Risk Factors for Neurosensory Disturbance After Bilateral Sagittal Split Osteotomy Based on Position of Mandibular Canal and Morphology of Mandibular Angle

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Purpose: The aim of the present study was to evaluate the potential morphologic risk factors for postoperative neurosensory disturbance (NSD) after bilateral sagittal split osteotomy.

Patients and Methods: The study subjects were 30 skeletal Class III patients (9 males and 21 females), with a mean age of 22.0 years (range, 16-39 years). All patients underwent bilateral sagittal split osteotomy for setback to correct mandibular prognathism. The bone marrow space between the outer mandibular canal and the lateral cortex of the ramus was measured on transaxial computed tomography images, and the length at the mandibular angle between the retromolar and gonion was measured on the lateral cephalograms. The NSD was tested bilaterally using discrimination to touch with the sharp head of a mechanical probe. Each patient was evaluated at 1, 3, and 6 months postoperatively.

Results: The median bone marrow space was 1.96 mm (range, 0-4.5 mm), and median length of the mandibular angle was 30.93 mm (range, 23-37 mm). Neurosensory disturbance was present on 15 sides (25.0%) at 1 month postoperatively, 9 sides (15.0%) at 3 months postoperatively, and 7 sides (11.7%) at 6 months postoperatively. The difference in the incidence of NSD with a small bone marrow space and a long mandibular angle from that with a large bone marrow space and short mandibular angle was highly statistically significant (P = .006 and P < .01, respectively).

Conclusions: The frequency of NSD after bilateral sagittal split osteotomy in Class III cases was dependent not only on the position of mandibular canal, but also on the length of the mandibular angle. A lateral course of the mandibular canal and a long mandibular angle appeared to result in a high risk of injury to the inferior alveolar nerve, resulting in NSD owing to a compromised splitting procedure.

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Bilateral sagittal split osteotomy (BSSO) is the orthognathic procedure most often used to correct mandibular deformities. One of the most frequent complications after BSSO is neurosensory disturbance (NSD) of the inferior alveolar nerve (IAN), with a reported incidence of 9% to 85%.1,2 Many factors can affect the development of NSD after BSSO, including patient age, the magnitude of the mandibular movement, the degree of nerve manipulation during surgery, the skill and experience of the surgeon, and the method and

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timing of the postoperative neurosensory evaluation.\textsuperscript{2,3} The anatomic location and course of the mandibular canal are major factors because of the risk of exposure of the IAN during the splitting procedure.\textsuperscript{3-5} Yamamoto et al\textsuperscript{5} described the contact between the mandibular canal and external cortical bone using computed tomography, and Tsuji et al\textsuperscript{6} reported the position and course of the mandibular canal of skeletal Class III patients using computed tomography. The bone marrow space between the mandibular canal and external cortex and its effect on injury to the IAN was evaluated. The morphology of the mandibular angle region varies in each patient. Clinically, surgeons sometimes encounter difficulty with the splitting method, and the procedure becomes more complex and longer. A few reports have evaluated the risk factors of postoperative NSD after BSSO in terms of the position of the mandibular canal and the morphology of the mandibular angle region. In the present study, we evaluated the position of the mandibular canal from preoperative transaxial computed tomography images and the length of the mandibular angle from the lateral cephalograms and examined the relationship between postoperative NSD after BSSO and these 2 factors.

**Patients and Methods**

The institutional ethics committee of Kyushu Dental College approved the present retrospective study. The study subjects were 30 skeletal Class III patients (9 males and 21 females), with a mean age of 22.0 years (range, 16-39 years). All patients underwent BSSO for mandibular setback at the Division of Oral and Maxillofacial Reconstructive Surgery at Kyushu Dental College (Kitakyushu, Japan) and had the same sequence of preoperative radiographic and clinical examinations, treatment planning, and pre- and postoperative orthodontic treatments. The mandibular third molars were removed at least 4 months before surgery in all cases. The operations were performed with the patient under general anesthesia and with local anesthesia with lidocaine plus adrenaline in the surgical area. The surgical technique was performed as described by Dal Pont.\textsuperscript{4,7} The horizontal medial cut was positioned as close to the lingual side as possible using a fissure bar. The bur continued the cut anteriorly, medial to the external oblique ridge. At the second molar teeth, the osteotomy was carried vertically to the inferior border of the mandible. A thin osteotome was partially malleted to the section from the anterior area. Confirming the mandibular split, care was taken that the neurovascular bundle was not contained in the proximal segment. Finally, a bone spreader was used to complete the split and for separation. Semirigid fixation was achieved using 4- or 6-hole miniplates and monocortical screws (Stryker, Freiburg, Germany). Intermaxillary fixation was used for about 4 days postoperatively, and elastic guidance was used for stable occlusion.

NSD was tested bilaterally using discrimination to touching with the sharp head of a mechanical probe. Each patient was evaluated 1, 3, and 6 months postoperatively.

For the transaxial computed tomography examination, a Toshiba Aquilion scanner (Toshiba, Otawara, Japan) was used, with a slice thickness of 2 mm and a scan time of 22 seconds for all patients. Transverse scans of the head were made parallel to the mandibular occlusal plane from the level of the temporomandibular joint to the inframandibular margin. A total of 60 computed tomography scans of the mandibular ramus from 30 patients were examined.

The bone marrow space between the outer mandibular canal and lateral cortex of the ramus was measured with a special 0.1-mm ruler with a magnifier (Fig 1). The measurement was made about 10 mm inferior to the occlusal plane. The bone marrow space was divided into 4 groups: group I, 1 mm or less; group II, 1 to less than 2 mm; group III, 2 to less than 3 mm; and group IV, greater than 3 mm.

The cephalometric evaluation was performed using the preoperative lateral cephalograms. To measure the length at the mandibular angle region, 2
measurement points were defined for the present study (Fig 2):

Retromolar (Rm): the point at each mandibular angle defined by drawing a perpendicular line from the intersection of the tangents to the anterior margin of the mandibular vertical ramus and superior margin of the mandibular body. The anterior margin of the mandibular vertical ramus was the line through the anterior- and posterior-most points evaluated from the Frankfort plane as a datum line. The superior margin of the mandibular body was the line through the superior-most symphyseal point and the distal point of the second molar.

Gonion (Go): the intersection of the tangents to the posterior margin of the mandibular vertical ramus and inferior margin of the mandibular body or horizontal ramus.

In the cephalometric evaluation, error analysis was performed by retracing and repeated measuring in all cases that averaged less than 0.4 mm for the line.

The length of retromolar-gonion is the length of the mandibular angle. The length was classified into 4 groups: group A, 28 mm or less; group B, 28 to less than 31 mm; group C, 31 to less than 34 mm; and group D, greater than 34 mm.

The number of patients with NSD at 1 month postoperatively was calculated for each group according to the bone marrow space and the length of the mandibular angle.

To evaluate the surgical risk according to the mandibular morphology, 2 groups were considered for each factor. The small mandibular space group included groups I and II, and the large mandibular space group included groups III and IV. The short mandibular angle group included groups A and B, and the long mandibular angle group included groups C and D.

The data for 1 month postoperatively were used to evaluate the surgical risk factors for NSD. The frequency differences in bone marrow space, length of the mandibular angle, and these 2 factors were analyzed using the $\chi^2$ test. The level of significance was set at $P = .05$.

### Results

The median bone marrow space was 1.96 mm (range, 0-4.5 mm), and the median length of the mandibular angle was 30.9 mm (range, 23-37 mm).

Neurosensory disturbance was seen on 15 sides (25.0%) at 1 month postoperatively, 9 sides (15.0%) at 3 months postoperatively, and 7 sides (11.7%) at 6 months postoperatively (Fig 3). The frequency of NSD decreased with an increasing bone marrow space. Neurosensory disturbance at 1 month postoperatively was observed in 8 (57.1%) of 14 in group I, 5 (25.0%) of 20 in group II, 1 (5.9%) of 17 in group III, and 1 (11.1%) of 9 in group IV. The incidence for group I was significantly different from that for group III ($P = .002$) and IV ($P = .03$; Fig 4). The frequency of NSD increased with the length of the mandibular angle. Neurosensory disturbance at 1 month postoperatively was observed in 1 (7.1%) of 14 in group A, 4 (22.2%) of 18 in group B, 5 (27.8%) of 18 in group C, and 5 (50%) of 10 in group D. The incidence in group D was significantly different statistically from that in group A ($P = .02$; Fig 5).

The incidence of NSD was significantly different in those with a small bone marrow space and a long mandibular angle versus a large bone marrow space and short mandibular angle ($P = .006$; Table 1). This suggests that the increase in the incidence of NSD after BSSO is related to less space between the outer mandibular canal and lateral cortical bone and a longer mandibular angle.

### Discussion

Neurosensory disturbance remains 1 of the major complications of BSSO. Previous studies have revealed that the risk factors include neurosensory damage, compression or decompression injuries during medial periosteal dissection, fixation methods, postoperative swelling or bleeding, patient age, the osteotomy line, and the direction of mandibular move-
Neurosensory disturbance arising from the splitting procedure can directly interfere with function; thus, it is important to consider each patient’s risk of NSD, according to the mandibular morphology determined from the preoperative medical images. The present study focused on the mandibular morphology and evaluated the risk factors for NSD after BSSO, according to the location of the mandibular canal and the morphology of the mandibular angle region.

The distance between the mandibular canal and the split surface was evaluated as a surgical risk factor for NSD after BSSO. It has been reported that the inferior alveolar nerve (IAN) is located as close as 0.5 mm to the buccal cortex, with a mean value of less than 2 mm. Hallikainen et al. noted that the distance between the canal and buccal cortex was less in cases of prognathism than in cases of retrognathism, using cross-sectional tomography. Tsuji et al. reported that the mandibular canal contacted the external cortical bone in 16 (22.9%) of 70 rami. In many cases, it was observed from the mandibular foramen to the mandibular angle. In the present study, we measured the distance between the mandibular canal and external cortical bone at a level 10 mm inferior to the mandibular foramen, and the median bone marrow space was 1.96 mm. The frequency of NSD was significantly different between group I and groups III and IV. This suggests that a shorter distance between the mandibular canal and lateral cortex increases the

FIGURE 3. Frequency of neurosensory disturbance at 1, 3, and 6 months after bilateral sagittal split osteotomy.

FIGURE 4. Frequency of neurosensory disturbance (NSD) after bilateral sagittal split osteotomy according to bone marrow space between mandibular canal and lateral cortical bone. *P < .01, **P < .05.
risk of NSD after BSSO. Nevertheless, NSD was observed on 2 sides (7.7%) in the large space group (groups III and IV); thus, other factors can also result in damage to the IAN.

Some physicians have recommended using a thin osteotome driven to the inferior border from a lateral cortical cut. Nevertheless, NSD sometimes occurs after careful use of a thin osteotome for sagittal split osteotomy, even with bone marrow space between the mandibular canal and external cortical bone.

During sagittal split osteotomy, difficulty is sometimes encountered during the splitting procedure, especially at the inferior portion of the split in the angle region because the cortex bends, but does not break. In such cases, the surgical procedure is more likely to be compromised by the deep insertion of surgical instruments compared with “easy” cases. We also evaluated the relationship between the frequency of NSD and the length of the mandibular angle. The frequency of NSD differed significantly between groups A and D. This supports the hypothesis that a compromised splitting procedure induced damage to the mandibular canal, resulting in NSD after BSSO. The surgical technique for BSSO used in this the present was based on that of Dal Pont. The medial bone cut was extended toward the posterior border before bending to the inferior border of the ramus. This method is intended to increase the splitting surface to complete the mobilization of each segment. The Hunsuck modification, a fracture through or behind the mandibular foramen toward the inferior border of the mandible, results in a smaller splitting area than the Dal Pont method; thus, the frequency of NSD could differ from our results. Also, in evaluating risk factors with the method used in the present study for the Hunsuck modification, another measurement points or lines might be needed for appropriate evaluation of the splitting area. Furthermore, van Merkesteyn et al reported that the use of splitting forceps and elevators without chisels led to a low percentage of persistent postoperative hypoesthesia; thus, the selection of surgical instruments could also affect the incidence of NSD after BSSO.

Additionally, other factors affected the incidence of NSD in our study. The effects of some factors on injury to the IAN, such as medial subperiosteal dissection in the region of the mandibular foramen, were difficult to evaluate because of the poor surgical view. All patients underwent BSSO performed by 2 oral

Table 1. FREQUENCY OF NSD ACCORDING TO BOTH FACTORS

<table>
<thead>
<tr>
<th>Bone Marrow Space</th>
<th>Length of Mandibular Angle</th>
<th>Patient Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small (I + II)</td>
<td>Short (A + B)</td>
<td>4/15 (26.7%)</td>
</tr>
<tr>
<td></td>
<td>Long (C + D)</td>
<td>9/19 (47.4%)†</td>
</tr>
<tr>
<td>Large (III + IV)</td>
<td>Short (A + B)</td>
<td>1/17 (5.9%)‡</td>
</tr>
<tr>
<td></td>
<td>Long (C + D)</td>
<td>1/9 (11.1%)</td>
</tr>
</tbody>
</table>

NOTE. Incidence of neurosensory disturbance (NSD) with small bone marrow space and long mandibular angle was significantly different from that with large bone marrow space and short mandibular angle.

*P = .006.
‡P < .01.

maxillofacial surgeons who have worked together for a long time. Thus, the surgical methods and instruments used were very similar, and the minor point of surgical factors could be ignored in our study. Another factor is the fixation technique: lag screw fixation has been reported to lead to a greater incidence of hypoesthesia; consequently, it was not used in our study. For osteosynthesis, 4- or 6-hole miniplates and monocortical screws were used. The compression force is less than with lag screws, and it is difficult to assess whether the screws contacted or injured the IAN directly.

Recovery from nerve damage was most marked during the first 3 postoperative months, consistent with the results of prospective 1-year follow-up studies of IAN recovery after BSSO. In the present study, the greatest frequency of NSD was at 1 month postoperatively, and it decreased with time. Compared with the reported frequency of NSD after BSSO, the percentage of NSD was relatively low in our series. Teerijoki-Oksa et al. reported that brush-stroke directional discrimination, warm/cold, and sharp/blunt discrimination were not sensitive enough to detect slight nerve disturbances. These test methods revealed severe nerve injuries when performed soon after surgery. If more sensitive tests were applied, such as the touch detection threshold, the frequency might have been greater; however, the frequency trend during the follow-up period or the type of mandibular morphology might not change significantly.

In conclusion, the frequency of NSD after BSSO in Class III cases depends not only on the position of the mandibular canal, but also on the length of the mandibular angle. A lateral course of the mandibular canal and long mandibular angle appear to result in a high risk of injury to the IAN, resulting in NSD, because of a compromised splitting procedure. The preoperative evaluation of medical images is important for assessing the risk of complications and improving the doctor–patient relationship.

References

MORPHOMETRIC RISK FACTORS OF NSD AFTER BSSO