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Long-lasting neurosensory disturbance following advancement of the retrognathic mandible: distraction osteogenesis versus bilateral sagittal split osteotomy

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Abstract. Neurosensory disturbance (NSD) of the inferior alveolar nerve (IAN) is the most common complication after bilateral sagittal split osteotomy (BSSO) and distraction osteogenesis (DO) of the retrognathic mandible. It is suggested that the risk is lower after DO than after BSSO. This retrospective study compared both techniques with regard to long-lasting NSD and overall patient satisfaction. 91 patients (representing 182 IANs) were included, they completed a questionnaire and underwent an objective neurosensory test. In the BSSO-group (90 nerves), long-lasting NSD was reported in 27 cases (30%) versus 21 cases (23%) in the DO group (92 nerves). In 39 cases (24 BSSO, 15 DO) the long-lasting NSD was reported in the lower lip, the chin or both. Of these cases, 9 (5 BSSO, 4 DO) were objectively tested positive. The overall prevalence was 8% in the BSSO group and 10% in the DO group. There was no significant difference in subjectively reported and objectively measured NSD between the groups. In this study patients seemed to over-report the NSD compared with the objective findings. For both procedures, overall patient satisfaction was high.

Keywords: bilateral sagittal split osteotomy; distraction osteogenesis; inferior alveolar nerve; neurosensory disturbance; patient satisfaction.

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In orthognathic surgery, bilateral sagittal split osteotomy (BSSO) of the mandible is the most common surgical procedure performed to advance the retrognathic mandible. Subsequent modifications of the technique have resulted in more predictable and stable results and reduced the risk of complications, such as neurosensory disturbance in the distribution area of the inferior alveolar nerve (IAN)[3,4,10,12,15,16,33,34]. The reported incidence of neurosensory disturbance immediately after BSSO ranges from 80% to 100%. In most patients, the normal sensation in the lower lip and chin recovers

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spontaneously. The prevalence of neurosensory disturbance 1 or 2 years after BSSO ranges from 0% up to 85%[2,6,14,16,26,27,29,31,43,44,47–49].

Distraction osteogenesis (DO) of the mandible using intraoral devices has proved to be a reliable alternative method for advancement of the retrognathic mandible[11,17,19,22–25,38,39]. DO has specific clinical benefits over BSSO, but complications still exist and may involve injury of the IAN. The incidence of neurosensory deficits after DO ranges from 0% to 52% of patients[21,45].

The incidence of neurosensory disturbance of the IAN after surgical correction of the retrognathic mandible using BSSO or DO is significant, but the reported prevalence of long-lasting (>1 year) neurosensory disturbance of the IAN varies. The risk of neurosensory disturbance seems to be lower in DO compared with BSSO.

The variation in reported prevalence of neurosensory disturbance after orthognatic surgery depends on whether objective measurements or subjective self-reports are used[8,46,50]. The results from objective clinical neurosensory tests do not always correspond with patients' subjective reports of neurosensory disturbance[5]. Patients seem to accept a mild neurosensory disturbance and might report sensory function as being normal, despite a slightly altered sensation[5,20,32,49]. 87–100% of patients who underwent orthognathic surgery were satisfied with the result and would recommend the treatment to others, independent of a neurosensory disturbance[5,9,13].

The aim of this retrospective study was to assess the occurrence of long-lasting (>1 year) neurosensory disturbance and overall patient satisfaction. Based on the results, an indication can be given whether DO is a more suitable procedure for the surgical correction of the retrognathic mandible compared with BSSO. This study also compared the results of a subjective patient questionnaire with the results of a recently developed objective neurosensory 'quick test'.

Material and methods

A retrospective clinical study was performed in 91 patients (38 males and 53 females) who had undergone mandibular advancement surgery. Group 1 consisted of 45 patients (10 males, 35 females; mean age 26.4 years (SD 10.4), age range 15–59 years) in which a BSSO had been performed at the University Medical Centre Groningen. Group 2 consisted of 46 patients (28 males, 18 females; mean age 15.0 years (SD 1.5), age range 11–18 years) who had undergone DO of the mandible in the VU Medical Centre in Amsterdam and the Kennemer Gasthuis in Haarlem.

Patients were selected based on the information on the operative procedure in their medical records and available surgery reports. Patients were included if either a BSSO or a bimaxillary procedure (group 1) or bilateral mandibular DO (group 2) had been performed. Within each group, surgery was always performed in a residency programme under the supervision of the same surgeon (JJ in group 1; AB in group 2). Patients who had previously undergone orthognathic surgery and patients in whom a genioplasty was concomitantly performed were excluded. In all patients in the BSSO group, rigid fixation was carried out using monocortical bone-screws and titanium miniplates. Exact data about the distance of advancement were not available in all surgery reports, but the indications for advancement did not exceed 7 mm in group 1 and 12 mm in group 2.

Of the 126 patients who were invited for this study, 91 patients (72%) accepted the invitation and gave their consent for participation. The patients were requested to complete a questionnaire and to undergo a clinical examination. Clinicians who performed the interviews and examinations were not involved in the surgical treatments.

The subjects were interviewed with special focus on their subjective experience of neurosensory disturbance after the surgical procedure. They were asked about perceived neurosensory disturbance in the distribution area of the IAN, duration of these changes, and any altered quality of life caused by these changes. A 10 cm visual analogue scale graded from 0 (no discomfort) to 10 (intolerable discomfort) was used to estimate the degree of disturbance. The grades were interpreted as follows: 0–2 mild discomfort; 2–4 mild to moderate discomfort; 4–6 moderate discomfort; 6–8 moderate to severe discomfort; and 8–10 severe discomfort[1]. Patients were also asked about their satisfaction with the result of the operation in relation to the neurosensory disturbance.

After completion of the questionnaire, a recently developed objective clinical neurosensory test was performed to assess long-lasting neurosensory disturbance[36,40]. This neurosensory test consisted of a mechanoceptive test (light touch sensation; large myelinated A-α and A-β afferent fibres) and a nociceptive test (cold sensation; small myelinated A-δ and unmyelinated C afferent fibers) and was performed by examiners who were unaware of the outcome of the questionnaire (JW in group 1; CV in group 2). The cutaneous areas of the lower lip and chin (both left and right side) were selected as test sites for assessment of the neurosensory function of the IAN. The upper lip was tested as a control site.

The mechanoceptive test was performed using a Semmes-Weinstein Pressure Aesthesiometer Monofilament #3.61 (North Coast Medical, Inc., San Jose, CA, USA), which applies a calibrated force of 455 mg[40,41]. The real stimulus was touching the test site, whereas approaching the test site with the filament turned away was the fake stimulus (Fig. 1). Touching the test site with monofilament #3.61 was detected in 99% of cases[41]. The nociceptive test was performed using a heat-conducting aluminium stick (shaft diameter 7.0 mm, tip diameter 2.0 mm) as a real stimulus (22 °C; cold sensation) (Fig. 2). The fake stimulus was produced by a non-heat-conducting Perspex® stick of neutral temperature. At touching, the difference in temperature between the aluminium and Perspex® sticks was distinguished by 99% of healthy subjects[36,40,41].

In both the mechanoceptive and the nociceptive neurosensory tests, the

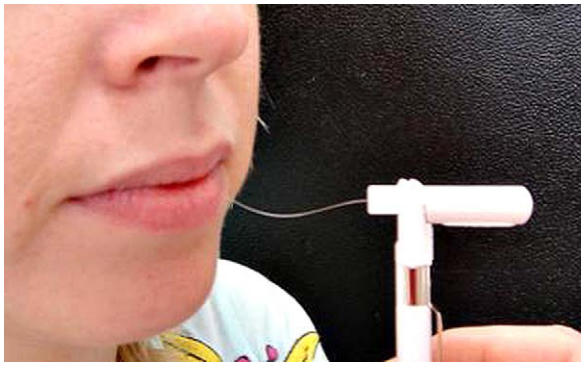

Fig. 1. Test stimulus with SW Pressure Aesthesiometer Monofilament #3.61 (North Coast Medical, Inc., San Jose, CA, USA), which applies a calibrated force of 455 mg.

Fig. 2. Test stimulus with a heat-conducting aluminium stick (shaft diameter 7.0 mm, tip diameter 2.0 mm) at 22 °C.

patients were offered a randomised series of seven successive pairs of stimuli. While the patients kept their eyes closed, either a real stimulus or a fake stimulus was presented after announcement of the first or second interval. After each pair, the patients were asked to report if the real stimulus was perceived at either the first or the second delivery. The subjects were forced to answer this question, regardless of whether the real stimulus was felt or not (2-alternate forced-choice method). The outcome of the neurosensory test was negative (no neurosensory disturbance) if the real stimulus was correctly detected in each of the seven consecutive pairs of applications. If a wrong answer was given (i.e. false detection of the real stimulus) the outcome of the test was positive, indicating neurosensory disturbance. By applying seven pairs of stimuli, the chance of a false-negative outcome is <0.01 ($<0.5^7 = 0.0078$)[36].

In the statistical analysis, the prevalence of long-lasting neurosensory disturbance was calculated for both group 1 and group 2 and the χ^2 test was used to compare both groups. $P < 0.05$ was considered significant.

Results

In group 1, the surgical procedure was performed between November 2000 and August 2005, and in group 2 between August 1999 and July 2006. The examination was performed after a postoperative period of 14–69 months (mean 32 months) in the BSSO group, and after 13–87 months (mean 45 months) in the DO group. 182 IANs (90 in group 1 and 92 in group 2) were tested.

Reports of neurosensory disturbance

Of 182 IANs, 113 nerves (62%) showed non-preoperatively existing nerve damage after surgery. BSSO had been performed in 61 cases (68% of 90), and in 52 cases (57% of 92) the neurosensory deficit appeared after the first operation of the DO procedure. No patients in group 2 reported new or altered sensory disturbance after the second procedure, when the distraction device was removed.

The patients were requested to report the duration of the sensory deficit of the IAN. In 48 nerves (26% of 182, 34 subjects) the neurosensory disturbance was reported as existing for more than 1 year. Within this group, a BSSO had been performed in 18 patients (4 male, 14 female; mean age 29.8 years (SD 8.4); age range 17–45 years), representing 27 nerves (30% of 90 nerves). The other 16 patients (6 male, 10 female; mean age 14.8 years (SD 1.6); age range 11–18 years) underwent DO and represent 21 nerves (23% of 92 nerves) (Table 1).

In 33 of the 48 cases, the long-lasting (>1 year) neurosensory disturbance was subjectively reported to exist in the cutaneous area of both the lower lip and chin (19 in group 1; 14 in group 2). In three cases (2 BSSO, 1 DO), the neurosensory disturbance was reported to exist in the lip only, and in another three cases the sensory deficits (all from group 1) existed in the chin only. Two patients in group 1 and seven patients in group 2 reported more combinations of affected areas other than the lip or chin (Table 2). In 13 cases (9 BSSO, 4 DO) the neurosensory disturbance was bilateral.

The neurosensory disturbance was described as a feeling of anaesthesia in 2 of 48 nerves (both BSSO). The disturbance in 24 nerves (50%; 14 BSSO, 10 DO) was perceived as hypoesthesia, and in 5 cases (all group 1) hyperesthesia was reported. In 12 cases (25%; 3 BSSO, 9 DO), the neurosensory disturbance was described as a combination of hypoesthesia and hyperesthesia. Descriptions of other sensory disturbances (5 nerves; BSSO 3, 2 DO) included descriptions of paraesthesia such as stiffness and tickling (Table 3).

The long-lasting altered sensation of the IAN was bothering the patient in 35 of 48 cases (73%), of whom 23 were in group 1 and 12 in group 2 (Table 1). The patients reported that the disturbance was bothering at varying times, varying from 'at touching' alone (6 nerves) or 'during eating' alone (5 nerves) to 6 sensory disturbances which 'always' bothered the patients. A combination of 'at touching' with one of the other occurrences was reported in 15 cases (Table 4).

In most of the 35 cases in which the neurosensory disturbance was bothering the subjects, the degree of discomfort was described as mild (9, all group 1), mild to moderate (8 in the BSSO group, 7 in the DO group) or moderate (2 nerves in group 2). The sensory disturbance in 5 nerves (3 BSSO, 2 DO) caused moderate to severe discomfort to the subjects. In group 1, two nerves caused no discomfort,

Table 1. Reported occurrence of non-pre-existing neurosensory disturbance after surgery.

	Number of IANs		
	BSSO	DO	Total
NSD after surgery	61	52	113
NSD >1 year after surgery	27	21	48
NSD >1 year after surgery and still bothering	23	12	35

Table 2. Location of long-lasting neurosensory disturbance after surgery.

	Number of IANs		
	BSSO	DO	Total
Lower lip + chin	19	14	33
Lower lip	2	1	3
Chin	3	–	3
Other areas	2	7	9
Total	26	22	48

Table 3. Description of long-lasting neurosensory disturbance after surgery.

	Number of IANs		
	BSSO	DO	Total
Anaesthesia	2	–	2
Hypoesthesia	14	10	24
Hyperesthesia	5	–	5
Hypoesthesia + hyperesthesia	3	9	12
Other	2	3	5
Total	26	22	48

Table 4. Occurrences at which the long lasting neurosensory disturbance was bothering.

	Number of IANs		
	BSSO	DO	Total
Touching	4	2	6
Eating	1	4	5
Speaking/eating	1	2	3
Touching/speaking	2	-	2
Touching/eating	4	2	6
Touching/kissing	2	-	2
Touching/other	2	-	2
Touching/speaking/kissing	2	-	2
Touching/speaking/eating/kissing	1	-	1
Always	4	2	6
Total	23	12	35

Table 5. Degree of discomfort caused by the long lasting neurosensory disturbance.

	Number of IANs		
	BSSO	DO	Total
No discomfort	2	–	2
Mild discomfort	9	–	9
Mild to moderate discomfort	8	7	15
Moderate discomfort	–	2	2
Moderate to severe discomfort	3	2	5
Severe discomfort	1	1	2
Total	23	12	35

whereas in both groups one patient experienced severe discomfort due to sensory disturbance (Table 5).

Degree of satisfaction

44 of 45 patients in group 1 (98%) were satisfied with the final result of the BSSO. 98% would undergo the surgery again if they were in the same situation or recommend the surgery to another person. In group 2, all patients (100%) were satisfied with the final result of the DO procedure. 41 patients (89%) would undergo the procedure again or recommend the surgery to others.

All of the 34 patients (100%) representing the 48 nerves with long-lasting neurosensory disturbance were satisfied with the result. One patient in group 1 would not undergo the BSSO again or recommend it to others, whereas 3 patients in group 2 would not undergo the DO procedure again or recommend it to others.

Table 6. Long lasting neurosensory disturbance: subjective report vs. objective measurement.

	Number of IANs		
	BSSO	DO	Total
Reported and measured	5	4	9
Reported, not measured	19	11	30
Measured, not reported	2	5	7
Total reported	24	15	39
Total measured	7	9	16

Neurosensory 'quick test'

Of the 90 IANs in the BSSO group, seven nerves (7.8%) in six patients tested positive, which means that in these cases long-lasting (>1 year postoperative) neurosensory disturbance existed at the time of testing. Nine nerves (9.8%) in seven patients tested positive in the DO group.

In 27 cases in group 1 (18 patients) the neurosensory disturbance was reported to have existed for over a year and was still present. In 24 cases (89% of these 27) the neurosensory deficit was reported in the cutaneous area of the lower lip, the chin or both. Of these 24 cases, only 5 could be objectively measured (21%). In two cases, long-lasting sensory disturbance was not subjectively reported, but nociceptive disturbance was found positive with the objective test.

In 15 of the 21 nerves (71%) in group 2 that were reported to show long-lasting neurosensory disturbance, the reported disturbance was present in the cutaneous area of the lower lip, the chin or both. Of these 15 nerves, 4 could be measured (27%), while 11 could not be objectified. In 5 cases, long-lasting neurosensory disturbance was not subjectively reported, but sensory disturbance tested positive (Table 6).

Discussion

Neurosensory disturbance following orthognathic surgery has been extensively described for BSSO, but its reported prevalence varies. Immediate postoperative paraesthesia is common, with reports of 80–100% incidence. Follow-up of the patients has shown a prevalence of 34–97% in the first week after surgery, and a prevalence of 0–85% 1 or 2 years postoperatively[6,16,20,26,29,44,47–49]. Few studies reported the prevalence of neurosensory disturbance after DO, but it ranges from 0% to 52% of patients[21,45]. The prevalence of long-lasting neurosensory disturbance after BSSO and DO found in this study (8% in group 1; 10% in group 2, $P > 0.05$) is relatively low within the limits found in the literature.

There could have been false-negative test results due to the materials used. The mechanoceptive test as a part of the neurosensory 'quick test' was performed using Semmes-Weinstein monofilament #3.61. It was found, that the touch of a monofilament #3.61 could be detected in 99% of cases[41]. The touch detection threshold corresponding to 95% positive responses are calibrated to be accomplished by using Semmes-Weinstein

monofilament #2.44 in the lower lip and #2.83 in the mental region of female subjects, and by using #2.83 in the lower lip and #3.22 in the mental region of male subjects. Thus, the monofilament #3.61, as used in this study, could have led to a higher number of false-negative test results of the mechanoceptive sensory modality. The authors findings accord with these observations. A similar difference between the 99th and 95th percentiles may mean that the outcome of the nociceptive test may also include false-negative test results.

The nociceptive test using a heat-conducting aluminium stick uses the temperature (skin temperature vs. stick temperature) as an index. Kabasawa et al. reported a novel evaluation method for neurosensory disturbance using a heat flux technique. This method allows the accurate measurement of thermal sensation in a short time and the quantitative measurement of warm and cold sense thresholds by using a thermostimulator. This thermode consists of Peltier elements that are either cooled or warmed linearly by 0.1 °C/s until the subject feels a cold or warm sensation[18].

In group 1, a concomitantly performed BSSO and LeFort I procedure may have resulted in a neurosensory disturbance of the upper lip, although it was not reported by the patients and it was not objectively tested positive.

There is little information in the literature on whether long lasting sensory disturbance after orthognathic surgery influences patient satisfaction with the outcome of the procedure. For BSSO, Westermark et al. found an overall patient satisfaction of 84%[42]. Al-Bishri et al. found that 91% of patients were satisfied with the result of the operation, and of the 4 dissatisfied patients only one patient was dissatisfied because of neurosensory disturbance[1]. In general, the long-term satisfaction rate in patients who underwent orthognathic surgery is 87–100%[5,9,13]. In cases where a neurosensory disturbance of the lower lip and chin existed, it was reported normal or not uncomfortable by the patients[5,20,28,31,49] In this study, a very high satisfaction rate was found after BSSO (98%) and DO (100%). This indicates that the discomfort of the nerve damage seems to be outweighed by the positive functional and aesthetic results. Together with the relatively low prevalence of long-lasting neurosensory disturbance, the high degree of patient satisfaction confirms the idea that both procedures are highly suitable for the surgical correction of the retrognathic mandible.

In group 1, 44 subjects would undergo the BSSO procedure again if they were in the same situation, whereas 43 patients in group 2 would do so with regard to the DO procedure (98% vs. 89%, respectively; $P > 0{,}05$). This finding could be attributed to factors that contribute to the level of discomfort experienced by patients undergoing DO, such as the duration of the distraction period and the disadvantage of requiring a second surgical intervention to remove the distraction device, and the procedure itself[37].

The relationship between objective assessments and the patients' subjective evaluation of neurosensory disturbance is unclear. Patients reported normal neurosensory function even though objective testing indicated continued neurosensory deficit[14]. Conversely, patients appeared to over-report (mechanoceptive) neurosensory problems when compared with the objectively tested level of disturbance[8].

Pepersack et al. found a reasonably high prevalence (61% of 123 patients) of permanent sensory alteration at least 5 years after BSSO for mandibular prognathism, testing with both tactile and thermal stimuli and sharp/blunt discrimination. Subjectively, only 42% of the patients reported sensory disturbances in the lower lip[30]. Coghlan et al. reported a higher prevalence of neurosensory disturbance among 19 patients in clinical neurosensory testing (66% of the nerves) than of subjective symptoms (26% of the nerves) two years after BSSO[7]. Fridrich et al. concluded that patients seem to adapt to a neurosensory disturbance and report normal neurosensory function even though objective testing indicates continued sensory deficit[14].

Leira et al. objectively found a sensory disturbance in 34% of the operated sides 4 days after BSSO and in 8% at 6 months after BSSO, whereas subjective sensory disturbance was present in 54% immediately after the operation, and in 34% at 6 months after BSSO[20]. Cunningham et al. found that more than 70% of 101 patients subjectively reported neurosensory problems, but objective assessment identified neurosensory deficits in less than 60% of the patients. They concluded that patients seem to over-report neurosensory disturbance[8], a conclusion that is supported by the results of the present study.

In earlier studies, a significant association between patient's age and neurosensory disturbance was reported[2,28,29,35,43]. The results of these studies showed significantly more neurosensory disturbance in patients aged 30 years or older than in patients younger than 30 years. Upton et al. suggested that the higher prevalence of neurosensory disturbance in older patients may not be due to a greater risk of nerve damage, but to poorer regeneration of damaged nerves[35]. Some studies have not revealed significant differences in the incidence of neurosensory disturbance by age, but this may be due to a small age range[14].

The subjects in group 1 (mean age 26.4 years) were significantly older than the patients in group 2 (mean age 15.0 years; $P < 0.05$). The results show that the difference in the mean age of the subjects in the two groups was significant with regard to the subjectively reported neurosensory disturbance (29.8 years (BSSO), 14.8 years (DO); $P < 0.05$) as well as with regard to the objectively measured sensory deficit (32.5 years (BSSO), 15.1 years (DO); $P < 0.05$).

There was no significant difference between group 1 and 2 with regard to the prevalence of both subjectively reported neurosensory disturbance (30% and 23%, respectively; $P > 0.05$) and of the objectively measured sensory deficit (8% and 10%; $P > 0.05$). If the mean age was about the same in both groups, the results of this study would imply that the prevalence of long-lasting neurosensory disturbance was relatively higher in the DO group, although there was no significant difference between the results.

The magnitude of mandibular advancement also influences the prevalence of neurosensory disturbance. Ylikontiola et al. found significantly higher rates of neurosensory disturbance in patients with mandibular movements larger than 7 mm[49]. Westermark et al. did not find a significant correlation between the neurosensory deficit and the magnitude of mandibular movement[44].

Whitesides et al. studied the function of the inferior alveolar nerve after mandibular DO of more than 10 mm advancement (rate 1 mm/ 24 h). They found that all nerves recovered to preoperative (40% of the nerves) or near preoperative (60% of the nerves) values within 1 year[45].

In this study, of the 39 cases in which the (mechanoceptive) neurosensory disturbance was reported to exist in the cutaneous area of the lower lip, the chin or both, only 23% was measured. Prior to the study, it was expected that objective measurement of occurrence of neurosensory disturbances of the inferior alveolar nerve more than 1 year after BSSO and DO would result in a higher prevalence of neurosensory disturbance than subjective assessment. This study showed that patients appear to over-report long-lasting

mechanoceptive neurosensory disturbance of the lower lip and chin compared with objective measurement. This difference may be a result of false-negative results with the mechanoceptive test.

Based on the results of this study, it can be concluded that both BSSO and DO are appropriate techniques for the treatment of mandibular retrognathia, with no significant difference in prevalence of long-lasting neurosensory disturbance of the IAN. There seems to be slightly more patient distress inherent in the DO technique than with the advancement of the mandible by BSSO, although the degree of satisfaction was high in both groups.

Other factors influence the outcome of BSSO and DO, such as stability and relapse, or patient factors such as discomfort and co-operation (DO procedure). The long-term results of DO are not well documented. A randomized clinical trial is needed to compare BSSO and DO to assess if either should be selected as the preferred surgical method in mandibular retrognathia.

Competing interests

None declared.

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Ethical approval

Not required.

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