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, postoperatively, 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 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 II III 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 (Hägensi 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 the time of surgery. All patients had pre- and postoperative orthodontic treatment. To reduce swelling and pain 125 mg methylprednisolone (Depo-medrol, Pfizer®, NY, USA) iv was administered peroperatively. Additionally 40 mg methylprednisolone (Depo-medrol, Pfizer®, NY, USA) was given intra muscularly. Prophylactic antibiotics were given with benzylpenicillin (Penicillin, Actavis®, Oslo, Norway) 5 mill ll x 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 (Pinxel 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...
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.

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 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. Anteroposterior 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 mm (range 2.1–3.9) after 3 years (Fig 6). Correction of the overjet was stable.

**Table 2**

Surgical and postsurgical changes (mean and 1 standard deviation) in 38 asymmetric Class III patients during the various time intervals (T1 – preoperatively, T2 – 1 week, T3 – 6 months, T4 – 3 years postoperatively).

<table>
<thead>
<tr>
<th>Variable</th>
<th>T1 to T2</th>
<th>T2 to T3</th>
<th>T3 to T4</th>
<th>T2 to T4</th>
<th>T1 to T4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Skeletal changes</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transversal (mm)</td>
<td>Me 4.7</td>
<td>2.6</td>
<td>–0.4</td>
<td>1.9</td>
<td>0.0</td>
</tr>
<tr>
<td>Anteroposterior (mm)</td>
<td>B-point –3.6</td>
<td>2.6</td>
<td>0.4*</td>
<td>1.2</td>
<td>0.1</td>
</tr>
<tr>
<td>Pg –3.0</td>
<td>2.9</td>
<td>0.6</td>
<td>1.4</td>
<td>0.2</td>
<td>1.1</td>
</tr>
<tr>
<td>Vertical (mm)</td>
<td>Me 0.3</td>
<td>1.2</td>
<td>0.6</td>
<td>1.2</td>
<td>–0.3*</td>
</tr>
<tr>
<td>ANB 2.2</td>
<td>1.6</td>
<td>–0.2*</td>
<td>0.6</td>
<td>–0.1</td>
<td>0.7</td>
</tr>
<tr>
<td><strong>Dental changes</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transversal (mm)</td>
<td>Ldm 4.6</td>
<td>2.2</td>
<td>0.3</td>
<td>1.2</td>
<td>–0.1</td>
</tr>
<tr>
<td>Udm to Ldm 4.0</td>
<td>1.8</td>
<td>0.2</td>
<td>0.8</td>
<td>–0.1</td>
<td>0.7</td>
</tr>
<tr>
<td>Anteroposterior (mm)</td>
<td>ll –4.4</td>
<td>2.4</td>
<td>0.1</td>
<td>1.3</td>
<td>0.3*</td>
</tr>
<tr>
<td>Overjet 4.4</td>
<td>2.4</td>
<td>0.1</td>
<td>1.2</td>
<td>–0.3*</td>
<td>0.5</td>
</tr>
<tr>
<td>Vertical (mm)</td>
<td>ll 0.7</td>
<td>1.3</td>
<td>0.8</td>
<td>1.3</td>
<td>–0.3*</td>
</tr>
<tr>
<td>Overbite 0.9</td>
<td>1.3</td>
<td>0.6</td>
<td>1.1</td>
<td>–0.2</td>
<td>0.6</td>
</tr>
</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.
3.4. 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

<table>
<thead>
<tr>
<th></th>
<th>T1 Mean</th>
<th>T1 SD</th>
<th>T2 Mean</th>
<th>T2 SD</th>
<th>T3 Mean</th>
<th>T3 SD</th>
<th>T4 Mean</th>
<th>T4 SD</th>
</tr>
</thead>
<tbody>
<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>0.9</td>
<td>0.8</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
deviations had not had maxillary surgery as it was considered inappropriate because of limited benefit to the patient.

Several authors have discussed the reliability of landmarks and measurements obtained from PA-cephalograms (e.g. Edler et al., 2004). Major et al. (1994) have observed that many landmarks used in PA-analysis have poor intra- and interobserver reliability, but that the midline landmarks and superior orbital rim have acceptable reliability. Crista galli was found to be less reliable, and therefore crista galli in the present study was used in combination with the midpoint between the medial orbital walls to establish the perpendicular to the x-axis. This coordinate system was also copied 3 times during the tracing of the successive radiographs of the same patient to improve accuracy. Variation in head position may also influence reliability of measurements obtained from serial cephalograms (Major et al., 1996). Cephalograms in this study were obtained with the same cephalostat with ear rods and support at soft tissue nasion to avoid rotation of the head between exposures. The intraclass correlation coefficient values indicate that these precautions resulted in acceptable reliability of the measurements from PA cephalograms.

Some unwanted side-effects were reported. Three patients with bad split in a sample of 38 patients are somewhat high and would now have been treated with plate osteosynthesis instead of intermaxillary fixation. Relatively few patients were reported to have macroscopic partial injury to the inferior alveolar nerve during surgery similar to another study of side effects from surgery (Al-Nawas et al., 2014). Three of the four reoperations were for repositioning of the osteosynthesis material to optimize the occlusion and took place within a week.

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 left. This right-side dominance has been reported by other authors but the aetiology is uncertain (Severt and Prof, 1997; Haraguchi et al., 2002).

Stability may be considered good both for correction of asymmetry and posterior 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).

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**Table 4**

<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>No or minimal alteration</td>
<td>71.1</td>
<td>28.9</td>
<td>50.0</td>
</tr>
</tbody>
</table>

**Table 5**

<table>
<thead>
<tr>
<th>Neurosensory function, patient satisfaction and decision about treatment: A comparison between asymmetric set-back (present study) and straight set-back (Hågensli et al., 2013) with BSSO 3 years postoperatively (frequency of patient).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asymmetric setback n = 38 Straight setback n = 65</td>
</tr>
<tr>
<td>%</td>
</tr>
<tr>
<td>-------------------------</td>
</tr>
<tr>
<td>Neurosensory function to lower lip/chin</td>
</tr>
<tr>
<td>Somewhat reduced</td>
</tr>
<tr>
<td>Markedly reduced</td>
</tr>
<tr>
<td>Hypersensitivity</td>
</tr>
<tr>
<td>Complete loss</td>
</tr>
<tr>
<td>Satisfaction with treatment</td>
</tr>
<tr>
<td>Very satisfied</td>
</tr>
<tr>
<td>Satisfied</td>
</tr>
<tr>
<td>Somewhat dissatisfied</td>
</tr>
<tr>
<td>Very dissatisfied</td>
</tr>
<tr>
<td>Same decision about surgery today</td>
</tr>
<tr>
<td>Yes, definitively</td>
</tr>
<tr>
<td>Yes, probably</td>
</tr>
<tr>
<td>Don’t know</td>
</tr>
<tr>
<td>No, probably not</td>
</tr>
<tr>
<td>No, definitively not</td>
</tr>
</tbody>
</table>

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* Not complete neurosensory alteration to the whole area of the lip and chin, but alteration to area/areas of it.
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).

Neurosensory 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 neurosensory 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 neurosensory 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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Conflict of interests

None.

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References


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