Stability of maxillary surgery in openbite versus nonopenbite malocclusions

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Treatment and long-term stability of anterior openbite malocclusions have frustrated clinicians for many years. Traditionally, openbites have been corrected with orthodontic tooth movement and/or dentofacial orthopedics. Studies have shown, however, that many of these patients will redevelop an openbite after treatment.[1,2] During the past 15 years, orthognathic surgery has emerged as a common method for correcting anterior openbites in adult patients. Many clinicians believe that openbites will not recur after surgery, because the skeletal imbalance has been corrected. However, this viewpoint is purely hypothetical, since no study has evaluated the relationship between maxillary surgery and openbite. Therefore, the purpose of this study is to assess cephalometrically the posttreatment stability of maxillary surgery in openbite and nonopenbite malocclusions.

Materials and methods

The sample consisted of 66 subjects: 55 females and 11 males. All subjects received orthodontic therapy and were treated with LeFort I osteotomies to reposition their maxillae superiorly. Indications for LeFort I osteotomies in these patients included one or more of the following: excessive facial height, excessive gingival display, or anterior openbite. Subjects were selected from the private practices of the faculty of the Department of Orthodontics at the University of Washington.

The following criteria were used to select the sample: (1) nongrowing patients; (2) Angle Class I or Class II malocclusion; (3) availability of cephalometric radiographs at three intervals: pretreatment (T_1), posttreatment (T_2), and at least one year posttreatment (T_3).

Abstract

Lateral cephalometric radiographs were evaluated to determine the posttreatment stability of 66 patients treated with LeFort I osteotomies to reposition their maxillae superiorly. The sample was divided into three groups based on the degree of pretreatment overbite: openbite subsample — no incisal overlap; overlap subsample — incisal overlap and no incisal contact; contact subsample — incisal overlap with incisal contact. The cephalograms were superimposed and linear measurements were made at each interval (pretreatment, posttreatment, and at least one year posttreatment). The results clearly show that the three subsamples reacted differently during the posttreatment interval. 42.9 percent of the subsample with pretreatment openbite showed a significant increase in facial height, significant eruption of maxillary molars, and a significant decrease in overbite. 28.6 percent of the openbite subsample and 16.7 percent of the overlap subsample showed a significant increase in facial height, significant eruption of maxillary incisors, and no change in overbite. The contact subsample had no significant posttreatment changes. Possible reasons for the posttreatment instability in the openbite subsample are proposed.

Key Words: Stability • Maxillary surgery • Openbite • Orthognathic surgery • Relapse

Cephalometric analysis

All cephalometric radiographs were traced and measured by the primary author. Eight dental and skeletal landmarks were used to establish the following seven linear measurements (Fig. 1):

(1) *Facial Height* (FH) — Nasion to Menton.

(2) *Overbite* (OB) — The distance between perpendicular lines projected onto the NMe line from the maxillary and mandibular incisal edges. Lack of incisal overlap was recorded as a negative value. Incisal overlap was recorded as a positive value or as zero when the incisal edges were at the same level.

(3) *Overjet* (OJ) — The distance between perpendicular lines projected onto the occlusal plane from the incisal edges.

(4) *Incisor Vertical Position* —

a. *Maxillary incisor* (MxIVP): Nasion to the tip of the upper incisor.

b. *Mandibular incisor* (MnIVP): Menton to the tip of the lower incisor.

(5) *Molar Vertical Position* —

a. *Maxillary molar* (MxMVP): the length of the perpendicular line from occlusal point to the SN line.

b. *Mandibular molar* (MnMVP): the length of the perpendicular line from occlusal point to mandibular plane (Me-Go).

The sample was divided into the following three subsamples based on the degree of pretreatment (T_1) overbite (Fig. 2):

(1) Those subjects with no pretreatment overlap of the maxillary and mandibular incisal edges (subsample OP). Subsample OP consisted of 28 subjects.

(2) Those subjects with pretreatment overlap but no contact of maxillary and mandibular incisal edges (subsample IO). Overlap subsample IO consisted of 24 subjects.

3. Those subjects with pretr atment incisal overlap and contact as verified from the pretreatment dental casts (subsample IC). The contact subsample IC consisted of 14 subjects.

Overall superimpositions were prepared according to Elmajian[3] and Nelson[4] using detail seen in the ethmoid triad. Mandibular superimpositions were made according to the technique described by Björk[5], using detail in the mandibular symphysis and mandibular canals.

Statistical analysis

Statistical analyses were performed using standard methods. The significance of changes between groups was compared by the Student's *t* test for independent groups; and the significance of changes across time vas determined by the Student's *t* test for paired data. The Pearson correlation coefficient was used to test for significant relationships between variables. Statistical significance was established at $p \leq 0.05$ and a correlation of $r \geq 0.6$ was considered clinically significant.

Errors in landmark identification, superimposition, and measurement were evaluated by trac-

Figure 1
The cephalometric measurements.
MxIVP — maxillary incisor vertical position
MxMVP — maxillary molar vertical position
MnIVP — mandibular incisor vertical position
MnMVP — mandibular molar vertical position
OB — overbite
OJ — overjet
Na-Me line — facial height

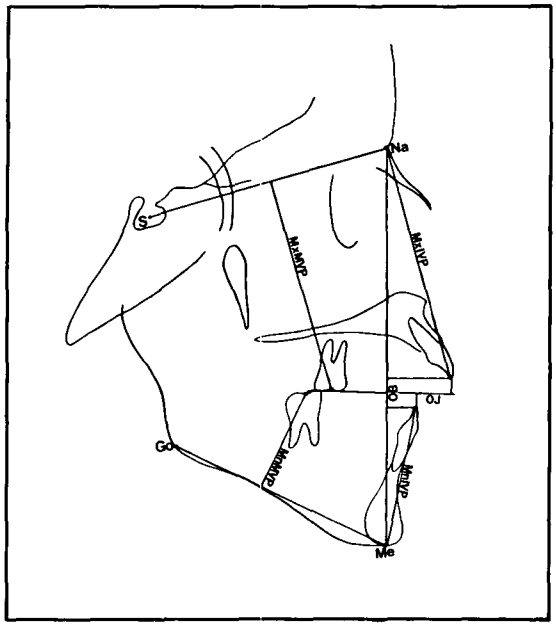

Figure 2
Three subsamples based on the degree of pretreatment overbite.
Subsample OP:
openbite — no pre treatment overlap and no contact of mandibular and maxillary incisal edges.
Subsample IO:
overlap — pretreat ment overlap but no contact of mandibular and maxillary incisal edges.
Subsample IC:
contact — pretreat ment incisal overlap with incisal contact.

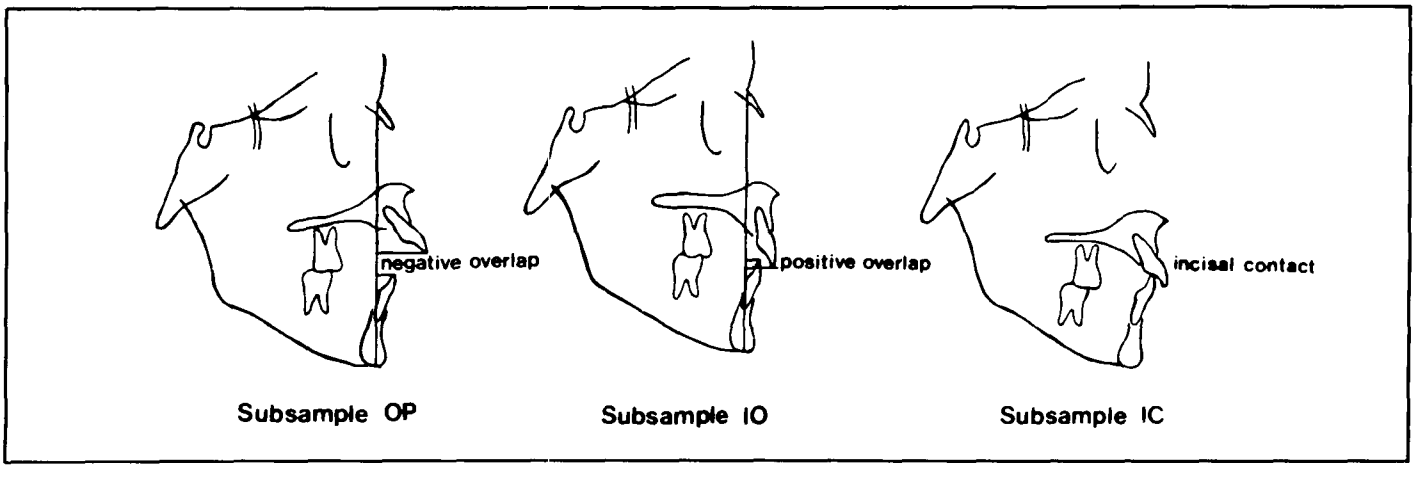

Table 2. The statistical significance of the mean posttreatment changes for each subsample.

	Subsample OP: (T3-T2) (N = 28)				Subsample IO: (T3-T2) (N = 24)				Subsample IC: (T3-T2) (N = 14)				
Variable	Mean Change	SD	p Value	r Value	Mean Change	SD	p Value	r Value	Mean Change	SD	p Value	r Value	Error
FH	* 2.13	1.55	*p≤ .0001	0.99	0.50	1.18	p≤ .049	0.97	0.07	0.18	p≤ .165	0.99	0.73
OB	* -0.96	1.56	*p≤ .003	0.61	0.25	0.78	p≤ .130	0.62	0.57	0.83	p≤ .023	0.52	0.88
OJ	0.73	1.20	p≤ .003	0.74	0.44	0.50	p≤ .0002	0.80	0.54	0.50	p≤ .002	0.76	0.95
MxIVP	1.02	1.17	p≤ .0001	0.99	0.60	0.81	p≤ .0013	0.98	0.50	0.79	p≤ .033	0.99	1.35
MnIVP	0.30	0.74	p≤ .038	0.98	0.48	0.62	p≤ .0009	0.98	0.18	0.64	p≤ .314	0.98	1.08
MxMVP	1.25	1.40	p≤ .0001	0.97	0.40	0.61	p≤ .004	0.99	0.32	0.54	p≤ .045	0.99	1.34
MnMVP	0.52	0.69	p≤ .0004	0.99	0.31	0.69	p≤ .036	0.98	0.29	0.51	p≤ .055	0.99	1.37

*Clinical significance after measurement error

ing ten randomly selected headfilms on three successive occasions over a period of three weeks. The error was derived by comparing changes between the time intervals for the three sets of data produced for these ten headfilms.

Mathematical correction for enlargement error was necessary for those subjects who had headfilms taken on different cephalometers. The relative distances between two midline skeletal landmarks (anterior or posterior clinoid process to nasion) on successive headfilms were measured and compared. The resulting magnification ratio was computed and applied to all linear measurements obtained from those headfilms.

Results

The mean measurement error was computed for the seven variables in each subsample (listed in Table 2). Although the p values in Table 2 indicate a statistically significant difference across time for most of the data, clinical significance cannot be concluded. Only two variables exhibited mean change values that were greater than the measurement error.

A significant increase in facial height ($X = 2.13 \pm 1.55$; $p \leq .0001$; $r = .99$) occurred during the posttreatment period in the openbite subsample OP. Overbite, measured from N-Me line, decreased significantly ($X = -.96 \pm 1.56$; $p \leq .003$; $r = .61$) from T_2 to T_3. The mean changes in the remaining five variables in the openbite subsample OP were statistically significant, but the changes were within the range of the measurement error. All mean changes for the overlap subsample IO and the contact subsample IC fell within the measurement error.

Differences between treatment changes (T_2-T_1) and posttreatment changes (T_3-T_2) are listed in Table 3. Although most mean differences were significant ($p \leq .05$), extremely low correlations existed between treatment and posttreatment changes with r values ranging from .01 to .50.

In the analysis of posttreatment changes (Table 4), the openbite subsample OP was significantly different than the overlap subsample IO for the following three variables: facial height ($p \leq .0001$), overbite ($p \leq .0009$), and maxillary molar vertical position ($p \leq .0057$). Furthermore, the openbite subsample OP was significantly different from the contact subsample IC for the same three variables. There were no significant differences in the posttreatment changes between the overlap subsample IO and the contact subsample IC.

Further investigation revealed several trends

Table 1 Sample Characteristics

	AGE	
	Median (yr-mo)	Range (yr-mo)
Pretreatment	24-0	12-0 to 42-10
Posttreatment	27-0	15-1 to 44-2
Posttreatment Recall	32-2	18-1 to 49-3
Posttreatment Recall Period	3-0	1-0 to 11-9

Table 3. The difference between mean treatment changes and mean posttreatment changes for each subsample.

	Subsample OP: (T2-T1)-(T3-T2)				Subsample IO: (T2-T1)-(T3-T2)				Subsample IC: (T2-T1)-(T3-T2)			
Variable	Mean Difference	SD	p Value	r Value	Mean Difference	SD	p Value	r Value	Mean Difference	SD	p Value	r Value
FH	4.80	2.70	p≤ .0001	0.18	3.02	4.44	p≤ .003	0.10	3.19	3.60	p≤ .006	0.08
OB	-6.59	2.54	p≤ .0001	0.22	-0.13	1.54	p≤ .674	0.19	2.86	1.80	p≤ .0001	0.21
OJ	4.86	3.66	p≤ .0001	0.33	-5.40	2.93	p≤ .0001	0.50	3.79	2.91	p≤ .0003	0.13
MxIVP	1.20	3.79	p≤ .104	0.37	3.17	3.29	p≤ .0001	0.16	5.86	3.52	p≤ .0001	0.09
MnIVP	-1.49	2.28	p≤ .002	0.11	2.20	3.40	p≤ .004	0.49	1.07	3.64	p≤ .293	0.37
MxMVP	3.36	2.80	p≤ .0001	0.32	2.80	2.60	p≤ .0001	0.17	3.00	2.12	p≤ .0001	0.46
MnMVP	1.11	2.88	p≤ .052	0.21	0.29	3.20	p≤ .658	0.19	0.08	2.67	p≤ .910	0.01

in the posttreatment data. Eight (8/28, 28.6%) subjects in the openbite subsample OP showed no significant changes from T_2 to T_3. The remaining twenty (20/28, 71.4%) had a significant increase in facial height ($\bar{X} = 2.93 \pm 1.03$; $p \leq .0001$; $r = .99$) during the posttreatment period. Two distinct subgroups were identified from the twenty subjects that showed an increase in facial height. Eight had no significant change in overbite but showed a significant increase in maxillary incisor vertical position ($\bar{X} = 2.09 \pm .65$; $p \leq .002$; $r = .99$). The other twelve exhibited a significant decrease in overbite ($\bar{X} = -2.63 \pm 1.09$; $p \leq .0002$; $r = .75$) and a significant increase in maxillary molar eruption ($\bar{X} = 2.29 \pm 1.04$; $p \leq .0002$; $r = .98$). Six of these twelve subjects had reopening of the anterior openbite beyond incisal overlap.

Only four subjects (4/24, 16.7%) in the overlap subsample IO exhibited a statistically significant increase in facial height ($\bar{X} = 1.9 \pm .85$; $p \leq .03$; $r = .97$). Maxillary incisor vertical position increased significantly ($\bar{X} = 2.00 \pm .71$; $p \leq .02$; $r = .98$) while overbite remained nearly unchanged. Furthermore, comparison of these changes with the subgroup of eight in the openbite subsample OP with similar increases in facial height and maxillary incisor position were not significantly different. No clinically significant posttreatment changes were identified in subjects from the contact subsample IC.

Discussion

In this study, the three groups of patients treated with maxillary surgery reacted differently during the posttreatment interval. Subjects with a pretreatment openbite (subsample OP), exhibited a significant mean increase in facial height and decrease in overbite posttreatment. Those subjects with pretreatment incisal overlap but no incisal contact (subsample IO), showed no clinically significant posttreatment changes. Subjects with pretreatment incisal contact (subsample IC) also had no clinically significant changes during the posttreatment interval.

It would be advantageous for clinicians to predict posttreatment stability in patients treated with maxillary surgery. The results of this investigation should help to satisfy this objective. Only 16.7 percent of the subjects with pretreatment incisal overlap exhibited significant increases in facial height, compared to 71.4 percent of the patients with pretreatment openbites. How could facial height increase during the posttreatment period in a nongrowing individual? Cephalometric superimpositions showed clockwise rotation of the mandible and molar eruption. However, an increase in facial height does not always produce a concomitant decrease in incisal overbite. Those subjects with pretreatment incisal overlap (subsample IO) had increased facial height with no significant change in overbite. A portion (28.6%) of the subjects with pretreatment openbites reacted similarly. Stability of the overbite in those patients can be linked to maxillary incisor eruption which maintained the overbite despite the increase in facial height.

Table 4. A comparison of the mean posttreatment changes between subsamples.

	OP: (T3-T2) vs. IO: (T3-T2)			OP: (T3-T2) vs. IC: (T3-T2)			IO: (T3-T2) vs. IC: (T3-T2)		
Variable	OP Mean Change	IO Mean Change	p Value	OP Mean Change	IC Mean Change	p Value	IO Mean Change	IC Mean Change	p Value
FH	2.13	0.50	$p \leq .0001$	2.13	0.07	$p \leq .0001$	0.50	0.07	$p \leq .0934$
OB	-0.96	0.25	$p \leq .0009$	-0.96	0.57	$p \leq .0002$	0.25	0.57	$p \leq .2309$
OJ	0.73	0.44	$p \leq .2398$	0.73	0.54	$p \leq .4569$	0.44	0.54	$p \leq .5601$
MxIVP	1.02	0.60	$p \leq .1500$	1.02	0.50	$p \leq .1425$	0.60	0.50	$p \leq .7006$
MxIVP	0.30	0.48	$p \leq .3607$	0.30	0.18	$p \leq .5919$	0.48	0.18	$p \leq .1610$
MxMVP	1.25	0.40	$p \leq .0057$	1.25	0.32	$p \leq .0038$	0.40	0.32	$p \leq .7072$
MnMVP	0.52	0.31	$p \leq .2882$	0.52	0.29	$p \leq .2703$	0.31	0.29	$p \leq .9000$

Posttreatment stability of incisal overbite is one criterion which defines treatment success for the clinician. The results of the present study reveal that 42.9 percent of the subjects with pretreatment openbites exhibited significant decreases in overbite posttreatment. Significant maxillary molar eruption without compensatory maxillary incisor eruption produced decreases in the overbite relationship. Six of these patients (21.4%) had no incisal overlap posttreatment. Why should nongrowing patients show such signficant changes after treatment?

A possible reason for instability could be the maxillary osteotomy procedure. Do all maxillary surgeries exhibit the same type of posttreatment relapse seen in the subjects with pretreatment openbites? In the subsample of patients with deep pretreatment overbites and incisal contact (IC), no clinically significant posttreatment changes occurred. 83.3 percent of the overlap subsample IO showed posttreatment stability in all variables, and none of the patients in the subsample had a significant change in overbite. Furthermore, patients with pretreatment incisal overlap (IO) and/or incisal contact (IC) were statistically similar for all variables studied. Clearly, all maxillary surgeries do not respond similarly during the posttreatment interval.

The data from this study suggest the posttreatment instability in patients with pretreatment openbites was due to dentoalveolar changes, not skeletal changes. Histologic studies have shown that most bone healing and remodeling at the osteotomy site is completed two to four months after surgery.[6-9] In addition, cephalometric studies have shown that significant postoperative movement of the bony fragments ceases within six months after surgery.[10,11] Orthodontic treatment continued in all of the subjects in this study for at least nine months after surgery. This suggests that the etiology of the posttreatment dentoalveolar changes is not due to postoperative skeletal movement.

In this investigation, the openbite recurred in 42.9 percent of those subjects with a pretreatment openbite. Therefore, stability of openbite correction after maxillary surgery cannot be assumed. Lopez-Gavito and associates[2] reported that more than 35 percent of their orthodontically treated patients with pretreatment openbites demonstrated a postretention openbite of 3mm or more. Both studies seem to implicate some common factor as the cause of openbite relapse. Although dental and skeletal malrelationships can be corrected, the role of orofacial musculature also must be addressed in orthodontic therapy. If tongue posture and hypotonic buccal musculature can cause a pretreatment openbite,[12-15] it is conceivable that recurrence of the openbite after treatment could be due to the same etiology. The stability of openbite correction may increase if the etiology of the openbite is eliminated during treatment.

This study has shown that openbites treated with LeFort I osteotomies exhibit significant posttreatment relapse. This does not mean that maxillary surgery is inappropriate for correcting

openbites in nongrowing patients. Maxillary surgery is still the treatment of choice for many adult patients with openbites, excessive facial height and gingival display. Nevertheless, posttreatment stability may improve as efforts to identify and manage the etiology of the malocclusion are undertaken.

Conclusion

Lateral cephalometric radiographs were evaluated to determine the posttreatment stability of 66 patients treated with LeFort I osteotomies to reposition their maxillae superiorly. The following three subsamples were delineated on the basis of pretreatment incisal overlap and incisal contact:

a. *Subsample OP* — no pretreatment overlap and no contact of mandibular and maxillary incisal edges.
b. *Subsample IO* — pretreatment overlap but no contact of mandibular and maxillary incisal edges.
c. *Subsample IC* — pretreatment incisal overlap with incisal contact.

On the basis of statistical analysis, the following conclusions were made:

1. 42.9 percent of the subsample with a pretreatment openbite (OP) demonstrated clinically and statistically significant: a) increases in facial height; b) eruption of the maxillary molars; c) decreases in overbite posttreatment.
2. 28.6 percent of the openbite subsample OP and 16.7 percent of the overlap subsample IO demonstrated clinically and statistically significant increases in facial height; eruption of the maxillary incisors, and no change in overbite posttreatment.
3. Six patients in the openbite subsample OP (21.4%) exhibited reopening of the anterior openbite beyond incisal overlap during the posttreatment period.
4. The contact subsample IC and 83.3 percent of the overlap subsample IO exhibited no clinically significant posttreatment changes.
5. No correlations existed between treatment changes and posttreatment changes in all three subsamples.

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