Original Article

Long-term stability of soft tissue changes in anterior open bite adults treated with zygomatic miniplate-anchored maxillary posterior intrusion

Eiman S. Marzouk[a]; Hassan E. Kassem[a]

ABSTRACT

Objectives: To evaluate soft tissue changes and their long-term stability in skeletal anterior open bite adults treated by maxillary posterior teeth intrusion using zygomatic miniplates and premolar extractions.

Materials and Methods: Lateral cephalograms of 26 patients were taken at pretreatment (T1), posttreatment (T2), 1 year posttreatment (T3), and 4 years posttreatment (T4).

Results: At the end of treatment, the soft tissue facial height and profile convexity were reduced. The lips increased in length and thickness, with backward movement of the upper lip and forward movement of the lower lip. The total relapse rate ranged from 20.2% to 31.1%. At 4 years posttreatment, 68.9% to 79.8% of the soft tissue treatment effects were stable. The changes in the first year posttreatment accounted for approximately 70% of the total relapse.

Conclusions: Soft tissue changes following maxillary posterior teeth intrusion with zygomatic miniplates and premolar extractions appear to be stable 4 years after treatment. (*Angle Orthod.* 2018;88:163–170.)

KEY WORDS: Anterior open bite; Zygomatic miniplates; Soft tissue; Posterior segment intrusion; Premolar extractions; Long-term stability

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INTRODUCTION

Facial esthetics may be the incentive for seeking orthodontic treatment, particularly in adults. The orthodontist is routinely asked about the impact of different treatment options on the soft tissue of the face.[1]

The change in soft tissue profile produced by tooth movement has diverse characteristics that cannot be calculated or simply defined by an exact formula.[2] It has been shown that there is a large variability in the soft tissue response to tooth movement.[3] Several cephalometric soft tissue analyses have been introduced for the purposes of treatment planning and outcome evaluation of the different treatment modalities on the integumental profile.[4–6]

Skeletal open bite classically presents with excessive posterior facial height, anterior open bite, and a retruded chin, hence it is considered a challenging orthodontic problem particularly in adults where growth modification is no longer a treatment option. Incisor extrusion to close the anterior open bite falls short of improving the skeletal problems underlying the facial deformity and is limited by the extent of esthetically acceptable incisor display. Thus, for improving facial esthetics, orthognathic surgery has been the preferred treatment option for adult patients with skeletal open bite.[7–9]

The introduction of temporary anchorage devices expanded the envelope of discrepancies that could be treated by orthodontic tooth movement to include cases traditionally treated with orthognathic surgery. In skeletal open bite malocclusions, miniplates and miniscrews have been used to intrude maxillary posterior teeth to produce autorotation of the mandible, thus reducing the excessive facial height, closing the anterior open bite, achieving lip competence, and improving chin projection.[10–19]

Previous studies[10–12,14–19] mostly reported the skeletal and dental effects of posterior intrusion with skeletal anchorage in skeletal open bite patients. Deguchi et al.[13] compared orthodontic treatment outcomes for open bite cases treated with premolar extractions using either conventional edgewise orthodontic treat-

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ment or implant anchorage for posterior intrusion. They reported marked reduction of the facial convexity and lip protrusion with an increase in lip competence in the implant-anchored group. However, there is a paucity of literature regarding soft tissues changes following the correction of open bite using skeletal anchorage and their long-term stability.

Because we have previously reported[20] on dental and skeletal changes in skeletal open bite adult patients treated with intrusion of maxillary posterior teeth using zygomatic miniplates followed by premolar extractions, the objectives of this study were to report the soft tissue changes and evaluate the stability of these changes at 1 year and 4 years posttreatment.

MATERIALS AND METHODS

The original sample consisted of 28 angle class I or class II patients with an age range of 19 to 28 years. All of the patients were of middle-eastern descent with an anterior open bite (range = 3–8 mm) and maxillary posterior vertical dentoalveolar excess according to the Burstone analysis.[21] The sample size was formerly calculated to investigate the skeletal and dental changes following intrusion of maxillary posterior teeth using zygomatic miniplates.[20]

The patients were treated at the Department of Orthodontics, Faculty of Dentistry, Alexandria University in Egypt. Each patient signed a written informed consent prior to the study. The protocol of the study was reviewed and approved by the Ethical Committee of the Institutional Review Board of Research in the Faculty of Dentistry, Alexandria University.

The clinical technique used was described in detail in 2 previous reports.[14,20] Segmental leveling and alignment were accomplished with anterior, right buccal, and left buccal sectional wires. When 0.019" × 0.025" stainless steel arch segments were reached, a double transpalatal arch was then cemented to resist the buccal tipping of the molars during intrusion. The lower arch was stabilized by a continuous 0.019" × 0.025" stainless steel archwire bypassing the lower incisors to hinder the compensatory eruption of the mandibular molars.

Titanium I-shaped miniplates (Gebrüder Martin GmbH & Co. KG, Tuttlingen, Germany) were surgically inserted bilaterally in the lower surface of the zygomatic buttress under local anesthesia. A nickel-titanium coil spring (GAC, Bohemia, N.Y.), extending from the miniplate hook to the first molar, provided an intrusive force of 450 g per side. When the overbite reached 1 to 2 mm, the intrusion was terminated and the maxillary molars were ligature tied to the miniplates.

Subsequent to posterior segment intrusion, four first premolars were extracted. The extraction decision was delayed to ascertain the position of the lips following molar intrusion. Both arches were leveled up to 0.019" × 0.025" stainless steel wires followed by closure of all remaining spaces.

Following the active treatment period, a strict retention protocol was prescribed. For the first year following debonding, a mandibular Hawley retainer was worn full time. A maxillary Hawley retainer was worn by day and one with a posterior bite plane was worn overnight. During the second year of retention, the patients were shifted to nighttime wear of the maxillary posterior bite plane retainer together with the mandibular Hawley retainer. During the third and fourth years, the previous retainers were used one night per week.[20]

Lateral cephalograms of the patients were taken at pretreatment (T1), immediately at the end of treatment (T2), 1 year posttreatment (T3), and 4 years posttreatment (T4). The same cephalometric device was used to obtain all cephalograms. The lateral cephalograms were obtained with the teeth in maximal intercuspation and the lips at repose as described by Burstone.[5]

All radiographs were traced by one observer on standard acetate paper with a sharp pencil. The lateral cephalometric radiographs were traced through the midpoints between the right and left structures. The linear measurements were measured using a digital caliper to the nearest 0.05 mm and any magnification was corrected in the measurements.

Tables 1 and 2 and Figures 1 and 2 show the landmarks, reference planes, and measurements used in the study.

Statistical Analysis

To determine the reliability of the measurements, 10 randomly selected radiographs were retraced and measured by the same examiner at least 2 weeks after the first measurements and by a second examiner. Paired *t*-tests showed no statistically significant difference between each pair of measurements at $P \leq .05$. The same examiner intraclass correlation coefficient was greater than 0.84 and the between-examiner was greater than 0.79.

The normality of the measurements was assessed visually using histogram and tested using Shapiro-Wilk test. Because there were only minor deviations, the use of parametric tests was preferred. Repeated measures analysis of variance was used followed by paired *t*-tests for post hoc comparisons. Correlation coefficients and mean ratios between upper molar intrusion and selected soft tissue variables were calculated. The statistical analysis was done using the Statistical Package for the Social Science (version

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Table 1. Landmarks and Reference Planes Used in the Study

Landmarks	
	S (Sella turcica): Point representing the midpoint of the pituitary fossa.
	G′ (soft tissue glabella): The most anterior point in the midsagittal plane of the forehead at the level of the superior orbital ridges.
	N′ (soft tissue nasion): The intersection between the Sella-Nasion line and the contour of the soft tissue profile.
	Pn (pronasale): The most anterior point on the sagittal contour of the nose.
	Sn (subnasale): The point at which the nasal septum between the nostrils merges with the upper cutaneous lip in the midsagittal plane.
	Ss (sulcus superius): Point of greatest concavity located between labrale superius and subnasale
	Ls (labrale superius): The most anterior point on the convexity of the upper lip.
	ULi (upper lip inferius): Upper lip lowest point.
	LLs (lower lip superius): Lower lip highest point.
	Li (labrale inferius): The most anterior point on the convexity of the lower lip.
	Si (sulcus inferius): Point of greatest concavity located between labrale inferius and soft tissue pogonion
	Pg′ (soft tissue pogonion): The intersection between the contour of the soft tissue profile and the line constructed through the pogonion (Pg) parallel to the HRL.
	Me′ (soft tissue menton): The intersection between the contour of the soft tissue profile and the line constructed through menton (Me) parallel to the VRL.
	U6: The mesial cusp of the upper first molar.
	U1: The most anterior maxillary central incisor.
	L1: The most anterior mandibular central incisor.
Reference planes	
	E-line (Ricketts' esthetic line): Line extending between Pn and Pg′.
	Sn-Pg′ plane (Burstone's esthetic plane): Line extending between Sn and Pg′.
	HRL (horizontal reference line): Drawn 7° below the Sella-Nasion line.
	VRL (vertical reference line): Constructed through Sella perpendicular to the HRL.
	PP (palatal plane): Reference line joining anterior nasal spine and posterior nasal spine.

20; IBM Corp., Armonk, N.Y.). The significance level was set at $P \leq .05$.

RESULTS

A total of 26 patients (15 women, 11 men) were included in the final analysis. The mean pretreatment age was 22.4 ± 2.3 years (range = 19.3–26.9 years).

The mean measurements and standard deviations for the cephalometric variables at T1, T2, T3, and T4 are presented in Table 3.

Table 2. Soft Tissue and Dental Measurements[a]

Soft tissue linear measurements	
Ls–E	Measured as the perpendicular distance from Ls to the E-line.
Li–E	Measured as the perpendicular distance from Li to the E-line.
Ls–Sn-Pg′	Measured as the perpendicular distances from Ls to the Sn-Pg′ plane.
Li–Sn-Pg′	Measured as the perpendicular distances from Li to the Sn-Pg′ plane.
ULT	Upper lip thickness at vermilion border: outer point of the upper lip at Ls to labial surface of the upper central incisor measured parallel to HRL.
LLT	Lower lip thickness at vermilion border: outer point of the lower lip at Li to labial surface of the lower central incisor measured parallel to HRL.
ULL	Upper lip length (vertical distance from Sn to ULi) measured parallel to VRL.
LLL	Lower lip length (vertical distance from LLs to Me′) measured parallel to VRL.
Ss–VRL Ls–VRL Li–VRL Si–VRL Pg′–VRL	Perpendicular distances from the respective points to VRL measured parallel to HRL.
Me′–HRL ULi–HRL LLs–HRL	Perpendicular distances from the respective points to HRL measured parallel to VRL.
Interlabial gap	Vertical distance between ULi to LLs measured parallel to VRL.
Soft tissue angular measurements	
SN′A′	Soft tissue SNA: S-N′/N′-Ss.
SN′B′	Soft tissue SNB: S-N′/N′-Si.
Soft tissue convexity	Angle of soft tissue convexity excluding the nose: 180° – (G′-Sn/Sn-Pg′).
Nlab	Nasolabial angle: angle formed between lines tangent to columella of nose and Sn-Ls.
Mlab	Mentolabial angle: angle formed between lines Li-Si and Si-Pg′.
Dental measurements	
U6–PP	Maxillary posterior dento-alveolar height, it is the perpendicular distance between the mesial cusp of the upper first molar and the palatal plane.
U1–VRL	Perpendicular distance between most anterior maxillary central incisor tip and the VRL.
L1–VRL	Perpendicular distance between most anterior mandibular central incisor tip and the VRL.

[a] Ls indicates labrale superius; Li, labrale inferius; Sn-Pg′ plane, Burstone's esthetic plane; HRL, horizontal reference line; ULi, upper lip inferius; Sn, subnasale; VRL, vertical reference line; LLs, lower lip superius; Si, sulcus inferius; Pg′, soft tissue pogonion; Me′, soft tissue menton; Ss, sulcus superius; PP, palatal plane.

Treatment Effect (T2–T1)

At the end of treatment, there was a significant reduction of the soft tissue facial height, as the distance between the soft tissue menton and the horizontal reference line decreased by 3.12 ± 0.58 mm ($P \leq .01$). The lower lip moved 4.85 ± 0.85 mm upward ($P \leq .01$), and the interlabial gap decreased by 3.63 ± 0.43 mm ($P \leq .01$). This was accompanied

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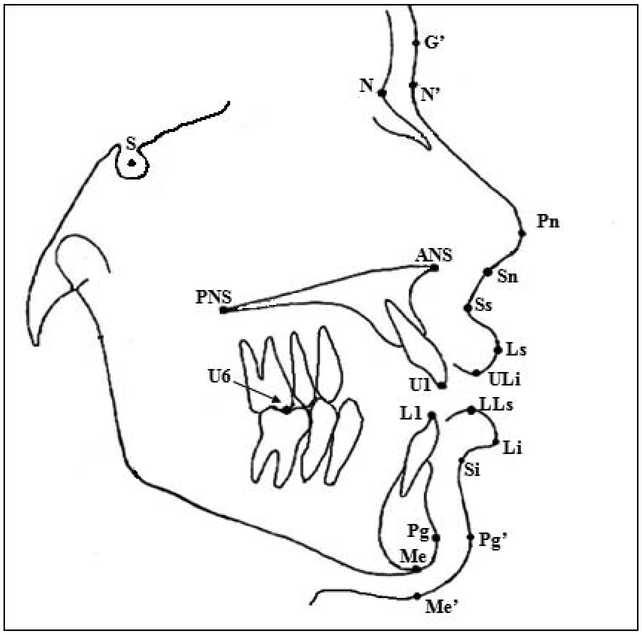

Figure 1. Reference points and landmarks used in the study.

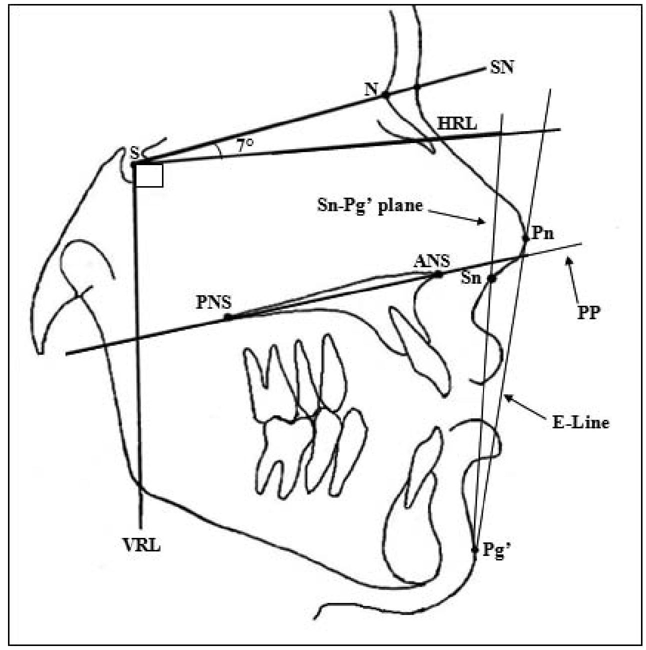

Figure 2. Reference planes used in the study.

by a marked forward movement of soft tissue pogonion by 2.43 ± 0.47 mm ($P \leq .01$), an increase in the SN′B′ angle by 2.12 ± 0.36° ($P \leq .01$), and a reduction of soft tissue convexity by 3.92 ± 0.67° ($P \leq .01$; Table 4).

Correlations between maxillary molar intrusion and the change in several soft tissue variables are shown in Table 5. A strong correlation was calculated between the maxillary molar intrusion and the change in soft tissue menton–horizontal reference line ($r = 0.882$, $P \leq .01$), soft tissue pogonion–vertical reference line ($r = –0.671$, $P \leq .01$) and soft tissue convexity angle ($r = 0.771$, $P \leq .01$). The mean ratio of molar intrusion to the upward movement of the soft tissue menton was 1:1.03, 1:0.8 to the forward movement of the soft tissue pogonion, and 1:1.28 to the reduction of the angle of soft tissue convexity.

In addition, both the upper and lower lips increased 1.5 ± 0.38 mm ($P \leq .05$) and 0.78 ± 0.29 mm ($P \leq .05$) in length, respectively, and 1.55 ± 0.48 mm ($P \leq .05$) and 1.19 ± 0.52 mm ($P \leq .05$) in thickness, respectively. The lower lip and lower lip sulcus moved forward 1.78 ± 0.74 mm ($P \leq .01$) and 1.7 ± 0.62 mm ($P \leq .05$) relative to the VRL, respectively, whereas the upper lip and the upper lip sulcus moved backward 2.75 ± 0.65 mm ($P \leq .01$) and 3.37 ± 0.47 mm ($P \leq .01$) relative to the VRL, respectively. Relative to the E line, the upper lip moved backward 2.36 ± 0.22 mm ($P \leq .01$) and the lower lip moved backward 1.23 ± 0.05 mm ($P \leq .05$). The nasolabial angle decreased by 3.5 ± 0.88° ($P \leq .01$). There was no significant change in the mentolabial angle (Table 4).

Relapse

In the first year following debonding, there was no significant change in most of the soft tissue measurements. However, the nasolabial and mentolabial angles showed a small but statistically significant decrease by 1.0 ± 0.48° ($P \leq .05$) and 0.6 ± 0.22° ($P \leq .05$), respectively. Otherwise, there were no significant differences between (T3–T2) and (T4–T3; Table 4).

At the end of 4 years posttreatment (T4–T2), there was a statistically significant increase of the soft tissue facial height, as seen by the increase of soft tissue menton–HRL (0.63 ± 0.34 mm, $P \leq .05$), and a backward movement of the soft tissue chin evident as the decrease of soft tissue pogonion–VRL (0.63 ± 0.26 mm, $P \leq .05$) and a decrease in the SN′B′ angle (0.66 ± 0.27°, $P \leq .05$). In addition, there was a small statistically significant forward movement of the upper lip (0.65 ± 0.24 mm, $P \leq .05$) and upper lip sulcus (0.78 ± 0.18 mm, $P \leq .05$). Both the nasolabial angle and mentolabial angle maintained a small statistically significant decrease of 1.60 ± 0.55° ($P \leq .05$) and 0.78 ± 0.15° ($P \leq .05$), respectively, at the end of the observation period (Figure 3).

The changes in the first year posttreatment accounted for 62.5% to 76% (approximately 70%) of the total relapse. Both the upper lip sulcus and upper lip horizontal position relapsed forward by about 16% at

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Table 3. Cephalometric Measurements at Pretreatment (T1), Immediately Posttreatment (T2), 1 Year Posttreatment (T3), and 4 Years Posttreatment (T4)

Soft tissue and dental measurements	T1		T2		T3		T4		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	P[b]
Ls–E	1.62	0.49	−0.75	0.8	−0.51	0.60	−0.43	0.31	**
Li–E	3.03	0.35	1.8	0.30	1.92	0.31	1.97	0.3	*
Ls–Sn-Pg′	8.19	0.76	6.04	1.07	6.19	1.05	6.26	1.04	**
Li–Sn-Pg′	8.09	0.59	6.94	0.61	7.04	0.61	7.09	0.63	*
ULT	14.0	0.77	15.55	0.81	15.33	0.83	15.23	0.83	*
LLT	15.57	0.98	16.76	0.98	16.57	0.96	16.48	0.96	*
ULL	23.9	0.96	25.40	0.86	25.19	0.87	25.12	0.86	*
LLL	43.33	1.4	44.12	1.37	43.94	1.4	43.89	1.40	*
Ss–VRL	81.41	1.09	78.04	1.36	78.59	1.46	78.82	1.48	**
Ls–VRL	84.33	1.17	81.58	1.23	82.02	1.27	82.23	1.27	**
Li–VRL	80.57	1.26	82.35	1.06	82.62	1.05	82.66	1.05	**
Si–VRL	72.3	1.22	73.99	1.16	74.13	1.11	74.14	1.10	**
Pg′–VRL	73.83	1.19	76.26	1.12	75.82	1.12	75.63	1.14	**
Me′–HRL	114.21	1.58	111.09	1.69	111.52	1.67	111.72	1.67	**
ULi–HRL	65.23	1.07	66.16	1.07	65.94	1.07	65.89	1.11	*
LLs–HRL	71.56	1.21	66.71	1.19	66.84	1.21	66.87	1.21	**
Interlabial gap	3.83	0.24	0.19	0.11	0.08	0.05	0.08	0.05	**
SN′A′	84.69	2.35	83.04	2.49	83.43	2.47	83.57	2.48	*
SN′B′	78.04	2.82	80.15	2.8	79.69	2.86	79.5	2.86	*
Soft tissue convexity (G′-Sn/Sn-Pg′)	17.7	0.81	13.79	0.54	14.04	0.55	14.17	0.56	**
Nlab	107.42	6.42	103.92	6.14	102.92	6.14	102.33	6.17	**
Mlab	133.92	2.42	134.06	3.10	133.46	3.33	133.27	3.25	**
U6–PP (mm)	28.27	2.55	25.23	2.14	25.54	2.17	25.64	2.17	**
U1–VRL (mm)	71.44	5.72	67.19	5.35	67.67	5.35	67.89	5.34	*
L1–VRL (mm)	64.98	3.96	67.11	4.03	67.33	4.19	67.45	4.12	*

[b] Repeated measures analysis of variance.
*$P \leq .05$; **$P \leq .01$.

T3, whereas the total relapse was 23.1% and 23.6% at T4, respectively. The soft tissue pogonion moved backward by 18.1% at T3 with a total relapse of about 26%. The soft tissue facial height lengthened by 13.8% at T3, increasing to 20.2% at T4. The SN′B′ relapsed backward by 22.2% at the end of the first year, with a total relapse of 31.1% at 4 years. The relapse of the change in the mentolabial angle was about 4.6-fold at T3 with a total relapse of almost sixfold at T4. The nasolabial angle continued to decrease by 28.6% at T3–T2 with an additional 17.1% at T4–T3 and with a total decrease of 45.7% (T4–T2) at 4 years (Table 6).

Net Treatment Effects (T4–T1)

There was a net reduction in the soft tissue facial height demonstrated by the decrease of soft tissue menton–HRL (2.5 ± 0.89 mm, $P \leq .01$). The SN′B′ angle increased by 1.46 ± 0.76° ($P \leq .05$) and the soft tissue pogonion moved forward 1.8 ± 0.65 mm ($P \leq .01$), resulting in a net reduction of the soft tissue convexity angle by 3.53 ± 0.85° ($P \leq .01$). The interlabial gap maintained a significant reduction of 3.75 ± 0.69 mm ($P \leq .05$; Table 4).

Both the upper and lower lips showed a net increase in length (1.23 ± 0.28 mm and 0.56 ± 0.18 mm, $P \leq .05$; respectively) and thickness (1.23 ± 0.34 mm and 0.92 ± 0.23 mm, $P \leq .05$; respectively). There was a net backward movement of the upper lip as seen in the reduction of the labrale superius–VRL (2.10 ± 0.59 mm, $P \leq .01$), sulcus superius–VRL (2.59 ± 0.79 mm, $P \leq .01$), and SN′A′ angle (1.12 ± 0.44°, $P \leq .05$) along with a downward movement of the upper lip (upper lip inferius–HRL) by 0.65 ± 0.44 mm ($P \leq .05$). The nasolabial angle showed a net decrease of 5.10 ± 1.25° ($P \leq .01$). The lower lip showed a net forward movement shown by the labrale inferius–VRL (2.1 ± 0.52 mm, $P \leq .01$) and sulcus inferius–VRL (1.84 ± 0.83 mm, $P \leq .01$) and upward movement shown by the lower lip superius–HRL (4.69 ± 0.86 mm, $P \leq .01$). The mentolabial angle maintained a modest net reduction of 0.65 ± 0.84° ($P \leq .05$; Table 4). At 4 years posttreatment, both the upper and lower lips showed favorable positions to the E-line (–0.43 ± 0.31 mm and 1.97 ± 0.3 mm, respectively; Table 3).

DISCUSSION

The present report describes the soft tissue changes following maxillary posterior teeth intrusion using zygomatic miniplate anchorage followed by premolar extractions in the treatment of skeletal open bite adult patients. The methodology used in this study was

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Table 4. Mean Differences in Cephalometric Measurements Between the Time Points[a]

Soft tissue and dental measurements	T2–T1			T3–T2			T4–T3			T4–T2			T4–T1		
	Mean	SD	*P*	Mean	SD	*P*	Mean	SD	*P*	Mean	SD	*P*	Mean	SD	*P*
Ls–E	−2.36	0.22	**	0.23	0.11	NS	0.08	0.03	NS	0.31	0.11	NS	−2.05	0.25	**
Li–E	−1.23	0.05	*	0.12	0.01	NS	0.06	0.01	NS	0.18	0.05	NS	−1.05	0.14	*
Ls–Sn-Pg′	−2.15	0.32	**	0.14	0.02	NS	0.07	0.01	NS	0.21	0.03	NS	−1.93	0.29	**
Li–Sn-Pg′	−1.15	0.22	*	0.10	0.62	NS	0.06	0.02	NS	0.16	0.02	NS	−0.99	0.14	*
ULT	1.55	0.48	*	−0.22	0.08	NS	−0.10	0.14	NS	−0.32	0.18	NS	1.23	0.34	*
LLT	1.19	0.52	*	−0.19	0.41	NS	−0.09	0.03	NS	−0.28	0.07	NS	0.92	0.23	*
ULL	1.50	0.38	*	−0.21	0.08	NS	−0.07	0.01	NS	−0.28	0.08	NS	1.23	0.28	*
LLL	0.78	0.29	*	−0.18	0.02	NS	−0.05	0.01	NS	−0.23	0.03	NS	0.56	0.18	*
Ss–VRL	−3.37	0.47	**	0.55	0.11	NS	0.22	0.02	NS	0.78	0.18	*	−2.59	0.79	**
Ls–VRL	−2.75	0.65	**	0.44	0.14	NS	0.21	0.17	NS	0.65	0.24	*	−2.10	0.59	**
Li–VRL	1.78	0.74	**	0.27	0.05	NS	0.05	0.01	NS	0.32	0.12	NS	2.10	0.52	**
Si–VRL	1.70	0.62	*	0.13	0.05	NS	0.01	0.01	NS	0.14	0.13	NS	1.84	0.83	**
Pg′–VRL	2.43	0.47	**	−0.44	0.11	NS	−0.19	0.03	NS	−0.63	0.26	*	1.80	0.65	**
Me′–HRL	−3.12	0.58	**	0.43	0.15	NS	0.20	0.01	NS	0.63	0.34	*	−2.50	0.89	**
ULi–HRL	0.93	0.18	*	-0.22	0.23	NS	−0.06	0.04	NS	−0.28	0.04	NS	0.65	0.44	*
LLs–HRL	−4.85	0.85	**	0.13	0.02	NS	0.03	0.01	NS	0.16	0.02	NS	−4.69	0.86	**
Interlabial gap	−3.63	0.43	**	−0.12	0.06	NS	0.00	0.00	NS	−0.12	0.06	NS	−3.75	0.69	**
SN′A′	−1.65	0.24	**	0.39	0.12	NS	0.14	0.02	NS	0.53	0.09	NS	−1.12	0.44	*
SN′B′	2.12	0.36	**	−0.47	0.17	NS	−0.19	0.05	NS	-0.66	0.27	*	1.46	0.76	*
Soft tissue convexity	−3.92	0.67	**	0.25	0.06	NS	0.13	0.03	NS	0.38	0.02	NS	−3.53	0.85	**
Nlab	−3.50	0.88	**	−1.00	0.48	*	−0.60	0.42	NS	−1.60	0.55	*	−5.10	1.25	**
Mlab	0.13	0.49	NS	−0.60	0.22	*	−0.19	0.07	NS	−0.78	0.15	*	−0.65	0.84	*
U6–PP (mm)	−3.04	0.79	**	0.31	0.07	NS	0.10	2.04	NS	0.41	2.03	NS	−2.61	0.48	**
U1–VRL (mm)	−4.15	0.82	**	0.43	0.19	NS	0.2	0.12	NS	0.68	0.08	NS	−3.55	0.38	**
L1–VRL (mm)	2.13	0.34	**	0.22	0.06	NS	0.13	0.56	NS	0.37	0.2	NS	2.46	0.24	**

[a] Negative values represent decreases during treatment; positive values represent increases during treatment. T2–T1 indicates changes at the end of treatment; T3–T2, changes during the first year posttreatment; T4–T3, changes after the first year to the end of 4 years posttreatment; T4–T2, changes during the entire 4 years posttreatment; T4–T1, net treatment effects after 4 years posttreatment; NS, not significant.
$^{*}P \leq .05$; $^{**}P \leq .01$.

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discussed in detail by the authors in previous publications.[14,20]

At the end of treatment, as the maxillary posterior teeth were intruded, the soft tissue chin moved forward and upward accompanied with significant reduction in the angle of soft tissue convexity (Table 4). Previous studies showed a postintrusion reduction in the facial soft tissue convexity of 1.9°[12] and 2.3°,[14] in comparison to the 3.92° decrease at the end of treatment in the present study. The current results agreed with the implant-anchored group in Deguchi et al.,[13] in which there was marked reduction of the soft facial convexity angle (6° compared with 3.92°) with an increase in lip competence and significant reduction in the upper and lower lip protrusion measured in relation to subnasale–

Table 5. Correlation and Mean Ratios Between Upper Molar Intrusion and Some Soft Tissue Variables

Soft Tissue Variables[a]	*r*[b]	Mean Ratio
Me′−HRL	0.882*	1: 1.03
Pg′−VRL	−0.671*	1: −0.8
Soft tissue convexity angle	0.771*	1: 1.28

[a] Me′, soft tissue menton; Pg′, soft tissue pogonion; HRL, horizontal reference line; VRL, vertical reference line.
[b] *r* indicates Pearson correlation coefficient.
$^{*}P \leq .01$.

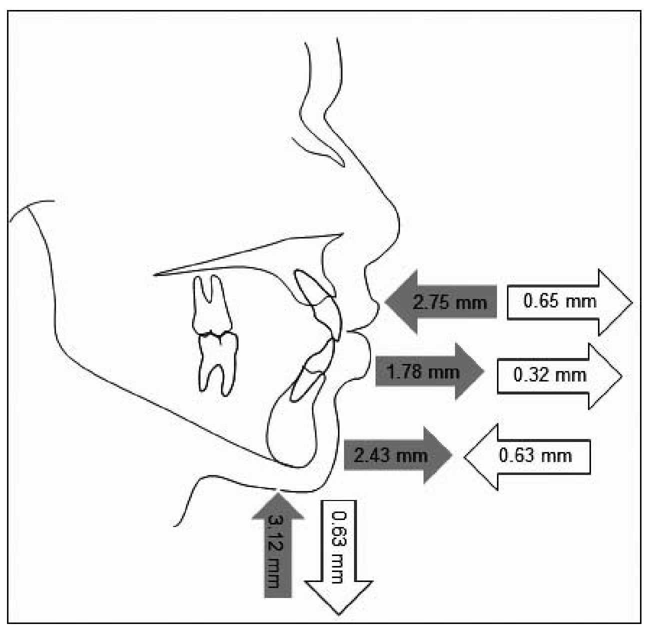

Figure 3. Direction and magnitude of soft tissue changes are depicted in gray (posttreatment [T2]–pretreatment [T1]) and in white (4 years posttreatment [T4]–posttreatment [T2]).

Table 6. Relapse at First Year Posttreatment, After the First Year to the End of 4 Years Posttreatment, and at 4 Years Posttreatment as a Percent of the Treatment Change and of Total Relapse[a]

Soft tissue measurements	Relapse T3−T2 to Treatment Change T2−T1 ([T3−T2]/[T2−T1]), %	Relapse T4−T3 to Treatment Change T2−T1 ([T4−T3]/[T2−T1]), %	Total Relapse T4−T2 to Treatment Change T2−T1 ([T4−T2]/[T2−T1]), %	Relapse T3−T2 to Total Relapse T4−T2 ([T3−T2]/[T4−T2]), %	Relapse T4−T3 to Total Relapse T4−T2 ([T4−T3]/[T4−T2]), %
Ss−VRL	−16.3	−6.8	−23.1	70.5	29.5
Ls−VRL	−16	−7.6	−23.6	67.7	32.3
Pg'−VRL	−18.1	−7.9	−25.9	69.8	30.2
Me'−HRL	−13.8	−6.4	−20.2	68.3	31.7
SN'B'	−22.2	−8.96	−31.1	71.2	28.8
Nlab	+28.6	+17.1	+45.7	62.5	37.5
Mlab	−461.5	−146.2	−607.7	76	24

[a] The negative sign (−) is for relapse while positive sign (+) is for the change in the same direction of treatment. T2–T1 indicates changes at the end of treatment; T3–T2, changes during the first year posttreatment; T4–T3, changes after the first year to the end of 4 years posttreatment; T4–T2, changes during the entire 4 years posttreatment; Ss, sulcus superius; Ls, labrale superius; Pg′, soft tissue pogonion; Me′, soft tissue menton; Nlab, nasolabial angle; Mlab, mentolabial angle; HRL, horizontal reference line; VRL, vertical reference line.

soft tissue pogonion (4.6 mm and 3.1 mm, respectively, compared to 2.15 mm and 1.15 mm, respectively). However, this study disagreed with the findings of Deguchi et al.,[13] who reported an 8.5° decrease in the mentolabial angle compared to 0.13 ± 0.49°, possibly as a result of the greater backward movement of the lower incisors reported in the present study (Table 4). A significant reduction in the nasolabial angle (3.5 ± 0.88°, $P \leq .01$) was found in the current study, whereas Deguchi et al.[13] reported a 6.3° increase in the nasolabial angle that was not statistically significant with a large standard deviation of 10.7°.

Different soft tissue behavior may be attributed to several factors: soft tissue thickness,[22–25] pretreatment labial tension,[25,26] face height,[27] variations in the amount of adipose or muscle tissue present in the lips, area of lip-tooth contact, lip length,[28] and different ethnicities.[29]

Previous studies have not reported the long-term soft tissue changes following the treatment of adult anterior open bite using skeletal anchorage. At the end of 4 years posttreatment, a statistically significant relapse was noted in the forward movement of the upper lip and upper lip sulcus, backward movement of the soft tissue pogonion, increase of the soft tissue facial height, and a reduction in the SN′B′ angle (Table 6). However, all of these changes were small and unlikely to be of clinical significance. Apart from the mentolabial angle, the total relapse rate ranged from 20.2–31.1%, that is, 68.9–79.8% of the soft tissue treatment effects achieved were maintained. The sixfold relapse rate of the mentolabial angle cannot be considered of clinical significance because its change at the completion of treatment was almost negligible (0.13 ± 0.49°), resulting in an inflation of the relapse percentage. An interesting finding was the continued reduction of the nasolabial angle following the end of active treatment. This may be attributed to continued adaptation of the upper lip to the combined effects associated with the reduction of the facial height and upper incisor retraction brought about by posterior teeth intrusion and premolar extractions, respectively. The stability reported in this study may be attributed to the strict retention protocol as mentioned in a previous study.[20]

The relapse in the soft tissue measurements at the first year posttreatment as a percentage of the total relapse (ranging from 62.5%–76%) corresponds to the percentage of first year relapse of molar intrusion (76.29%) and overbite (73.2%) to total relapse reported previously.[20]

CONCLUSIONS

- The treatment of skeletal open bite adults with miniplate anchored maxillary posterior intrusion and premolar extractions produced favorable changes in the soft tissues of the face.
- Long-term stability of soft tissue changes can be considered acceptable.
- Most of the relapse occurred in the first year of retention.

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