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Effect of maxillary advancement on the change in the soft tissues after treatment of patients with class III malocclusion

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Abstract

The aesthetic outcome of treatment has become increasingly important to patients having orthognathic surgery. The aim of this observational cohort study based on clinical records was to evaluate the effect of maxillary advancement on changes to the soft tissues. We studied 53 patients with class III malocclusion (29 women and 24 men, mean (SD) age 28 (11) years). We identified all patients treated between 1 January 2002 and 30 December 2013 who could be monitored postoperatively for 6 months. To study the effect of maxillary advancement on changes to the soft tissue we distinguished between patients who had had less than 6 mm, and those with 6 mm advancement or more. In those who had had less than 6 mm, we found no significant changes in the soft tissue in the region of the nasolabial angle. However, the lip-chin- throat angle ($p=0.016$), cervical length ($p=0.002$), lower lip ($p=0.007$) and upper lip distance ($p=0.0001$) from the aesthetic line changed significantly. On the other hand, the changes to the soft tissue in the submental and nasolabial regions were significant in patients with 6 mm advancement or more, and indicated a clear improvement in the aesthetic outcome of this region. This aesthetic change for the good in the submental and nasolabial regions after maxillary advancement of 6 mm or more should be considered when planning treatment, and reduction in the mandibular setback will reduce the risk of development of a double chin.

Keywords: Orthodontic and orthognathic treatment planning; Maxillary advancement

Introduction

Moderate to severe Class III malocclusion is often treated by a combination of orthodontics and operations. The most important goal for patients, orthodontists, and maxillofacial surgeons is not only to correct the dental malocclusions but also to achieve the best possible soft tissue profile. It is therefore essential to be able to predict postoperative soft tissue changes that result from orthognathic surgery reliably, so that aesthetics can be predicted more accurately.[1–3] Many studies have attempted to evaluate the relation between operations on hard tissue and the effects they have on the overlying soft tissue. Changes in hard tissue are easy to predict, but those in soft tissue are less predictable.[4]

A calculation of the ratios between the movement of hard tissue and soft tissue is a simple and effective way to quantify postoperative changes in the soft tissue profile. These

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ratios are used by prediction software programs to guide surgeons, orthodontists, and patients in making their decisions. Various studies have evaluated the precision of such computerised programs in predicting the postoperative profile with all possible surgical options.[5–7] Chew[8] found that movements of hard and soft tissue after bimaxillary surgery strongly correlated horizontally, but not vertically. However, Marsan et al[9] reported that movements of maxillary and mandibular soft and hard tissue correlated significantly in both horizontal and vertical directions after bimaxillary surgery. The study by Enacar et al[10] suggested that the soft tissue responses to two-jaw surgery were similar to those of mandibular setback alone, with the exception of the changes in projection of the nasal tip, and the upper lip. Louis et al[11] found that in patients who had maxillary advancement with a Le Fort I osteotomy but without adjunctive nasal procedures, the superior rotation of the important soft tissue points occurred with horizontal movement of the maxilla, and the correlation coefficients showed a small relation between the soft:hard tissue ratios.

There are controversial studies about the amount of maxillary advancement and the resulting stability,[12–14] most of which show that the mean maxillary advancement was 6 mm. However, none of these studies discussed the effect of maxillary advancement on the submental region and the soft tissue. Our aim in the present study was to evaluate whether maxillary advancement of more or less than 6 mm would result in different changes to the soft tissue, which are critical to the aesthetic outcome. Based on previous studies[12–14] we used the cutoff of 6 mm for maxillary advancement. The aesthetic outcome was assessed by the nasolabial angle, the aesthetics of the upper and lower lip, and the cervical length. We hypothesised that there would be no significant changes in the aesthetic outcome between the 2 groups.

Patients and methods

We retrospectively studied 53 patients with skeletal Class III malocclusion (29 women and 24 men, mean (SD) age 28 (11) years) who were selected from the patients treated in our department between 1 January 2002 and 30 December 2012.

All the patients met the inclusion criteria of a *Wits* appraisal of $< 0^\circ$, [15] and Le Fort I advancement. No additional operations were done. Patients with cleft lip and palate and other congenital craniofacial anomalies were excluded.

Standard lateral cephalograms were available for only 48 patients, and we divided these into 2 groups based on the amount of their maxillary advancement. The first included 28 patients (13 women and 15 men) in whom it was less than 6 mm, and the second comprised 20 patients (14 women and 6 men) in whom it was 6 mm or more. Preoperative cephalograms were taken before the orthodontic treatment, and the postoperative films 6 months later, to ensure that postoperative swelling did not mask actual changes in the soft tissue. All radiographs were taken with the teeth in centric occlusion and the lips in repose. The cephalograms were digitised using ONYX software (OnyxCeph Version 2.7.8, Image Instruments, Chemnitz, Germany) by one experienced examiner.

The landmarks measured included gonion angle, *Wits* appraisal, upper 1 inclination, lower lip to E-line, nasolabial angle, soft tissue facial angle, prominence of the nose, thickness and length of the upper lip, length of the lower lip, cervical length, lip-chin-throat angle, and upper lip to E-line (Fig. 1).

The reliability of the measurements was confirmed by randomly selecting 15 cephalograms before and after operation. The cephalograms were measured a second time by 2 other investigators unaware of the previous result. The SD of the error of each measurement was calculated by Dahlberg's formula[16] ($\sqrt{\Sigma D2 /2N}$), where D is the difference between the first and the second measurement and N is the number of double measurements. The "values of error" study were within acceptable limits (less than 1 mm) (Table 1).

Because of the limited sample size and the observational character of our study, we have restricted our statistical evaluation to an independent samples *t* test. To assess the significance of the difference between the two groups (< 6 mm compared with 6 mm or more), an independent samples *t* test assuming inhomogeneity of variance was used. This causes adjusted degrees of freedom (df) for the *t* distribution according to Satterthwaite (Table 2). To assess the different distributions of the two groups by sex, we used Fisher's exact test (Table 2).

Results

The 48 eligible patients who underwent orthodontic and orthognathic treatment for Class III malocclusion had a mean (SD) maxillary advancement of 5.4 (3.1) mm, and the position of the maxilla was changed by a maximum of 12.7 mm and a minimum of 3.8 mm.

The soft tissue balance differed significantly relative to differences in the change at point A between patients with <6 mm advancement and those in whom it was 6 mm or more($p= 0.0001$). The *Wits* appraisal also changed significantly in the two groups. The mean (SD) distance of the upper lip changed by 2.3 (2.2) mm in the less than 6 mm group and by 5.9 (3.2) mm in the 6 mm or more group.

The distance of the lower lip to the aesthetic line also changed significantly depending on the advancement ($p=0.0072$). In patients in whom it was less than 6 mm, the mean (SD) difference was -0.88 (9.7) mm, and in patients in whom it was 6 mm or more it was 9 (15.3) mm. The cervical length also differed significantly ($p=0.001$) between the 2 groups (Table 2).

The prominence of the nose changed significantly in the 2 groups (0.005). The mean (SD) change of the lip-chin-throat angle was 0.9 (9.8)° in the less than 6 mm group. When the movement was 6 mm or more, the change was 3.95 (15.5)°.

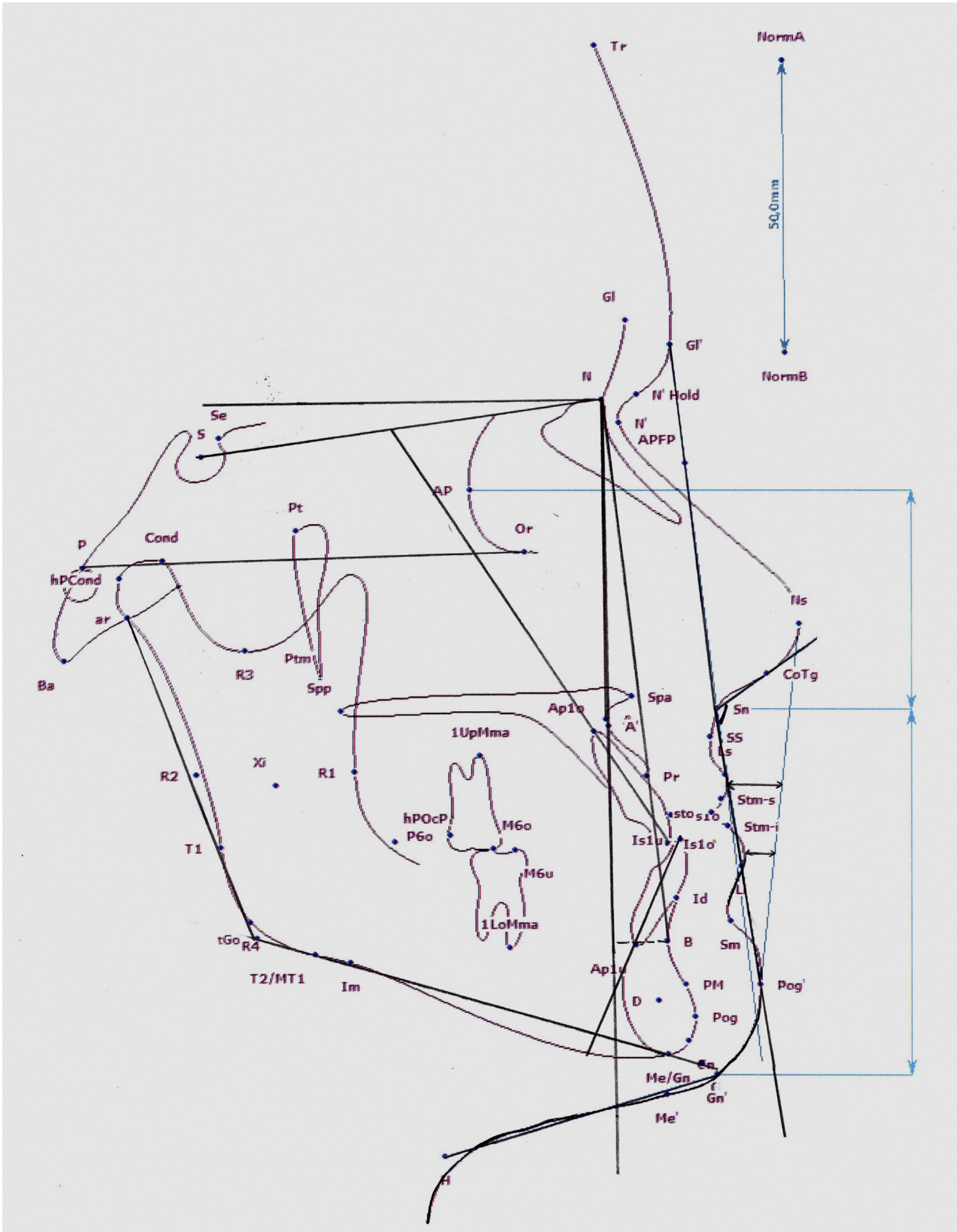

Fig. 1. Tracing of hard and soft tissue (gonion angle, mandibular inclination, upper 1inclination, lower lip to E-line, nasolabial angle, soft tissue facial angle, nose prominence, upper lip thickness, upper lip length, lower lip length, cervical length, lip chin throat angle, facial contour, and upper lip to E-line).

These changes were significantly associated with the baseline measurement and the horizontal skeletal change (p= 0.015).

Changes in the gonion angle are shown in Table 2. There is no significant difference between the A point changes and the gonion angle between the 2 groups (p=0.984). The mean (SD) change in the soft tissue facial angle in patients with <6 mm was - 0.55 (2.5)° and in patients with 6 mm or more advancement - 0.90 (3.3)°. There was no significant change

Table 1
Mean (SD) values of selected cephalometric variables before and after operation with.

Variables	Preoperatively	Postoperatively	Dahlberg's SD of error
SNA (°)	78 (4.9)	83 (4.6)	0.8
SNB (°)	81 (4. 49)	80.5 (3.45)	0.79
Wits appraisal (mm)	-9.5 (4 .23)	-3.0(2.86)	0.75
Gonion angle (°)	127.5(8.69)	128 (8.19)	0.69
Maxillary inclination (°)	34.61 (6.8)	34.76(6.44)	0.78
Upper 1 inclination (°)	105.61 (7.61)	104.88(5.80)	0.81
Lower lip to E-line (mm)	-8.3 (3.3)	-5.7 (3.7)	0.51
Nasolabial angle	-2.5 (3.3)	-3.4 (3)	0.78
Soft tissue facial angle	110 (12.5)	100.6 (12.2)	0.8
Upper lip thickness (mm)	18.2 (3.5)	16.5 (3.3)	0.51
Pg' (mm)	13(3)	13(4)	0.7
Upper lip length (mm)	21.9 (4.3)	23.7 (4.4)	0.4
Lower lip length (mm)	46.5 (7.5)	48.1 (6.1)	0.6
Cervical length (mm)	50.6 (10)	47.9 (10)	0.72
Lip-chin-throat angle	50.6 (10)	47.9 (10)	0.77
Upper lip to E-line (mm)	-8.3 (3.3)	-5.7 (3.7)	0.74

Dahlberg's SD of error for each variable.

of the soft tissue facial angle in the 2 groups (p=0.686) (Table 2).

The mean (SD) change in the thickness of the upper lip was an anterior movement of - 0.9 (3.5) in patients with a <6 mm advancement and -2.6 (3.7) in patients in whom it was 6 mm or more. This was not significant (p=0.129). The length of the lower lip did not change significantly in relation to the degree of advancement (p=0.418), and neither did the length of the upper lip (p=0.634) (Table 2).

Discussion

The modern treatment of orthognathic deformities requires planning of treatment by the orthodontist and the orthognathic surgeon together, and should be initiated at the patient's first presentation. The aesthetic outcome is important, and the possible change in the soft tissues as a result of changes in the hard tissue should be considered during planning. How to achieve optimal facial aesthetics has interested many research workers from different disciplines,[17] as it influences the social and psychological development of patients and can have an important role in their interpersonal relationships.[18,19] Many factors such as nose, lips, chin, and cervical length have a fundamental influence on the aesthetic outcome. Ho et al.,[20] showed that the chin is a key aesthetic unit that contributes to the balance and harmony of the lower third of the face. The lip-chin-throat angle and the cervical length are also important in aesthetics and should be considered at the same time. However, the change in the lip-chin-throat angle that depends on the degree of maxillary advancement has not often been taken into account in previous publications.[21]

The main purpose of this study was to find out what effect maxillary advancement had on the nasolabial area, the aesthetics of the lip, and the submental region. It should be noted that various types of bias can affect observational studies. We had no performance bias because we used the same surgical methods, whereas attrition bias was present.

In general, it is difficult to assess the degree of bias in the study results. Of course the randomisation of patients to the extent of maxillary advancement is not possible. To validate the measurements (which may show considerable variation)

Table 2
Mean (SD) soft tissue cephalometric index in relation to amount of maxillary advancement (*t* test for inhomogeneous variances), comparison of groups within sex (Fisher's exact test).

	Mean (SD) differences: maxillary advancement < 6 mm (n=28)	Mean (SD) differences: maxillary advancement 6 mm or more (n=20)	(t) (df)	p Value
Sex (F/M)	13 / 15	14/6	-0.35	0.725
Age (years)	30.42 (11.59)	28.80(8.96)	0.55 (45.65)	0.586
Gonion angle	0.48 (5.33)	0.45 (5.28)	0.02 (41.31)	0.984
Wits appraisal (°)	4.8 (3.01)	8.5 (4.4)	-3.18 (31.51)	0.003
Upper 1 inclination (°)	-2.07(7.2)	0.15 (6.33)	-1.12 (43.63)	0.268
Lower lip to E-line (mm)	0.18 (2.6)	2.25 (2.35)	-2.82 (43.29)	0.007
Nasolabial angle	-5.44 (8.45)	-5.6 (10.27)	.06 (36.19)	0.954
Soft tissue facial angle	-.55 (2.50)	-0.90 (3.32)	0.39 (33.92)	0.699
Nose prominence	-1.29 (2.30)	-3.10 (1.83)	2.99 (44.72)	0.005
Upper lip thickness (mm)	-0.88 (3.46)	-2.55 (3.74)	1.55 (39.21)	0.129
Upper lip length (mm)	1.22 (2.62)	1.75 (4.86)	-0.44 (27.13)	0.634
Lower lip length (mm)	-0.62 (4.1)	-2.05 (6.87)	0.88 (28.92)	0.418
Cervical length (mm)	-1.00 (5.6)	4.10 (4.49)	-3.43(44.77)	0.001
Lip chin throat angle	7.00 (2.12)	10.16 (10)	-2.55(24.73)	0.015
Upper lip to E-line (mm)	2.29 (2.16)	5.9 (3.17)	-4.38(31.56)	0.0001

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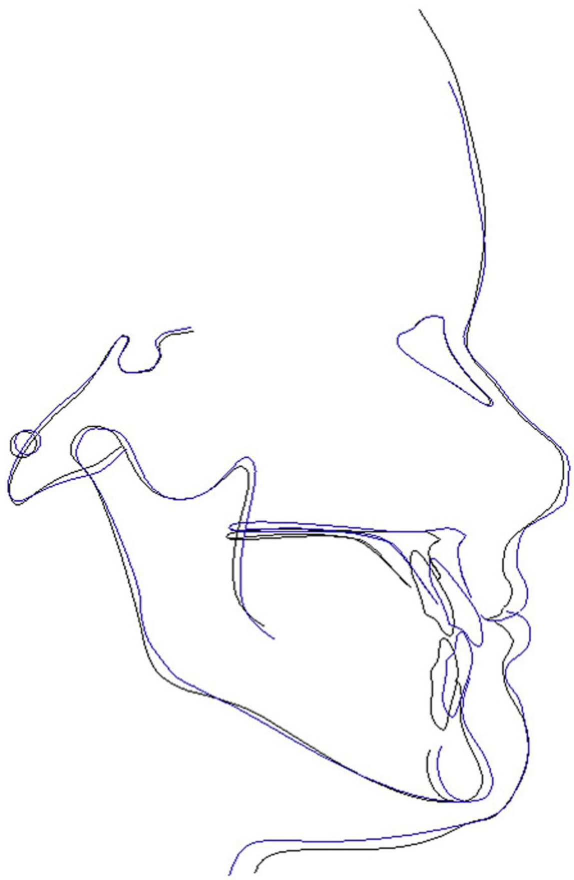

Fig. 2. Tracing of hard and soft tissue before and after maxillary advancement of more than 6 mm.

we calculated the SD of error using Dahlberg's formula.[16] Because of the limited size of the sample we were not able to account for confounding variables by doing a multivariate analysis. However, compared with other studies[20] our well-defined sample enrolled over such a long period makes it an important clinical group.

Cervical length is important because of the possibility of creating a double chin, which is aesthetically unpleasant. In our study the only operation done was maxillary advancement. As other studies have shown, the mandible moves forward after the anterior and cranial movement of the maxilla.[22] However, one of our goals was to show the relation between the change in the cervical length and the lower lip on the one hand, and the degree of maxillary movement on the other. Fig. 2 shows the influence of maxillary advancement on the cervical length and the aesthetics of the lower lip. The preoperative cervical length was similar in both groups, whereas postoperatively it clearly increased in the group with advancement of 6 mm or more.

There were significant changes in the lip-chin-throat angle in the 2 groups. The mean (SD) change was 7.0(2.1)° if the maxilla was advanced less than 6 mm, and 10.2 (4.5)° if the advancement was 6 mm or more (Table 2).

Modern treatment of Class III deformity consists of maxillary advancement and mandibular setback, and the amount of repositioning of any jaw can influence its functional, aesthetic, and long-term stability. Lim et al[19] pointed out that the impact of changes in the soft tissue after mandibular setback were more in the lower lip and chin than in the upper lip and corner of the mouth. The generation of a double chin should be considered, depending on the amount of movement of the jaw, and the treatment should not be based purely on the findings of the cephalogram.

Until 2005, our correction of Class III malocclusion was focused primarily on mandibular setback (as far as possible) and advancing the maxilla to compensate for the rest. The main rationale for planning treatment was the cephalographic findings. We increasingly adapted the amount of movement of the jaw to the anatomical findings and the actual deformity on the one hand, but aimed for optimum aesthetic and functional outcome on the other. We adapted the amount of movement of the jaw individually, not only based on the cephalograms. As suggested by Arnett et al,[17] we should consider a combination of clinical, facial, and soft tissue cephalometry as effective guidance to the treatment not only of occlusion but also the face in three dimensions, so improving the aesthetic outcome. We also considered the shape and the size of the nose, the nasolabial angle, the chin, and the cervical region. Our study has clearly shown the improving effect of maxillary advancement on submental aesthetics. Many recent studies have suggested bimaxillary surgery as the best option for Class III deformity for different reasons.[21]

One reason is an appreciable increase in the width of the airway postoperatively, which is beneficial to the patient, whereas the opposite could prove detrimental. We think that if this fact is ignored in planning treatment, it will also result in an undesired effect on the submental region, which may require additional procedures such as liposuction.[17] A double-jaw operation increases the amount of maxillary advancement and will reduce the need for extensive mandibular setback. Reduced mandibular setback can influence the aesthetic and functional outcome, as shown in this and other studies, by respecting anatomical feasibility. This has also been shown to give better long-term stability.[22–24] However, we need greater scope to show the long-term stability in these 2 different groups.

Conflict of Interest

We have no conflict of interest.

Ethics statement and confirmation of patients' permission

Not required.

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