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Open bite: stability after bimaxillary surgery—2-year treatment outcomes in 58 patients

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SUMMARY Stability after bimaxillary surgery to correct open bite malocclusion and mandibular retrognathism was evaluated on lateral cephalograms before surgery, 8 weeks post-operatively, and after 2 years. The 58 consecutive patients were treated to a normal occlusion and good facial aesthetics. Treatment included the orthodontic alignment of teeth by maxillary and mandibular fixed appliances, Le Fort I osteotomy, and bilateral sagittal split ramus osteotomy. Twenty-six patients also had a genioplasty. Intra-osseous wires or bicortical screws were used for fixation. Twenty-three patients had maxillo-mandibular fixation (MMF) for 8 weeks or more, six for 4–7 weeks, 14 for 1–3 weeks, and 15 had no fixation. At follow-up 2 years later, the maxilla remained unchanged and the mandible had rotated on average 1.4 degrees posteriorly. Seventeen patients had an open bite. Among them, eight patients had undergone segmental osteotomies. The relapse was mainly due to incisor proclination. The most stabile overbite was found in the group with no MMF after surgery.

Introduction

Open bite malocclusions tend to recur after treatment (Denison *et al*., 1989), particularly after only a bilateral sagittal split osteotomy and maxillo-mandibular fixation (MMF) (McNeill *et al*., 1973; Ive *et al*., 1977; Schendel and Epker, 1980). Anterior open bite is characterized by aberrations in both the maxilla and the mandible (Ellis *et al*., 1985). For the last 10 years, bimaxillary surgery has therefore been preferred to reduce relapse, and to achieve a good occlusion and a harmonious facial profile (Brammer *et al*., 1980; Hiranaka and Kelly, 1987; Lello, 1987; Turvey *et al*., 1988; Ayoub *et al*., 1993; Miguel *et al*., 1995). Comparative studies of post-surgical skeletal fixation have shown that rigid fixation with plates and monocortical screws is more favourable for stability than wire fixation (Hennes *et al*., 1988; Rondahl *et al*., 1988; Skoczylas *et al*., 1988; Satrom *et al*., 1991; Ayoub *et al*., 1994). There is controversy over post-operative MMF and for how long it should be used. Krekmanov *et al*. (1988) claimed that, while early mobilization and the ability to chew will promote healing, and contribute to good occlusion, it primarily offers the advantage of reducing post-operative discomfort. This finding is inconsistent with earlier reports claiming that the dentition can compensate for minor skeletal changes during the fixation period (Will *et al*., 1984). Rehabilitation of patients with anterior open bite and mandibular retrognathism is a complex, lengthy procedure involving both orthodontic treatment and bimaxillary surgery. It is therefore important that the result of treatment is stable. Most earlier evaluations of the outcome open bite treatment are based on a small number of patients.

The aim of this study was to analyse stability after bimaxillary surgery in all patients with open bite treated at the Maxillofacial Surgery Clinic, Sabbatsbergs Hospital, Stockholm, Sweden, over a period of 8 years, and to analyse the effects of different modes of skeletal fixation and duration of MMF.

Subjects and methods

The subjects comprised all patients treated with Le Fort I osteotomy and sagittal ramus osteotomy

at the Maxillofacial Surgery Clinic, Sabbatsbergs Hospital, Stockholm, Sweden between 1984 and 1992. The orthodontic diagnosis was dental and/or skeletal open bite in combination with a retrognathic mandible. After exclusion of patients with syndromes, the number of participants was 58: 40 women and 18 men. Their mean age at surgery was 23 years (14–49 years). Mean cephalometric variables including sagittal relationship, mandibular inclination, overbite, and overjet at the start of treatment are shown in the first column of Table 1. Treatment included pre- and post-surgical fixed orthodontic appliances. The duration of orthodontic treatment and retention periods are shown in Table 2.

Surgery

All patients underwent a Le Fort I osteotomy according to Bell (1975) and sagittal ramus osteotomy. Nineteen patients underwent segmental maxillary osteotomies: the maxilla was adjusted to its pre-planned position with an intermediate splint and fixed in position with intraosseous wires, or four-hole plates and monocortical screws. The mandibular surgery comprised a bilateral sagittal split osteotomy, using the technique advocated by Obwegeser (1955), modified according to Dal Pont (1961) and Hunsuck (1968), and fixation with intraosseous wires or bicortical screws. The duration of MMF varied from 0–>8 weeks. Twenty-six patients underwent an additional genioplasty. Two surgeons carried out the procedures for all patients, treating 31 and 27 cases, respectively.

Cephalometric analyses

Landmarks on lateral cephalograms obtained at the start of treatment, pre-operatively, and 8 weeks and 2 years post-operatively were digitized by one operator (KF), and stored in a computer. All landmark registrations were performed twice and the mean values were used for the analyses. Definitions of the landmarks are shown in Figure 1 and Table 3. The latter also includes the definition of cephalometric lines. Linear and angular variables were calculated. The measurements were corrected for radiographic magnification.

Statistical methods

The arithmetic mean and standard deviation were calculated for each cephalometric measurement. Normal distribution of the measurements was verified by the Kolmgorov–Smirnov normality tests ($P < 0.05$). The stability was determined as the difference between measurements obtained 8 weeks post-operatively and after 2 years. A Student's *t*-test for paired observations was used ($P < 0.05$). The relationships between changes were analysed with the correlation coefficient (r; $P < 0.05$).

Error of method

The error of the method included double determination of the cephalometric landmarks in 15 patients randomly selected from the study, and was calculated according to Dahlberg (1940):

$$S(i)^2 = \Sigma d^2/2N$$

where d is the difference between two measurements and N is the number of double determinations. The error of variance, $S(i)^2$ was less than 3 per cent of the total biological variance $(sd)^2$ for all variables studied, apart from NSL/NL, for which it was 3.75 per cent and for the overbite 6 per cent, which corresponded to 0.2 mm. It was concluded that the registration technique was sufficiently accurate to detect any morphological differences existing between the groups in this study.

Results

The mean plot of the 58 patients at the start of treatment, 8 weeks after surgery and 2 years later are shown in Figure 2. Table 1 presents the cephalometric variables obtained pre-orthodontically, pre-operatively, and at 8 weeks and 2 years post-operatively. The orthodontic and surgical outcomes as well as the relapse are also shown. With respect to relapse, the mean values

Table 1 Mean (SD) and range of cephalometric variables recorded pre-orthodontically, pre-operatively, 8 weeks post-operatively, and at 2-year follow-up, and operative effects and relapse.

	Pre-orthodontics	Pre-operative	Orthodontic effects	8 weeks post-operative	Operation effects	2 years post-operative	Relapse	Significance
Vertical relations								
SN/ML	45.7 (7.2) 31.1–59.6	46.2 (6.8) 30.5–59.1	0.5 (1.8) –4.7–4.6	42.2 (6.7) 24.3–55.5	–4.0 (3.1) –17.4–3.1	43.7 (6.7) 24.6–57.2	1.4 (2.0) –2.0–7.6	*
SN/NL	6.2 (3.3) –0.2–13.8	6.6 (3.4) 0.1–16.5	0.4 (1.8) –8.6–2.7	7.2 (4.4) –1.4–15.2	0.6 (3.7) –10.2–7.5	6.9 (3.7) –1.1–14.0	–0.3 (2.6) –10.2–4.3	NS
ML/NL	39.5 (6.5) 21.4–50.8	39.6 (6.0) 23.1–49.5	0.1 (2.2) –9.7–3.2	35.0 (6.6) 18.9–48.9	–4.6 (4.6) –17.2–5.3	36.7 (6.3) 20.6–46.9	1.7 (2.8) –3.8–10.9	*
Sagittal relations								
SNA	79.9 (4.1) 71.6–91.4	80.2 (3.9) 73.6–90.3	0.3 (1.4) –3.5–2.6	81.6 (4.3) 72.6–93.1	1.4 (2.5) –9.3–4.4	81.3 (4.6) 72.5–91.7	–0.3 (1.5) –4.7–3.9	NS
SNB	71.5 (3.9) 61.3–81.1	71.7 (3.8) 61.6–80.2	0.2 (1.4) –3.8–3.1	75.7 (4.0) 66.9–86.5	4.0 (2.3) –8.3–2.1	75.1 (4.0) 64.2–85.1	–0.5 (1.3) –2.1–4.3	NS
ANB	8.3 (3.0) 0.9–15.1	8.5 (2.9) 0.1–14.6	0.2 (1.7) –4.0–4.0	5.9 (2.8) –1.6–13.3	–2.6 (2.3) –8.4–2.1	6.2 (3.3) –2.6–13.1	0.3 (1.4) –2.6–5.0	*
Dentoalveolar								
ILS/SN	105.0 (8.2) 84.2–129.1	103.5 (7.5) 83.8–121.8	–1.5 (5.9) –19.5–11.7	99.5 (7.5) 78.2–117.4	–4.0 (5.6) –20.3–6.9	99.7 (7.9) 81.5–117.4	0.2 (3.2) –7.5–7.7	NS
ILI/ML	94.8 (7.6) 71.3–108.9	93.0 (7.1) 77.7–108.7	–1.7 (7.5) –21.1–11.2	92.2 (7.2) 75.8–105.6	–0.8 (4.7) –11.6–12.8	93.0 (6.4) 81.4–105.9	0.8 (3.9) –12.4–6.9	NS
ILS/ILI	114.5 (10.4) 92.1–142.8	117.3 (9.8) 101.0–143.6	2.8 (10.1) –26.8–14.4	126.0 (9.4) 109.4–153.1	8.8 (6.5) –24.5–5.4	123.6 (6.4) 108.6–150.9	–2.4 (4.9) –9.7–12.1	*
Overbite (mm)	–0.8 (2.8) –7.9–5.8	–0.9 (2.6) –7.3–3.4	–0.1 (2.3) –5.0–4.1	–1.3 (1.1) –3.4–1.2	2.2 (2.4) –2.9–10.0	0.8 (1.4) –1.9–4.8	–0.5 (1.3) –3.6–1.4	*
Overjet (mm)	8.3 (2.8) 2.3–16.5	8.4 (3.3) 0.0–15.6	0.1 (2.9) –6.2–7.7	3.1 (0.8) 1.7–5.1	–5.3 (3.3) –12.3–2.4	3.9 (1.6) 1.1–7.2	0.8 (1.5) –2.5–4.3	*

*$P < 0.05$; NS, not significant.

Table 2 Mean time for orthodontic treatment and retention in months (n = 58).

Orthodontic treatment	Retention time (months)
Pre-surgical orthodontics	13.2
Post-surgical	7.0
Retention in the upper arch	6.3
Retention in the lower arch	8.9

were generally small, but there were marked individual variations. The sagittal (SNA) and vertical (SN/NL) positions of the maxilla after 2 years were stable. There was, however, a significant correlation (r = 0.6) between the vertical changes at surgery and relapse. The mandible showed a significant posterior rotation (SN/ML –1.4) after 2 years, the sagittal relationship (SNB) was stable. The inter-incisor relationship (ILS/ILI) showed a significant relapse (–2.4) depending

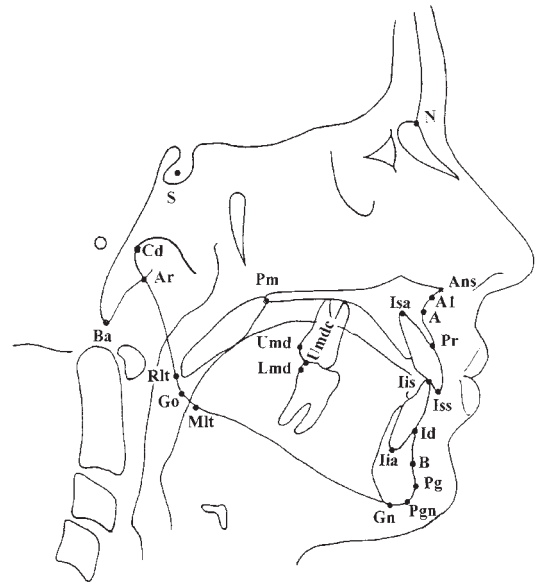

Figure 1 Cephalometric landmarks.

Table 3 Reference points and lines used in the cephalometric analysis and/or in the mean plots.

A	Point A. Subspinale. The most posterior point on the anterior contour of the upper alveolar process.
A1	Point on the lower contour of the anterior nasal spine where the vertical thickness is 3 mm.
Ans	The tip of the anterior nasal spine.
Ar	Articulare. The intersection between the external contour of the cranial base and the dorsal contour of the condyle.
B	Point B. Submentale. The most posterior point on the anterior contour of the lower alveolar process.
Ba	Basion. The most inferior point on the clivus of the occipital bone.
Cd	Condylion. The most superior–posterior point of the condylar head.
Gn	Gnathion. The most inferior point of the mandibular symphysis.
Go	Gonion. The intersection between the external contour of the mandible and the bisector of the angle between the RL and ML lines.
Id	Infradentale. The most anterior superior point on the lower dento-alveolar margin.
Iia	Incision inferior. Apex of the most prominent mandibular central incisor.
Iis	Incision inferior. Incisal edge of the most prominent mandibular central incisor.
Isa	Incision superior apex. Apex of the most prominent maxillary central incisor.
Iss	Incision superior incisal edge of the most prominent maxillary central incisor.
Lmd	Lower molar distal. The most distal point of the crown on the lower first molar.
Mlt	Mandibular tangent point. Tangent point on the lower contour of the mandible from Gn.
N	Nasion. The most anterior point of the frontonasal suture.
Pg	Pogonion. The most anterior point on the mandibular symphysis.
Pgn	Prognathion. The point on the mandibular symphysis farthest from Cd.
Pm	Pterygomaxillare. The intersection between the nasal floor and the posterior contour of the maxilla.
Pr	Prosthion. The most anterior inferior point on the upper alveolar margin.
Rlt	Ramus tangent point. Tangent point on posterior contour of the ramus line from Ar.
S	Sella. The centre of sella turcica.
Umd	Upper molar distal. The most distal point of the crown on the upper first molar.
Umdc	Upper molar distal cusp. The distal cusp of the upper first molar.
ILI	Length of the axis of the most prominent lower incisor. A line through Iis and Iia.
ILS	Length of the axis of the most prominent upper incisor. A line through Iss and Isa.
ML	Mandibular line. The tangent to the lower border of the mandible through Gn.
NL	Nasal line. The line through Ans and Pm.
S–N	Sella–nasion line.

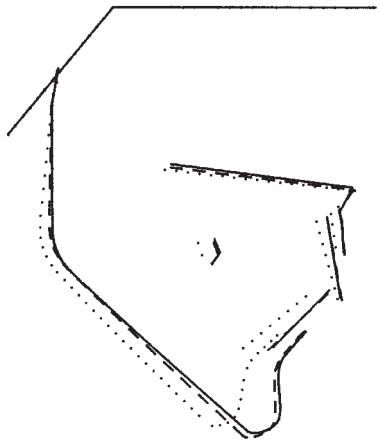

Figure 2 A mean plot of cephalograms orientated to the sella–nasion line demonstrating start of treatment (· · · · ·), and the 8 week (—) and the 2 year controls (– – – –).

on incisor proclination. There was a significant relapse of overjet (0.8 mm) and overbite (–0.5 mm): overbite relapse was correlated ($P < 0.05$) with incisor proclination. The least relapse in overbite occurred in the group undergoing inter-maxillary fixation (IMF) for 1–3 weeks and the least relapse in overjet in the group without IMF (Table 4). Significantly more overjet relapse was associated with 8 weeks IMF than with 1–3 weeks. With respect to overbite, the most stable results were recorded in patients without any fixation. Seventeen patients had an open bite at the 2-year follow-up. Among them eight patients had undergone segmental osteotomies. In all, 42 per cent of the segmental osteotomies showed an anterior open bite after 2 years, while only 18 per cent of the Le Fort I subjects where the maxilla was not divided relapsed to an open bite. No correlation was found between surgeon and relapse.

Discussion

Every clinician is concerned about the long-term stability of treatment outcome. Quality assurance is now as much a part of routine clinical procedures as taking care of patients. Rehabilitation of patients with anterior open bite and mandibular retrognathism is a complex, lengthy procedure, involving both orthodontic treatment and bimaxillary surgery. It is therefore unfortunate when relapse occurs. Most earlier studies of the outcome of open bite treatment are based on limited material. In the present study, all 58 patients had an open bite and a retrognathic mandible. The surgical procedures were undertaken by only two surgeons, and age and sex distribution is representative of patients commonly undergoing combined orthodontic/surgical treatment. Analysis of stability indicates that the maxilla remains stable, but the mandible shows a tendency to posterior rotation. These findings are in close agreement with several previous reports (Lello, 1987; Turvey *et al*., 1988; Ayoub *et al*., 1993).

In the present study the incisors had been retroclined during orthodontic treament, and the mean duration of maxillary and mandibular fixed retention was 6.3 and 8.9 months, respectively (Table 1). Some of the relapse in the position of the incisors as well as the open bite may be attributable to the retroclination and the relatively short duration of fixed retention. There are

Table 4 Changes of overjet and overbite in mm (SD), and range from 8 weeks to 2 years follow-up related to length of intermaxillary fixation (MMF), groups A, B, C, and D.

Length of MMF	No. of patients	Changes in overjet in mm (SD)	Changes in overbite in mm (SD)
(A) None	15	0.94 (1.7) – 0.8. 4.3	0.10 (0.8) – 1.4–1.1* (B,D)
(B) 1–3 weeks	14	0.06 (0.7) – 0.9–1.1* (D)	–0.66 (1.1) – 3.2–1.0
(C) 4–7 weeks	6	0.68 (2.0) – 2.5–2.9	–0.32 (1.7) – 3.3–1.2
(D) >8 weeks	23	1.12 (1.6) – 1.9–4.0	–0.92 (1.4) – 3.6–1.4

* Significant difference between groups.

several reasons for mandibular relapse after surgical advancement, and it is difficult to distinguish between relapse of orthodontic origin and changes due to skeletal instability. Facial growth continues at a slow rate throughout life and changes observed over a follow-up period may represent a continuation of growth, rather than post-treatment relapse (Björk, 1963). It has therefore been proposed that stability would be enhanced by overrotating the mandible at surgery to a decreased mandibular plane angle (Proffit *et al*., 1992).

Mode of breathing, tongue position, and tongue thrust may be of importance for both the development and the relapse of an open bite malocclusion (Linder-Aronson, 1970).

A tongue thrust swallow is known to be closely related to an increase in the frequency of distal occlusion, extreme maxillary overjet and open bite (Melsen *et al*., 1979). Hoppenreijs *et al*. (1996) found significant correlations between tongue position and occlusion in both the anterior and the posterior regions of the jaws. Modification of tongue behaviour may improve the stability of corrected open bite. The relationship between patterns of orofacial muscle activity and malocclusion, however, is still not clearly understood. In the present retrospective study only treatment variables were related to the stability, as myofunctional abnormalities were not always noted in the case record.

Post-operative MMF is still controversial. In the present study, 75 per cent of the patients had MMF for varying times. The greatest stability in overjet was found in the group with MMF for 1–3 weeks and the greatest stability in overbite in the group without any MMF. This finding is inconsistent with earlier reported observations claiming that the dentition compensates for skeletal changes during fixation (Will *et al*., 1984). The protocol for performing MMF is usually to provide non-rigid fixation. Krekmanov *et al*. (1988) concluded that omitting MMF had no negative effect on the post-operative stability of the fragments. However, in this study fixation was performed with bone plates/screws and wire osteosynthesis alternately. Accordingly, some patients had rigid fixation, as well as a short period of MMF. This indicates that the reason for using MMF was mainly the surgeon's preference. It should be emphasized that changes in cephalometric values are not always signs of reduced function or of a malocclusion. This study observed patients with some degree of relapse. At the 2-year follow-up, 17 patients had an open bite. Among them eight patients had undegone segmental ostetomies, which corresponds to 42 per cent of those with a segmented maxilla. This is a high number, which requires further study. However, relapse after treatment of anterior open bite is a question of definition. In the case of a patient with a negative overbite of 8 mm before treatment, a positive overbite post-operatively, and at 2-year follow up an open bite of 1 mm, should this be recorded as a relapse? For the patient, the reduction in negative overbite from 8 to 1 mm is undoubtedly a marked improvement. However, there is still an open bite and the patient cannot bite into a sandwich.

This study was based on cranial base superimposition of lateral skull radiographs according to Björk and Skieller (1983). Landmark identification can be a problem when landmarks are altered and/or obliterated as a result of surgery. The validity of cephalometric measurements was discussed by Wall and Rosenquist (1996), who emphasized that the accuracy of cephalometry is poor and an inaccurate tool for post-operative follow-up of minor segment migration, typical of ostetomies. Staburn and Danielsen (1982) have shown that one observer held definite opinions as to the cephalometric landmark localization, resulting in apparently improved precision, but there are inter-observer differences in the interpretation of the definition and the localization of landmarks. In this study, one observer performed all the cephalometric recordings.

Changes occurring during the first 8 weeks post-operatively were not recorded. Although most relapses often occur during this period (Kahnberg *et al*., 1994), for the patient and for the clinician, the long-term outcome is of greater interest. Post-treatment changes appear to be a multifactorial problem and the relative influence of different factors varies from one individual to another. Further investigations are required

to evaluate the influence of such factors as tongue position, tongue pressure, and mode of breathing.

Conclusions

After bimaxillary surgery of open bite malocclusion and mandibular retrognathism the maxilla remains in the post-surgical position, while the mandible slightly rotates posteriorly. MMF for 0–3 weeks post-operatively appears to enhance stability.

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