Orginal Article

Long-Term Stability of Surgical Open-Bite Correction by Le Fort I Osteotomy

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Abstract: Skeletal changes greater than those observed in untreated adults have been noted beyond 1 year post-surgery in adult patients who had surgical correction of a long face deformity. The stability of skeletal landmarks and dental relationships from 1 to >3 years post-surgery was examined in 28 patients who had undergone surgery of the maxilla only, and in 26 patients who had undergone 2-jaw surgery to correct >2 mm anterior open bite. Although the average changes in almost all landmark positions and skeletal dimensions were less than 1 mm, point B moved down >2 mm and face height increased >2 mm in one-third of the maxilla-only group and in 40% of the 2-jaw group (>4 mm in 10% and 22% respectively). Overbite decreased 2–4 mm in only 7% of the maxilla-only and 12% of the 2 groups, with no changes >4 mm, because in three-fourths of the patients with an increase in anterior face height, further eruption of the incisors maintained the overbite relationship. In the maxilla-only group, mandibular length (Co-Pg) showed >2 mm long-term change in 45% of the patients, two-thirds of whom showed an increase rather than a decrease in length. In the 2-jaw group, no patients showed a decrease in Co-Pg length and one-third had an increase. For both groups, changes in overjet were smaller and less frequent than changes in mandibular length. (*Angle Orthod* 2000;70:112–117.)

Key Words: Open bite; Orthognathic surgery; Long-term stability

INTRODUCTION

Anterior open bite can be due to lack of eruption of anterior teeth, but most often is caused by rotation of the jaws or excessive eruption of posterior teeth. On cephalometric analysis, the major indicators of a skeletal relationship that predispose an individual to open bite (the ''skeletal open bite'' pattern) are a short mandibular ramus and downward rotation of the posterior maxilla. Both tend to produce a downward-backward rotation of the mandible that increases anterior face height and separates the anterior teeth. Although a long face adds a skeletal dimension to open bite problems, about one-third of those who seek treatment for a long-face deformity have normal or excessive overbite rather than open bite, due to compensatory eruption of the anterior teeth.[1]

Successful treatment of skeletal open bite during growth requires control of downward growth of the maxilla and eruption of posterior teeth so that mandibular rotation is prevented. This can be extremely difficult to accomplish. Continued vertical growth in the late teens is a major problem that often occurs after orthodontic treatment has been completed. After excessive vertical growth has occurred, there are only 2 approaches to treatment of open bite: elongate the anterior teeth, which leaves the skeletal component of the deformity uncorrected, or depress the posterior teeth.

If an appropriate force system could be developed and applied, it would be possible to intrude posterior teeth. Bite blocks between the posterior teeth, with or without magnets, can prevent further eruption, but significant intrusion in adolescents or adults is difficult to document and rarely if ever achieved.[2] Open bite can be corrected in patients who are beyond the adolescent growth spurt with a multiloop edgewise technique, but the major effect is extrusion of anterior teeth rather than intrusion posteriorly.[3] Once excessive vertical development has occurred, orthognathic surgery is the only way to correct the jaw rotations and reduce anterior face height.

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Superior repositioning of the maxilla by Le Fort I osteotomy is the most stable orthognathic procedure during the first post-surgical year.[4] Although it is possible to correct open bite by mandibular ramus surgery as an isolated procedure,[5] 2-jaw surgery generally is preferred when the mandible must be repositioned in open bite patients.[6] Superior repositioning of the maxilla is used to obtain the correct face height, and mandibular ramus osteotomies are used to adjust the antero-posterior position of the mandible (usually, to further advance it) if it does not rotate into the correct position after the maxilla is moved.

Although the short-term stability of this surgery is excellent, many long-face patients have changes in the position of cephalometric landmarks from 1 to 5 years post-surgery following superior repositioning of the maxilla with or without simultaneous mandibular advancement.[7–10] On the average, changes of less than 1 mm occur, but the data show that long after surgical healing is complete, the maxilla moves downward slightly, the mandible rotates downward slightly, and overbite may decrease. Larger changes occur in a small number of patients, and the number of post-surgical patients with clinically significant long-term relapse toward open bite has not been reported. Lo and Shapiro[10] reported that all the patients in their sample of surgically-treated patients had incisor overlap at the end of post-surgical orthodontic treatment, but 25% did not at the most recent follow-up. It has been suggested that condylar resorption and relapse in jaw position is particularly likely in long face, mandibular-deficient patients treated with 2-jaw surgery.[11] Relapse toward open bite is likely in these patients.

This paper reports stability beyond 1 year post-surgery for patients in the University of North Carolina (UNC) Dentofacial Program database who had surgical correction of >2 mm anterior open bite via Le Fort I osteotomy with or without simultaneous ramus osteotomies. The data set overlaps the previously reported stability for long-face patients, but only about half of those treated surgically for a long-face problem have anterior open bite of this severity.

METHODS

All patients who had surgical correction of anterior open bite >2 mm by either Le Fort I osteotomy alone or the combination of Le Fort I and mandibular ramus osteotomies, for whom presurgery, immediate post-surgery, 1-year and at least 3-year post-surgery cephalometric radiographs were available, were selected from the UNC database. Data for 54 patients, 28 with maxilla-only and 26 with 2-jaw surgery, were available. Mandibular advancement beyond upward-forward rotation occurred in most but not all the 2-jaw patients (ie, the 2-jaw sample included some open bite patients who did not have mandibular deficiency). Characteristics of the sample, which included patients with wire and rigid fixation, are shown in Table 1.

Table 1. Characteristics of Long-Term Open Bite Sample

Characteristic	Maxilla Only	Two Jaw
Mean age at surgery, y	21.8	24.5
Standard deviation, y	8.1	10.2
Range, y	13–54	15–47
Mean longest follow-up, y	5.33	5.29
Range, y	2.6–12.0	3.0–13.7
Female, %	61	62
Non-white, %	7.4	3.8
With genioplasty, %	32	27
With maxilla segments, %	55	39
Rigid fixation of the mandible, %	—	46
Rigid fixation of the maxilla, %	18	38

The cephalometric radiographs were digitized using the UNC 140-point model and changes in landmark positions were evaluated relative to a previously described x-y coordinate system.[6,7] Open bite was measured from the cephalometric radiographs as the vertical distance between the incisal edges of the upper and lower incisors projected to the true vertical line. Mixed linear models using the likelihood-based estimation approach were used to assess the effect of demographic and surgical variables and time on the cephalometric measures. Evaluation of variance and covariance structures using Akaike's Information Criterion and Schwarz' Bayesian Criterion indicated that the unstructured model provided the best fit for the data.

The initial model for each cephalometric variable included the main effects of time (presurgery, immediate post-surgery, 1-year, and longest follow-up), type of surgery (maxilla-only or 2-jaw), type of maxillary fixation (wire or rigid), presence of genioplasty (yes or no), age (19 years or younger, older than 19 years) and gender, as well as all possible 2- and 3-way interactions. For each cephalometric measure, the model was reduced by eliminating the nonstatistically significant 3-way and then 2-way interactions. Interactions with P values of .025 or less were maintained in the reduced models. Effects in the final model were considered statistically significant if the P value associated with the Type III Sum of Squares was .01 or less. Comparisons between visits were performed using pairwise contrasts for testing the univariate difference between presurgery and 1-year follow-up, and between 1-year and longest follow-up. The level of significance was set at .01 because of the number of cephalometric measures being analyzed.

Changes >2 mm or >2 degrees were considered clinically significant, and changes >4 mm or >4 degrees highly clinically significant. The percent of each group with change of these magnitudes was calculated.

This study focuses on changes beyond 1 year post-surgery. Mean changes from presurgery to the end of the first post-surgical year are displayed in composite cephalometric tracings in Figure 1. These changes are quite similar to those previously reported for long-face patients from our database[7,8] and by Hoppenreijs et al.[9]

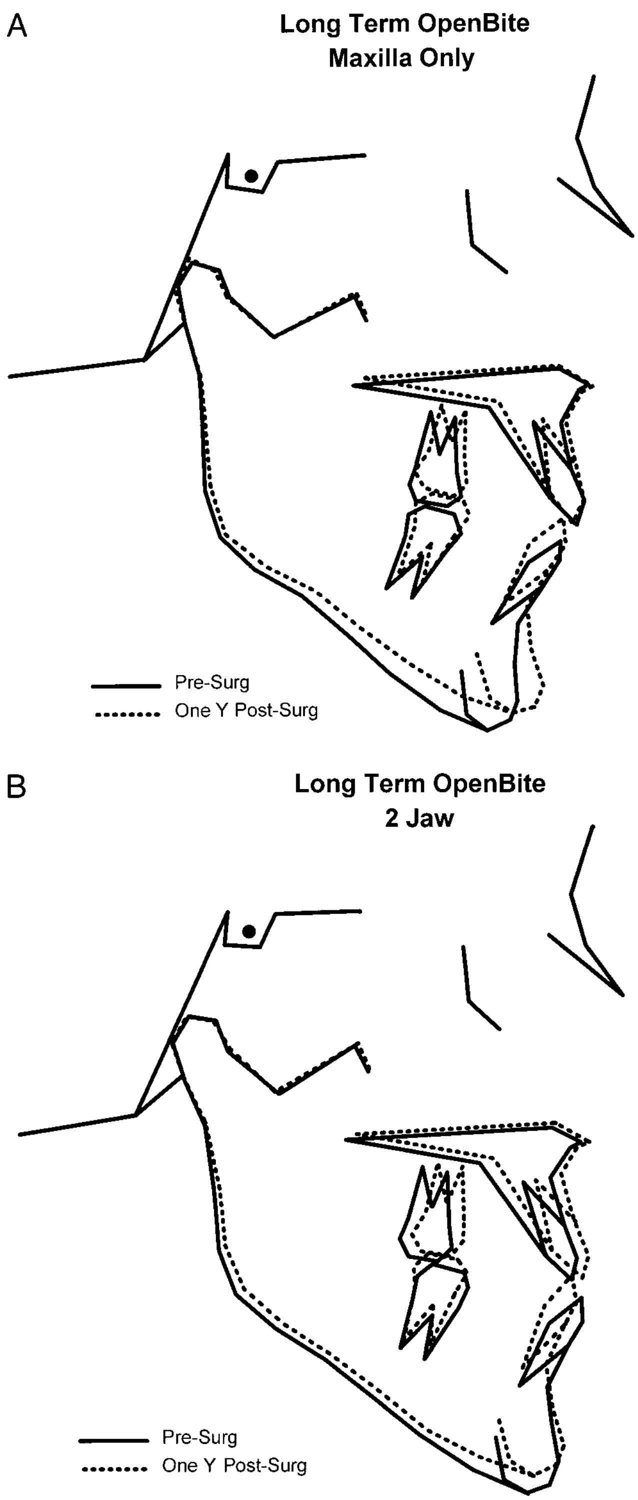

FIGURE 1. Composite cephalometric tracings for changes from pre-surgery to 1 year post-surgery for the maxillary surgery only (A) and 2-jaw surgery (B) groups.

RESULTS

Mean changes in selected cephalometric landmarks and dimensions from 1 year post-surgery to longest follow-up are shown in Tables 2 and 3, and composite cephalometric superimpositions for this time period are displayed in Figure 2. On average, beyond 1 year post-surgery there was a tendency for the maxilla and mandible to move slightly downward in both groups, and for maxillary posterior teeth and both maxillary and mandibular anterior teeth to erupt. The average change was quite small and almost identical in the 2 groups. For both surgical groups, statistically significant changes in the mandibular plane angle, the vertical position of point B, and total face height were observed ($P < .001$ in each case). The statistical modeling showed that even in the long-term, the type of surgery did affect overbite, the antero-posterior position of the chin and lower incisor, and the gonial angle (Table 3). Despite these skeletal changes, there was almost no mean change in overbite in the maxilla-only group, and the small decrease in overbite in the 2-jaw group was not statistically significant. Overbite in the maxilla-only and 2-jaw patients differed prior to surgery and was different at longest follow-up ($P < .01$), although the change from 1 year to longest follow-up was not significant.

Table 2. Changes From 1 Year to 3 or More Years Postsurgery

	Mean	S.D.	P value
Horizontal			
Pt A	0.04	1.21	0.80
PNS	−1.11	2.38	0.001
Pt B	−0.40	2.31	0.21
Pg	−0.35	2.77	0.36
Go	−0.39	2.71	0.26
Co	0.24	2.37	0.23
Max Inc	0.02	1.79	0.93
Mand Inc	0.02	2.08	0.94
Max Molar	0.13	2.50	0.71
Mand Molar	0.23	2.83	0.55
Vertical			
Pt A	0.38	2.28	0.23
PNS	0.30	1.13	0.06
Pt B	1.51	2.89	0.0004
Pg	0.72	2.30	0.03
Go	−0.38	2.47	0.27
Co	−0.59	1.80	0.02
Max Inc	0.39	1.21	0.02
Mand Inc	0.64	1.40	0.002
Max Molar	0.62	1.17	0.0002
Mand Molar	0.32	1.51	0.12
Pal Plane	−0.54	2.15	0.07
Mand Plane	0.96	1.70	0.001
Na-ME	1.05	1.46	0.001

Table 3. Long-Term Changes That Differ for Maxilla-Only and Two-Jaw Patients

	Maxilla Only, mm		Two Jaw, mm		
	Mean	SD	Mean	SD	*P* Value
Overjet	0.13	1.68	−0.28	1.25	.007
Overbite	0.02	1.21	−0.55	1.24	.003
Co-Pg	0.22	2.71	1.22	1.92	.03

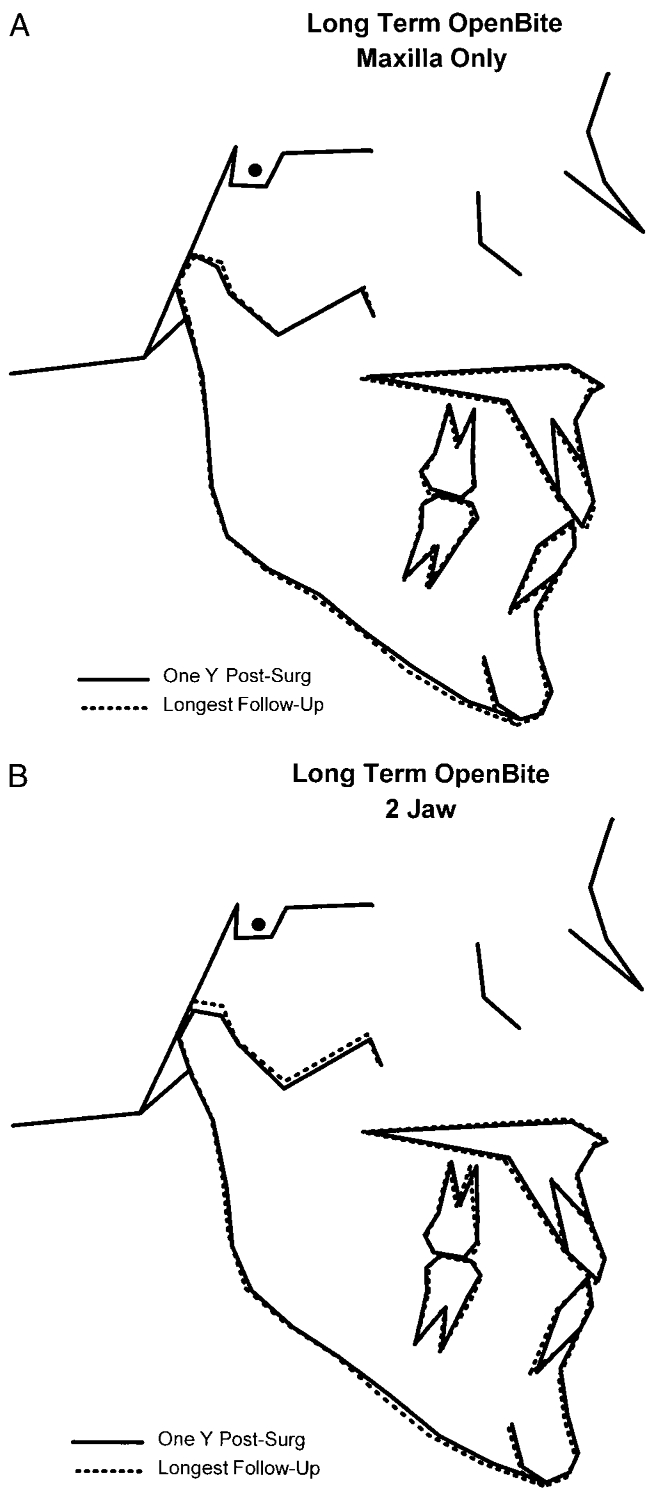

FIGURE 2. Composite cephalometric tracings for changes from 1 year post-surgery to longest follow-up (>3 years) for the maxillary surgery only (A) and 2-jaw surgery (B) groups.

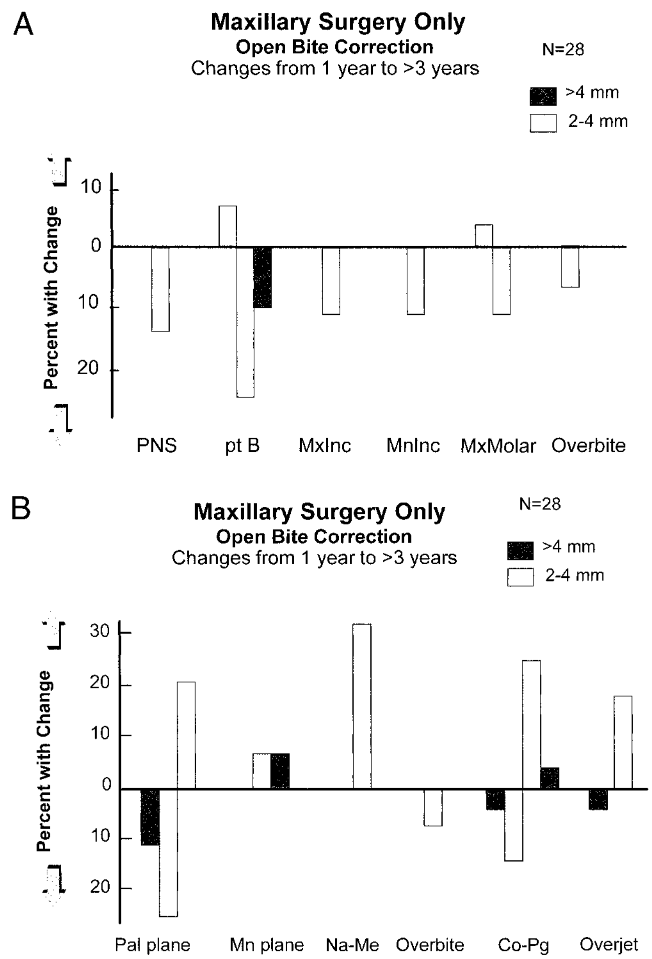

FIGURE 3. Percentages of maxilla-only patients with clinically significant changes in cephalometric landmark positions (A) and dimensions and relationships (B).

The percentage of patients with changes >2 and >4 mm for skeletal landmarks and overbite, and for >2 and >4 mm/degrees in dimensions and relationships and overbite and overjet, are displayed graphically in Figures 3 and 4, respectively. Note that point B moved down >2 mm in one-third of the maxilla-only group and 40% of the 2-jaw groups (>4 mm in 10% and 22% respectively). Face height (Na-Me) increased 2 to 4 mm in 32% of the maxilla-only group, while 27% of the 2-jaw group had a 2 to 4 mm increase and 4% had >4 mm increase. In contrast, overbite decreased 2 to 4 mm in only 7% of the maxilla-only and 12% of the 2-jaw groups, with no changes >4 mm.

With maxillary surgery only, long-term changes >2 mm in Co-Pg length were noted in 45% of the patients. Of these, one-third (15% of the total group) had a decrease in mandibular length, and two-thirds (30%) showed an increase (Figure 4). Overjet changed less than mandibular length, in both directions, but 15% had a 2 to 4 mm increase in overjet. In the 2-jaw group, no patients showed a clinically significant decrease in Co-Pg length (ie, there was no evidence of long-term condylar resorption, and one-third of these patients had >2 mm increase in mandibular length).

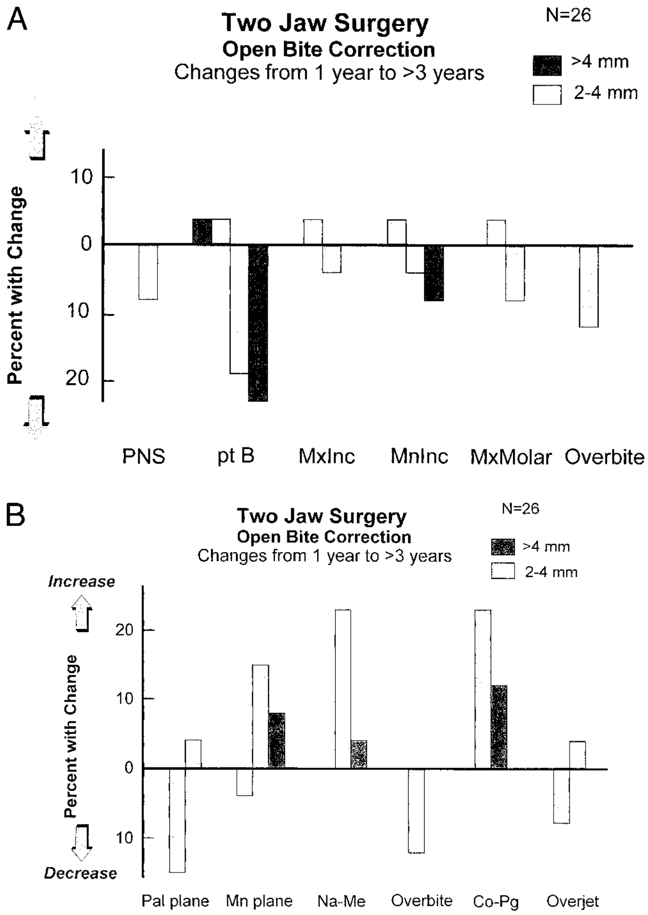

FIGURE 4. Percentages of 2-jaw patients with clinically significant changes in cephalometric landmark positions (A) and dimensions and relationships (B).

DISCUSSION

These data make it clear that >2 mm decrease in overbite rarely occurs beyond 1 year after surgical correction of anterior open bite, despite a pattern of long-term change resembling renewed growth in the long-face pattern in nearly one-third of the patients. The relative lack of change in dental relationships, given the frequency and amount of skeletal change, is surprising. In this regard, the long-face patients with severe open bite prior to surgery behave very similarly to those with normal or deep bite: dental relationships tend to be maintained when long-term skeletal changes occur. It is interesting to consider why so many of these patients showed skeletal changes long after surgical healing was complete, and why the amount of relapse toward open bite was as small as it was.

Behrents'[12] data from long-term recall of subjects from the Bolton growth study clearly show that changes in facial dimensions occur during adult life, and that because facial growth continues in its original pattern, malocclusions tend to recur. Recently, Schubert et al[13] evaluated changes in cephalometric landmark positions and dimensions in patients who were recalled 5 years after the completion of adult orthodontic treatment. Their data show significantly less change than after orthognathic surgery at similar ages. It appears, therefore, that something more than normal skeletal remodeling is happening in the post-surgical patients.

The data indicate that, when a long-term increase in face height occurs in the long-term post-surgically, there are 3 components: (1) downward movement of the posterior palate (PNS), with a corresponding decrease in the palatal plane angle; (2) eruption of the maxillary molar (beyond the amount that it would be carried along with downward movement of the posterior maxilla); and (3) downward rotation of the mandible and an increase in the mandibular plane angle, unless a compensatory increase in ramus height occurs.

Why should more downward maxillary growth occur in these post-surgery patients than in untreated adults? Serial cephalometric radiographs for 5-year intervals in untreated adults are rare, and although the adult group surveyed by Schubert et al[13] had similar ages and duration of follow-up as our surgery patients, they did not have skeletal deformities as severe as the surgery patients. For that reason, we cannot be sure that long-term changes in the post-surgery group really were different from what would have been observed in untreated individuals with skeletal open bite. Nevertheless, the number of surgery patients with relatively large vertical changes long after surgery is more than we expected.

It seems reasonable that this could be related to the pattern of physiologic adaptation to the surgery. When the maxilla is moved superiorly, the postural length of the mandibular elevator muscles changes, the mandible rotates upward and forward to a new ''rest'' (really postural) position, and the freeway space between the posterior teeth remains about the same. If physiologic adaptation of this type is more complete in some individuals than others, it might affect the amount of post-surgical change. How this might occur is unknown—we simply do not understand how muscle function interacts with late vertical maxillary growth. At this point we really have no idea why about one-third of our subjects had some post-surgical vertical maxillary growth in the long-term and the other two-thirds did not. This cannot be explained by age alone. Nor do we understand why many, but not all, of those patients with downward movement of the maxilla also had an increase in mandibular length.

Recent progress toward understanding the control of tooth eruption sheds some light on how adaption to surgery might affect this component of long-term change. Data from observations of erupting human premolars suggest that heavy intermittent forces, like those from swallowing or other activity, have little or no effect on an erupting tooth.[14] Animal experiments have shown the same results and also show that very light pressure, like that exerted by the tongue (or other soft tissues) at rest, can stop eruption if they are maintained for 25 to 50% of the time.[15] Changes in tongue posture occur post-surgically, and the changes in vertically-directed resting pressure against the posterior teeth produced by these changes probably play a role in the extent to which tooth eruption occurs. The pattern of adaptation in jaw and tongue posture certainly could affect whether or not teeth erupt post-surgically.

When vertical change (growth plus posterior eruption) occurred in these post-surgical patients, eruption of the anterior teeth largely compensated for it, so that significant opening of the bite usually did not occur. Why, in most cases, did the anterior teeth erupt when they needed to, and why did this compensation fail to occur in about 25% of the patients with late vertical growth? Patients with anterior open bite typically swallow with their tongue between their anterior teeth. Although speech adapts to changes in tooth position, there is some electromyographic evidence to support the frequent clinical impression that tongue activity in swallowing does not adapt as completely.[16] It is possible that incomplete adaptation in tongue posture leaves the tongue between the anterior teeth at rest in some individuals. Perhaps the anterior teeth are able to erupt in concert with an increase in face height despite tongue activity in swallowing, unless the tongue is interposed between the teeth during sleep or at rest more generally.

The data from our study also shed some light on the issue of mandibular shortening and condylar resorption as related to surgery for long-face problems. As reported previously, the UNC data show that about 10% of mandibular advancement patients show a modest long-term shortening of mandibular length, whether or not simultaneous maxillary surgery was carried out. This is associated with $>$2 mm increase in overjet in about 5% of the patient population.[8,17] The 2-jaw open bite patients in our study showed a mean increase in condylion-pogonion dimensions in the long-term. No patients had a $>$2 mm decrease in Co-Pg dimensions, while 23% had a 2 to 4 mm increase and 12% had a $>$4 mm increase. This suggests that in long-face, high-mandibular plane angle patients with significant anterior open bite, 2-jaw surgery with mandibular advancement is not a risk factor for condylar remodeling and resorption beyond 1 year post-surgery. In fact, perhaps just the opposite. Although remodeling of the condyles post-surgically with a decrease in length is possible and certainly occurs in some individuals, further mandibular growth post-surgically is more likely.

We conclude that when the maxilla is moved superiorly in the treatment of open bite due to skeletal discrepancies, with or without an accompanying ramus osteotomy, there is approximately a 10% chance of 2 to 4 mm relapse toward anterior open bite in the long term. The correction of dental occlusion is maintained better than the decrease in anterior face height typically produced by this surgery.

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