Asymmetric mandibular prognathism: Outcome, stability and patient satisfaction after BSSO surgery. A retrospective study

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Abstract
Purpose: To investigate surgical outcome, long-term stability, the time course of relapse, neurosensory disturbances, and patient satisfaction after BSSO for correction of mandibular asymmetry. Another objective was to examine whether osteotomies for transverse rotation of the distal segment represent an increased risk for nerve injury.

Subjects and methods: In a retrospective study lateral and postero-anterior cephalograms, information from patient files and questionnaires were analysed for 38 patients having more than 4 mm asymmetry at the chin pre-treatment (mean 8.4 mm). The radiographs were analysed preoperatively, post-operatively, after 6 months and 3 years.

Results: Asymmetry of the chin to the facial midline improved on average by 56%. Skeletal relapse was about the same for transverse and antero-posterior surgical changes (10–15%). 58% of the patients had asymmetry of more than 3 mm at menton 3 years post-surgery. Discrepancy between upper and lower dental midlines improved on average 80%. Normal or near normal sensation to the lower lip/chin was reported by 44% of the patients which is similar to sensory disturbances after BSSO straight set-back performed by the same surgical team. A difference in the incidence of neurosensory disturbance between the two osteotomy sides was observed. Satisfaction with the treatment result was reported by all patients except for two.

Conclusion: Correction of mandibular asymmetry by BSSO is fairly stable. Although the risk for sensory impairment for the individual patient was similar to impairment in a sample having straight setback, rotation of the distal segment during surgery may represent an increased risk for sensory impairment on the deviating side (P = 0.06). Three years after surgery patients were generally satisfied with the result even if more than 3 mm of asymmetry at the chin remained for 58%. The findings have implications for treatment planning and the decision to elect one-jaw, bimaxillary surgery and/or additional genioplasty.

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1. Introduction

Asymmetry of the face is a common complaint among patients with maxillofacial deformities, even if the asymmetry may be combined with other deviations (Severt and Profitt, 1997). Usually the mandible is more asymmetric than the maxilla (Haraguchi et al., 2002).

Bilateral sagittal split osteotomies (BSSO) allow the distal segment of the mandible to be repositioned in the three planes of space, and transverse deviation from the facial midline may thus be corrected. There is a greater displacement between the distal and proximal segments takes place on the longer side of the mandible. Furthermore adaptation of the segments to obtain optimal bony contact may be necessary. This is one of the most challenging orthognathic procedures to plan and carry out which may have implications for long-term post-treatment stability and iatrogenic effects like sensory impairment.

Few reports on the stability of transverse mandibular corrections are available. Severt and Profitt (1997) observed about 40 per cent relapse after correction of the chin by both BSSO-only and bimaxillary procedures one year postoperatively. Ko et al. (2009),

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on the other hand, reported stability after transverse correction of the chin by bimaxillary surgery. Correction of the mandibular skeletal midline by BSSO has been reported by Yamashita et al. (2009). No information about the follow-up period was presented in these studies. So far, no studies have examined whether rotation of the mandibular distal segment in the horizontal plane is associated with an increased risk of sensory alterations. Patients’ satisfaction with outcome of treatment for mandibular asymmetry remains to be investigated.

The aim of the study was therefore to investigate long-term stability after transverse mandibular correction by BSSO and if/when relapse occurs. Additional objectives were to examine whether osteotomies for rotation of the distal segment represent an increased risk for nerve injury, and if patients are satisfied with the overall result.

2. Subjects and methods

Patients treated orthodontically and surgically for skeletal Class III malocclusion with mandibular asymmetry were retrieved from the archives at the Department of Orthodontics, University of Oslo. Between 1993 and 2005 38 consecutive patients (26 females and 12 males) who had BSSO and rigid fixation as the only surgical procedure were identified and represented the study sample according to the following inclusion criteria: 1) patients with mandibular prognathism and Class III malocclusion at least on one side, 2) clinically diagnosed asymmetry of the lower face with a mandibular midline deviation of at least 4 mm at menton, 3) an orthognathic maxilla with no or only slight asymmetry, 4) a post-surgery observation period of 3 years, and 5) complete records of lateral and posterior–anterior (PA) cephalograms of good quality presurgery (T1), postoperatively (T2), 6 months (T3), and 3 years after surgery (T4). Patients with craniofacial anomalies (i.e. hemifacial microsomia and syndromes) and fracture of facial bones were excluded. A sample of 65 C Ili patients operated by BSSO for straight mandibular set-back served as reference for assessment of sensory impairment and patient satisfaction, and the data for this group has been presented previously (Hågensli et al., 2013).

All patients had pre- and postoperative orthodontic treatment. No physiotherapy or speech therapy was part of the treatment. If patients had third molars in the mandible, they were removed at a period of 48 h. Subsequently 40 mg slow releasing methylprednisolone (Depo-medrol, Pfizer®; NY, USA) was given intra muscularly. Prophylactic antibiotics were given with benzylpenicillin (Penicillin, Actavis®; Oslo, Norway) 5 mill II × 8 iv during the same period of 48 h. The first dosage of antibiotics was given peroperatively. Postoperative pain was treated with a combination of paracetamol and codeine (Pinex Forte, Actavis®; Oslo, Norway).

Information about the surgery and subsequent observations was extracted from the patients’ files. Alterations in sensibility to the lower lip/chin were investigated by a combination of questionnaires and clinical examination (light touch by cotton swabs). Data related to the patients’ opinions about the treatment outcome was collected from questionnaires distributed at the 3-year review.

The outline of the stable structures in the cranial base from both the lateral and PA cephalograms was transferred on acetate paper from the x-ray of best quality to the other x-rays. The tracings were scanned and the magnification was adjusted by 5.6% to the actual size and digitized with a software program (Facad, Ilexis AB, Linköping, Sweden).

On the PA cephalograms a coordinate system was constructed through the orbital roofs (x-axis) and a perpendicular through the best fit upper facial midline (y-axis). Best fit midline was determined by a combination of crista galli and the midpoint between the medial orbital walls as reference landmarks (Fig. 1). On the lateral cephalograms a coordinate system was constructed through the sella with a horizontal reference line (x-axis) rotated 7° down from the sella–nasion line. The y-axis was perpendicular to the x-axis through sella (Fig. 2).

For reliability analysis 20 lateral and 20 PA cephalograms were retraced after 3 weeks by the same person (NH) and intraclass correlation coefficient (ICC) values were calculated. To test for statistical significance of changes in cephalometric variables between different stages, Student’s t-test for paired data was performed. All statistical analysis was made with SPSS (IBM Corporation, Armonk, New York, USA).

The study was approved by the Norwegian Social Science Data Services (Project no. 29918).

3. Results

The reliability analysis for the lateral cephalometric variables gave ICC-values between 0.94 and 0.99. For the PA cephalograms the ICC values varied between 0.85 and 0.99.

3.1. Surgery

Four patients had macroscopic partial injury to the inferior alveolar nerve of which one was bilateral. In none of the patients the nerve was completely severed. The alveolar nerve bundle was

<table>
<thead>
<tr>
<th>Table 1</th>
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<tbody>
<tr>
<td>Patient characteristics.</td>
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<tr>
<td>Mean</td>
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<tr>
<td>---</td>
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<tr>
<td>Age at surgery (yr)</td>
</tr>
<tr>
<td>SNA angle</td>
</tr>
<tr>
<td>SNB angle</td>
</tr>
<tr>
<td>ANB angle</td>
</tr>
<tr>
<td>Overjet (mm)</td>
</tr>
<tr>
<td>Overbite (mm)</td>
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<tr>
<td>Asymmetry of upper dental midline (mm)</td>
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<tr>
<td>Asymmetry of lower dental midline (mm)</td>
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<tr>
<td>Asymmetry at menton (mm)</td>
</tr>
<tr>
<td>Discrepancy between upper and lower dental midline (mm)</td>
</tr>
</tbody>
</table>

* Asymmetry measured relative to the facial midline (for definition see text and Fig. 1).
distance from the upper dental midline to the facial midline of more than 2 mm and usually in the same direction as the deviation of the chin (11 patients 0–1 mm, 6 patients 1–2 mm, 16 patients more than 2 mm). In 5 patients the upper dental midline deviated (0–1 mm) to the opposite side of the chin deviation. On average the chin deviated 8.4 mm and the lower dental midline 6.8 mm (Table 1). After surgery the immediate mean transverse change was 4.7 mm at menton and 4.6 mm for the lower dental midline representing an improvement of 56.0% and 67.7%, respectively (Table 2). During the follow-up period, a mean relapse of 0.4 mm was observed at menton (9.1%) and of the lower dental midline (9.9%) resulting in a net improvement of 51.2% and 60.3% of the asymmetry, respectively. Four patients had a transverse relapse at menton of 2–4 mm and three patients more than 4.0 mm (Fig. 3). Accordingly 81.6% of the patients had less than 2.0 mm relapse during the 3 year follow-up period. The relapse took place during the first 6 postoperative months and the position of the chin was stable the next 2.5 years. 57.9% of the patients had an asymmetry of the chin of more than 3 mm 3 years postoperatively (Fig. 4). Discrepancy between the upper and lower dental midlines improved from a mean value of 5.1 mm to 1.0 mm which represents an average improvement of 80.3% (Table 3). Five patients had a deviation between upper and lower dental midlines of more than 2 mm (range 2.1–3.9) after 3 years (Fig. 5).

3.3. **Antero-posterior changes** (Table 2)

During surgery the immediate mean sagittal posterior change was 3.6 mm at B-point and remained relatively stable post-operatively (mean relapse 0.5 mm, 13.9%). Three patients had a relapse of more than 2.0 mm (Fig 6). Correction of the overjet was stable.

<table>
<thead>
<tr>
<th>Variable</th>
<th>T1 to T2 Mean SD</th>
<th>T2 to T3 Mean SD</th>
<th>T3 to T4 Mean SD</th>
<th>T2 to T4 Mean SD</th>
<th>T1 to T4 Mean SD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Skeletal changes</strong></td>
<td>Transversal (mm)</td>
<td>4.7 2.6 0.4 1.9 0.0 1.4 0.4 2.1 4.3 2.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Anteroposterior (mm)</td>
<td>3.6 2.6 0.4 1.2 0.1 1.1 0.5 1.4 3.1 2.2</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>B-point</td>
<td>3.0 2.9 0.6 1.4 0.2 1.1 0.8 1.6 2.2 2.6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Vertical (mm)</td>
<td>0.3 1.2 0.6 1.2 0.3 0.8 0.4 1.3 0.7 1.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Angular</td>
<td>2.2 1.6 0.2 0.6 0.1 0.7 0.3 0.8 1.9 1.4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ANB</td>
<td>4.6 2.2 0.3 1.2 0.1 0.9 0.4 1.5 4.2 1.7</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Udm</td>
<td>4.0 1.8 0.2 0.8 0.0 0.7 0.1 1.1 4.1 1.7</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Udm to Ldm</td>
<td>4.5 2.4 0.1 1.3 0.3 0.9 0.4 1.3 4.0 2.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Anteroposterior (mm)</td>
<td>4.4 2.4 0.1 1.2 0.3 0.5 0.3 1.2 4.1 1.7</td>
<td></td>
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<tr>
<td></td>
<td>Overjet</td>
<td>0.7 1.3 0.8 1.3 0.3 0.8 0.5 1.4 1.3 1.6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Overbite</td>
<td>0.9 1.3 0.6 1.1 0.2 0.6 0.5 1.2 1.4 1.5</td>
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<td></td>
<td></td>
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</tbody>
</table>

*p < 0.05, †p < 0.01, ††p < 0.001.

Transversal changes: Positive values indicate movement in direction of the midline; negative values indicate relapse to the side of the initial deviation.
Anteroposterior changes: Positive values indicates anterior movement; negative values indicate posterior movement.
Vertical changes: Positive values indicate superior movement; negative values indicate inferior movement.
Angular changes: Positive values indicate an increase; negative values indicate a decrease.

3.2. **Transverse preoperative status, surgical changes, and stability**

63.2% of the patients had a chin deviating to the left which indicates excess growth on the right side. 42.1% of the patients had a visible in part of the split in most patients. Four patients were re-operated because the occlusion was not satisfactory, three within one week and one after 3 years.

**Fig. 1.** Reference lines for measurement of transverse variables (see text). Deviation of transverse variables were recorded as distances from menton, upper and lower midlines to the facial midline.

**Fig. 2.** Landmarks and coordinate system used for recording sagittal variables (see text).
3.4. Vertical changes (Table 2)

Mean vertical change at menton was 1.3 mm superiorly during treatment overbite increased by 1.4 mm.

3.5. Sensory disturbances and patient satisfaction with the result 3 years postoperatively (Table 4)

44.7% of the patients had normal/almost normal sensation to the lower lip/chin. 50.0% had neurosensory alterations on the side.

Table 3
Skeletal and dental asymmetry (mm) at different treatment stages. T1 – preoperatively, T2 – 1 week, T3 – 6 months, T4 – 3 years postoperatively.

<table>
<thead>
<tr>
<th>Variable</th>
<th>T1</th>
<th></th>
<th>T2</th>
<th></th>
<th>T3</th>
<th></th>
<th>T4</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Me to midline</td>
<td>8.4</td>
<td>3.1</td>
<td>3.8</td>
<td>2.7</td>
<td>4.3</td>
<td>2.6</td>
<td>4.1</td>
<td>2.7</td>
</tr>
<tr>
<td>Ldm to midline</td>
<td>6.8</td>
<td>2.2</td>
<td>2.5</td>
<td>1.8</td>
<td>2.6</td>
<td>1.6</td>
<td>2.7</td>
<td>1.9</td>
</tr>
<tr>
<td>Udm to Ldm</td>
<td>5.1</td>
<td>1.7</td>
<td>1.1</td>
<td>0.8</td>
<td>0.8</td>
<td>0.9</td>
<td>1.0</td>
<td>0.9</td>
</tr>
</tbody>
</table>

Me: Menton, Midline: facial midline (see Fig. 1), Ldm: Lower dental midline, Udm: Upper dental midline, Udm to Ldm: Discrepancy between dental midlines. For definition of variables see text.

3.4. Vertical changes (Table 2)

Mean vertical change at menton was 1.3 mm superiorly during treatment overbite increased by 1.4 mm.

3.5. Sensory disturbances and patient satisfaction with the result 3 years postoperatively (Table 4)

44.7% of the patients had normal/almost normal sensation to the lower lip/chin. 50.0% had neurosensory alterations on the side.
to which the chin was deviating, compared to 28.9% who were affected on the opposite side ($P$-value = 0.06, Table 4, Fig. 7). 97.4% were satisfied with the treatment and 94.8% would have made the same decision to have treatment based on their present experiences. There were only minor differences in these parameters between the asymmetric set-back and straight set-back performed by the same surgical team (Hågensli et al., 2013).

4. Discussion

The patient sample comprised only 38 patients from a larger number of asymmetric patients operated during the actual time interval. Many were excluded according to the strict inclusion criteria as they had anomalies of the maxilla, additional LeFort I and/or genioplasty, records of insufficient quality or failed to attend follow-up sessions. The eligibility of the participants is in accordance with the STROBE statements (www.strobe-statement.org). Ideally it would be preferable to have a sample with strictly symmetric maxillary dentition, but patients with only moderate

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**Fig. 5.** Discrepancy between upper and lower dental midlines before surgery (blue bars) and at the 3 year follow-up (red bars) in each of 38 operated individuals arranged according to the magnitude of the preoperative discrepancy.

**Fig. 6.** Postero-anterior surgical change at B-point (blue bars) and postoperative change during the 3 year follow-up period (red bars) in each of 38 operated individuals. Relapse (anterior movement) is given a positive value while further posterior movement is given a negative value.
Comparing perchase between asymmetric set-back (present study) and straight set-back
Neurosensory function, patient satisfaction and decision about treatment: A comparison between asymmetric set-back (present study) and straight set-back
Neurosensory function, patient satisfaction and decision about treatment: A comparison between asymmetric set-back (Hågensli et al., 2013) and straight set-back (Hågensli et al., 2013) with BSSO 3 years postoperatively (frequency of patient).

<table>
<thead>
<tr>
<th>Neurosensory alteration</th>
<th>Non-deviating side</th>
<th>Deviating side</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>%</td>
<td>n</td>
<td>%</td>
<td>n</td>
</tr>
<tr>
<td>Neurosensory alteration</td>
<td>28.9</td>
<td>11</td>
<td>50.0</td>
</tr>
<tr>
<td>No or minimal neurosensory alteration</td>
<td>71.1</td>
<td>27</td>
<td>50.0</td>
</tr>
</tbody>
</table>

Table 4
Frequency of neurosensory changes to the lower lip/chin related to the transversal movement of the two sides during surgery (evaluated 3 years after surgery).

Fig. 7. Schematic representation of the situation after the distal segment of the mandible has been repositioned, but before any bone adjustments (in this illustration the deviation of the chin initially was to the right). The arrow indicates a location where there can be an increased risk for injury to the alveolar nerve.

The rotational/transverse movement necessary to correct mandibular asymmetry is a surgical challenge because it is often necessary to carry out bone adjustments at the osteotomy site (Fig. 7). Several authors have proposed modifications to the sagittal split technique which illustrates that the rotational movement may represent a problem (Yoshida et al., 2001; Peacock and Lee, 2011; Yang and Hwang, 2014). Post-surgical skeletal stability in this study was, however, comparable to the stability observed in a study of relapse after straight BSSO set-back by the same surgical unit (Hågensli et al., 2013).

The majority (63.2%) of the patients in this study had excessive growth of the mandible on the right side with the chin deviating to the right. This right-side dominance has been reported by other authors but the aetiology is uncertain (Severt and Profitt, 1997; Haraguchi et al., 2002).

Stability may be considered good both for correction of asymmetry and postoperative movement of the mandible. A mean relapse of less than 0.5 mm for both transverse and posterior movement is not clinically significant. The occlusion had excellent stability and the upper and lower dental midlines were generally coordinated post-treatment.

Almost all patients had clinically significant improvement of their asymmetry. A reason why about 60 per cent of the patients were still somewhat asymmetric (>3 mm at menton) after surgery was because more than 40% of the patients had an asymmetric upper dental midline of more than 2 mm to the same side as the mandibular deviation, and that the maxillary dentition was used as a guide for the surgical positioning of the lower jaw. Another factor was that most patients were slightly undercorrected relative to the upper dental midline, and furthermore the lower dental midline was generally less asymmetric than the chin. Many patients therefore may have had an ideal result by additional LeFort I surgery and/or genioplasty, but the treatment plan was agreed with the patients based on information about efforts, benefits and risks involved. In a report on bimaxillary surgery for correction of marked asymmetry, the results were significantly different from a symmetric control group, but were comparable to findings in patients with mild asymmetry (Edler et al., 2004).
In another study symmetric results were reported after bimaxillary surgery (Ko et al., 2009). A recent report has classified mandibular asymmetry according to treatment need (Kim et al., 2014).

Neurosensoryst disturbances have been reported to occur in between 12% and 85% of the patients after BSSO (Westermark et al., 1998). Several recent papers have, however, reported a low incidence of neurosensoryst alterations (Al-Bishri et al., 2005; Borstlap et al., 2005; van Merkesteyn et al., 2007). The variation in the incidence may be due to the surgical approach as well as differences between methods used to record the disturbances. It was therefore considered appropriate to compare the present findings with results from a study of sensory disturbances in a sample operated with BSSO and straight set-back in the same hospital (Hågensli et al., 2013) because of the similarities in general surgical approach and recording of sensory alterations. A similar incidence of nerve affection in these two studies indicates that asymmetric set-backs are not generally related to a significantly increased risk for sensory impairment for the individual patient. There were, however, differences in neurosensoryst function based on the actual surgical repositioning. A higher rate of disturbances was recorded on the side with displacement of the chin (Table 5). This could be explained by the need for surgical adjustment of the bone at the deviating side, and related to this, an increased risk of injury to the inferior alveolar nerve. Another factor could be the risk of squeezing the nerve at the posterior edge of the distal fragment when the osteosynthesis was performed (Fig. 7).

The impact of a remaining mandibular asymmetry of more than 3 mm at the chin, which was observed in many patients, should be considered when planning treatment although patients in this study were generally satisfied and would have made the same decision about surgery based on their experiences three years post-surgery.

5. Conclusion

Correction of mandibular prognathism and asymmetry by BSSO and rigid fixation is fairly stable even if a moderate skeletal relapse occurs during the first six months after surgery. Rotation of the distal segment during surgery may represent an increased risk of sensory impairment on the side with mandibular displacement. Patients are generally satisfied even if some residual asymmetry may still be present.

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None.

References
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