835, p = 1.000, and p = 0.851, respectively). Regarding the level of the cervical spine, the rate of lateral mass fracture was significantly higher at C-6 (9.3%) than at other cervical levels (p = 0.035). Incidences of lateral mass fracture were 5.6% and 3.6% with 4.0-mm screws and 3.5-mm screws, respectively (p = 0.318). When the effects of screw diameter on the fracture rate were assessed in patients with DSA, the incidence of lateral masses fixed with 4.0-mm screws was higher than that of those fixed with 3.5-mm screws, with no significant difference (25.6% vs 8.0%, p = 0.106).

**Multivariate Analysis**

In the multivariate analysis, independent risk factors identified by stepwise logistic regression were DSA (OR 7.890 [95% CI 3.430–18.200], p < 0.001) and screw placement in the C-6 lateral mass (OR 2.800 [95% CI 1.190–6.590], p = 0.018) (Table 5).

**Management for Intraoperative Lateral Mass Fracture**

During intraoperative management to deal with intraoperative lateral mass fracture, screw insertion at the corresponding level was abandoned in 15 of the 26 lateral masses with fractures (Table 3). In 3 of these 15 lateral masses, the fusion level was extended to the adjacent level. In the remaining 11 lateral masses in which the screw was placed at the level of fracture, the screw trajectory or length was altered in 5 lateral masses. Overall, the occurrence of this complication compelled the surgeon to reinsert the screw or abandon screw placement in 77% of cases.

**Discussion**

**Findings of the Present Study**

The present study demonstrated the following findings. 1) The overall incidence of lateral mass fractures during cervical lateral mass fixation was 4.7%. 2) The incidence was highest in patients with DSA (18.8%). 3) Independent risk factors identified using multivariate analyses were patients with DSA and screw placement in the C-6 lateral mass.

**Previous Studies on Intraoperative Lateral Mass Fracture**

The previous clinical studies by Katonis et al., Sekhon, and Inoue et al. reported that the incidence of lateral mass fractures during cervical lateral mass screw fixation was 1.6%–4.0%. The incidence reported in the present study (4.7%) is higher than the value in the previous studies. In a cadaveric study by Choueka et al., however, lateral mass fractures on screw insertion were not detected in 6% of masses fixed with Roy-Camille screws and in 7% of masses fixed with Magerl screws. From a clinical viewpoint, the apparently higher incidence indi-

**Fig. 2.** Drawings showing the modified Magerl technique. The entry point of this procedure was 1 mm medial to the midpoint of the lateral mass. The screws were directed approximately 30° laterally and superiorly (parallel to the facet joint).
cate in the present study may be attributed to the following factors. First, surgical indication has been expanded to complex deformities and instabilities as well as patients with DSA and RA complicated by substantial bone fragility.12,18,26,28,29 Consequently, the incidence in our current practice may well be higher than the value reported in previous literature. Incidentally, incidence of patients without poor bone quality such as either RA or DSA was 2.6%, which corresponds to the value reported in previous studies. Additionally, there is a difference in skeletal size between the Japanese and Caucasian populations, and thus the use of screws of the same size range in our patient population may have led to an increased incidence of this complication in this study.

In regard to the risk factors for intraoperative lateral mass fractures, Katonis et al.14 claimed that an excessively lateral screw trajectory was a technical factor associated with increased incidence of lateral mass fracture. However, detailed subgroup comparisons or multivariate analyses were not performed in the previous studies, and thus the risk factors leading to this complication have not been well clarified.

**Bone Fragility in Patients With Long-Term Hemodialysis**

We found that DSA is a highly correlated risk factor for intraoperative lateral mass fractures. In 1984, Kuntz et al. first described radiological features of DSA of the spine characterized by disc space narrowing, vertebral erosion, and irregular endplate destruction in conjunction with minimal osteophyte formation as a complication observed in patients undergoing long-term hemodialysis.16 Since 1984 the number of reports regarding DSA has been increasing.20 The cervical spine is the most commonly involved spinal region. In a 5-year radiological prospective study, Leone et al.17 reported finding cervical spine DSA in 19% of patients. Patients with DSA have severe bone fragility due to renal osteodystrophy and a decrease in bone mineral density.18,19,29 The quality of bone in patients with renal osteodystrophy was compromised by various pathologies such as secondary hyperparathyroidism, 1,25-dihydroxyvitamin D deficiency, previous immunosuppression therapy, chronic acidosis, secondary amenorrhea, and chronic aluminum and heparin exposure.27 It has been reported that the age-adjusted incidence of hip fractures in the hemodialysis population was 4.4 times greater than that in the general population, while the relative risk of hip fracture increased as the time period since first dialysis increased.2 Risk factors for the development of DSA include the duration of renal failure, duration of hemodialysis therapy, and clinical variables.17,20 The mean duration of hemodialysis in patients with DSA in the present study was 19 years (range 12–30 years), and the impaired bony properties in this population were thought to be correlated to an increased incidence of intraoperative lateral mass fracture.
Intraoperative lateral mass fracture of lateral mass screw fixation

**TABLE 4: Incidence of lateral mass fracture**

<table>
<thead>
<tr>
<th>Variable</th>
<th>No. of Fractured Lateral Masses (%)</th>
<th>p Value†</th>
</tr>
</thead>
<tbody>
<tr>
<td>age at op in yrs</td>
<td></td>
<td>0.835</td>
</tr>
<tr>
<td>&gt;65</td>
<td>10/200 (5.0)</td>
<td></td>
</tr>
<tr>
<td>&lt;65</td>
<td>16/355 (4.5)</td>
<td></td>
</tr>
<tr>
<td>sex</td>
<td></td>
<td>1.000</td>
</tr>
<tr>
<td>female</td>
<td>10/209 (4.8)</td>
<td></td>
</tr>
<tr>
<td>male</td>
<td>16/346 (4.6)</td>
<td></td>
</tr>
<tr>
<td>side</td>
<td></td>
<td>0.851</td>
</tr>
<tr>
<td>rt</td>
<td>15/276 (5.4)</td>
<td></td>
</tr>
<tr>
<td>lt</td>
<td>14/279 (5.0)</td>
<td></td>
</tr>
<tr>
<td>level</td>
<td></td>
<td>0.035</td>
</tr>
<tr>
<td>C-3</td>
<td>1/98 (1.0)</td>
<td></td>
</tr>
<tr>
<td>C-4</td>
<td>9/173 (5.2)</td>
<td></td>
</tr>
<tr>
<td>C-5</td>
<td>6/177 (3.4)</td>
<td></td>
</tr>
<tr>
<td>C-6</td>
<td>10/107 (9.3)</td>
<td></td>
</tr>
<tr>
<td>screw outer diameter in mm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.5</td>
<td>9/249 (3.6)</td>
<td></td>
</tr>
<tr>
<td>4.0</td>
<td>17/306 (5.6)</td>
<td></td>
</tr>
<tr>
<td>preop diagnosis</td>
<td></td>
<td>NA</td>
</tr>
<tr>
<td>trauma</td>
<td>4/143 (2.8)</td>
<td></td>
</tr>
<tr>
<td>CSM</td>
<td>5/119 (4.2)</td>
<td></td>
</tr>
<tr>
<td>RA</td>
<td>3/73 (4.1)</td>
<td></td>
</tr>
<tr>
<td>OPLL</td>
<td>0/36 (0)</td>
<td></td>
</tr>
<tr>
<td>DSA</td>
<td>12/64 (18.8)</td>
<td></td>
</tr>
<tr>
<td>cerebral palsy</td>
<td>0/30 (0)</td>
<td></td>
</tr>
<tr>
<td>tumor &amp; other</td>
<td>2/90 (2.2)</td>
<td></td>
</tr>
</tbody>
</table>

* NA = not available.
† Chi-square test. Value in boldface is statistically significant.

**Level of Fixation**

The incidence of intraoperative lateral mass fracture was shown to be significantly higher at the C-6 level than at other cervical levels. This tendency may be due to the anatomical characteristics of the subaxial cervical spine. It has been shown that the width of the C-6 lateral mass in general is thinner than that of C-3. Moreover, there have been several reports showing anatomical differences between C-3 and C-6. We have previously reported that the majority of facet violations were detected at the C-6 level with a significantly higher incidence compared with other levels. Therefore, the results of this study and findings in previous literature may instill caution for placing screws at the C-6 level.

**Relationship With Screw Diameter**

Our study demonstrated no statistically significant difference between 4.0-mm and 3.5-mm screws with regard to intraoperative lateral mass fracture (5.5% vs 3.6%). In a supplemental subgroup analysis, use of 4.0-mm screws in patients with DSA was associated with an increased risk for intraoperative lateral mass fracture compared with 3.5-mm screws (25.6% vs 8.0%). Thus, in primary posterior cervical spinal fusion for patients with DSA, 3.5-mm screws may be selected to reduce the risk of intraoperative lateral mass fracture. In assessment of the effect of screw diameter on the incidence of this complication, the size of the lateral mass can be another factor influencing the results; however, analysis in this regard was not feasible due to the lack of data relevant to volume of the lateral mass.

**Management for Intraoperative Lateral Mass Fracture**

Considering the intraoperative management to deal with the occurrence of lateral mass fracture, the screw trajectory/length was altered or screw placement at the corresponding level was abandoned in approximately 80% of the cases. Sekhon recommended conversion to a modified Roy-Camille technique when the insecurity of the fixation was in doubt. Conversion to a modified transarticular screw technique as proposed by Miyamoto et al. is another option. In the case of substantial lateral mass fracture at C-6 at the lowest fixation level, conversion to the C-7 pedicle screw technique may be a way to deal with this complication.

**TABLE 5: Analysis of risk factors by multivariate analyses**

<table>
<thead>
<tr>
<th>Variable</th>
<th>OR (95% CI)</th>
<th>p Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>DSA</td>
<td>7.890 (3.430–18.200)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>C-6 level</td>
<td>2.800 (1.190–6.590)</td>
<td>0.018</td>
</tr>
</tbody>
</table>

* Logistic regression. Boldface indicates significance.
Study Limitations

There are some limitations of this study. First, the study design is a retrospective review based on the operative record, and surgeries were performed by multiple surgeons with varying levels of experience. Therefore, confounding variables such as errors of entry point or the trajectory of lateral mass screws were involved in the occurrence of this complication. Second, diagnosis of the fracture was solely based on the surgeon’s perception; however, CT scanning is the most effective way of evaluating the postoperative condition of the lateral masses. If the complication had been assessed by CT in the early postoperative period, the actual incidence may have been greater than the value reported here. Third, because bone mineral density data were not available for all patients in the current study and the volume of the lateral mass was measured by CT reconstruction, it was impossible to analyze this complication in relation to bone quality or lateral mass size. Finally, the effect of this complication on the subsequent clinical course was not examined in the analysis. A clinical follow-up evaluation for this group of patients is required to examine the significance of the present study.

Conclusions

The overall incidence of lateral mass fracture during cervical lateral mass screw fixation was 4.7%. The occurrence of this complication compelled the surgeon to reinsert the screw with a different trajectory/screw length or skip the fixation at the corresponding level. Independent risk factors identified by multivariate analyses were DSA and screw placement in the C-6 lateral masses. Use of 4.0-mm screws in patients with DSA may be a principal risk factor for this complication.

Disclosure

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author contributions to the study and manuscript preparation include the following. Conception and design: Inoue, Okada, Maruo, Horinouchi. Acquisition of data: Inoue, Moriyama, Tachibana, Oka-da, Maruo. Analysis and interpretation of data: Inoue, Moriyama. Drafting the article: Inoue. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Inoue. Study supervision: Yoshiya.

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