ESTHETIC IMPROVEMENTS WITH MAXILLARY PROTRACTION APPLIANCE IN CLASS III MALOCCLUSIONS

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HOW TO CITE THIS ARTICLE:
Sameer Ahmed, Jahnavi R, Shireen. “Esthetic Improvements with Maxillary Protraction Appliance in Class III Malocclusions”. Journal of Evidence based Medicine and Healthcare; Volume 2, Issue 30, July 27, 2015; Page: 4389-4401, DOI: 10.18410/jebmh/2015/621

ABSTRACT: INTRODUCTION: This retrospective study was conducted to investigate the effect of treatment with a maxillary protraction appliance (MPA) on the maxilla and mandible. METHODS: Twelve patients (8 male and 4 female; mean age 10.3±1.12 years) with skeletal Class III malocclusion were included in this study and were evaluated by the use of lateral cephalograms obtained before and after treatment. Treatment changes were determined by means of linear and angular measurements. RESULTS: A significant increase in maxillary forward growth, inhibition of mandibular forward growth, and clockwise rotation of the mandible were observed. The maxillary incisors were significantly proclined and the mandibular incisors significantly retroclined. A multiple-regression analysis revealed that maxillary growth had a significant positive effect on the upper-airway dimension. CONCLUSIONS: Facilitation of maxillary growth with a maxillary protraction appliance can contribute to significant changes in the maxillary dimension and also an increase in the upper airway dimensions.

INTRODUCTION: The final goal of any orthodontic treatment should be not only to obtain good function but also to improve facial attractiveness. The main focus of concern for the Class III patient, presenting a concave facial profile, a retrusive nasomaxillary area, and a protrusive lower face and lip, is usually the profile rather than the occlusion. However, achieving a harmonious soft tissue profile is sometimes difficult because a Class III malocclusion is one of the most challenging problems confronting the orthodontist. Early treatment is commonly indicated for Class III individuals because if left untreated they will ultimately comprise a substantial percentage of patients seeking orthognathic surgery as adults.

Typically, treatment approaches for young patients with Class III malocclusion have been directed at growth modification.(1) Maxillary protraction appliances (MPA) have been used for the treatment of skeletal Class III malocclusions in growing patients with maxillary retrusion.(2-3) Numerous studies have demonstrated that these appliances stimulate the forward displacement of the maxilla however there has always been disagreement on the actual forward displacement of the maxilla during such treatment. This study was undertaken to evaluate what treatment response was achieved in class III patients treated with maxillary protraction appliance in our department.

MATERIALS AND METHODS: This retrospective study utilized the pretreatment and post-treatment lateral cephalometric radiographs of 12 patients, 8 male and 4 female, treated with Petit (GAC 17-100-20, Bohemia, NY) type face masks. The mean chronological age of the patients was 10.3±1.12 years at the beginning of the treatment.
INCLUSION CRITERIA:
- Skeletal and dental Class III malocclusions with maxillary retrusion,
- Edge to edge incisor relationship or anterior cross bite,
- Flat or concave facial profile,
- No congenital anomalies or endocrine problems.

Appliance Design and Activation: In order to obtain a forward movement of the maxilla and maxillary dentition during the treatment period, elastic forces were applied between the face mask and the hooks which were soldered to a bonded maxillary splint in the canine-primary molar area above the occlusal plane. The maxillary splint incorporated a Hyrax type expansion screw in the middle of the palate which was activated once per day for 8-10 days to produce a disruption in the sutural system. The face mask was delivered 2-6 weeks after placement of the splint. The magnitude of the force applied was 350 grams per side and its direction was 30 degrees downward from the occlusal plane. The patients used their face masks 14 hours a day, and the treatment was continued until a normal over jet was achieved. The mean treatment time was 8±2.1 months.

All the lateral cephalograms were traced on a transparent cellulose acetate sheet of 0.003 inches thickness at the same time and by the same operator. Similar conditions of the light box and general illumination were maintained during viewing and tracing of all head films. All reference points were first identified, located, and marked. The reference planes were drawn, and, when the bilateral structures cast double shadows on the film, the technique of averaging the bilateral images was used.

Radiographic Procedures: Pairs of lateral cephalograms from each patient in centric occlusion with the lips in repose were analyzed using the cephalometric landmarks described and the cervical vertebrae maturation index was evaluated.

Each cephalogram was traced and 40 variables (12 angular, 28 linear) were measured. Cephalometric measurements were realized at three stages as follows:
1. Skeletal and dental measurements.
2. Holdaway’s soft tissue analysis and other soft tissue measurements. For Holdaway’s analysis, tracings were oriented with the horizontal line (HL) at 5.6° below the sella-nasion line and parallel to the Frankfurt plane. (4)
3. Horizontal linear measurements with respect to the vertical reference line.

The vertical reference line: For horizontal linear measurements used in this study, a vertical line (VL) perpendicular to the occlusal line (OL) passing through the sella point was selected as a reference line. This reference system was transferred by structural imposition of the anterior cranial base using the sella as registration point, from the first to the second head film in each case.
Fig. 2: Skeletal and dental measurements; 1. SNA; 2. SNB; 3. ANB; 4. SNPg; 5. SNGoMe; 6. N-ANS; 7. ANS-Me; 8. N-Me; 9. Is-NA; 10. Is/NA; 11. II-NB; 12. II/NB.

Fig. 3: Holdaways soft tissue cephalometric analysis. 13. Soft tissue facial angle; 14. Nose prominence; 15. Superior sulcus depth; 16. Subnasale H line; 17. Skeletal profile convexity; 18. Upper lip thickness(to Ss); 19. Upper lip thickness(to Verm); 21. H angle; 22. Si to H line; 23. Soft tissue chin thickness.
**Fig. 3**

**Fig. 4:** Soft tissue measurements. 24. Nasolabial angle; 25. Chinlabial angle; 28. Convexity angle.
**Fig. 5:** The position of upper and lower lips to Steiner S esthetic line; 26. Ls to Steiner S line; 27. Li to Steiner S line.

**Fig. 6:** Horizontal linear measurements; 29. A-VL; 30. B-VL; 31. Pg-VL; 32. Is-VL; 33.Ii-VL; 34. NS-VL; 35. PrN-VL; 36. Ss-VL; 37. Ls-VL; 38. Li-VL; 39. Si-VL; 40. PgS-VL.

**STATISTICAL ANALYSIS:** The effects of the maxillary protraction appliance on hard and soft tissue structures were investigated by means of a paired t-test.
RESULTS: The statistical description and comparison of changes between pre-treatment and post treatment groups are given in Tables.

Skeletal Measurements: Cervical maturation index showed that seven patients were at acceleration stage and five at transition stage.

In the treatment group, the significant increase in the SNA and SNGoMe angles (p <0.001) showed that the maxilla moved anteriorly because of the orthopedic forces delivered by the mask, whereas the mandible rotated in a backward and downward direction. Accordingly, the SNB and SNPg angles decreased, and the lower anterior (ANS-Me) and total anterior (N-Me) facial heights increased significantly (p <0.001). As a result of the opposite movement of the two jaws, the ANB angle increased significantly (p < 0.001)

Dental Measurements: During the treatment period, there was no significant changes on dental parameters, though the Is-NA distance increased as a result of the anterior movement of the upper incisors, but not significantly, and the Ii-NB distance decreased but not significantly, as a result of the posterior movement of the lower incisors.

Soft Tissue Analysis: In the post treatment group, a significant decrease was observed in the soft tissue facial angle (p<0.001), along with an increase in the skeletal profile convexity (p<0.001).This beneficial effect of treatment on facial profile was accompanied by the significant increase in the H angle (p<0.001) and decrease in the NS-Sn-PgS angle (p<0.001). As suggested by the statistically significant change (p<0.001) in the distance of the Ls to the Steiner S line, the upper lip moved anteriorly. A statistically significant increase (p <0.05) in the Si to H line distance showed that in the course of the treatment, the depth of the lower lip sulcus was accentuated.

The comparison of the changes in the pre and post treatment groups showed that there was no significant changes in the depth of the upper sulcus (p > 0.05) and the thickness of the upper lip (to Verm.) (p>0.05).

Horizontal Linear Measurements: In the post treatment group, significant increases in the NS-VL (p<0.05), PrN-VL (p<0.001), A-VL (p<0.001), Ss-VL (p<0.001), Is-VL (p<0.001) and Ls-VL (p < 0.001) distances indicated the protrusive effect of the treatment on hard and soft tissues of the upper jaw, whereas no significant change was found in the lower face. Comparison of the pre-treatment and post treatment groups revealed significant increases in the parameters related to upper face (A-VL, Ss-VL, Is-VL, Ls-VL), and no significant changes in the parameters related to the lower face (B-VL, Si-VL, Pg-VL, PgS-VL, Ii-VL).
Fig. 11: Cephalometric tracings superimposed on the nasion-sella line with sella as registration point.

| Parameters | Pre Treatment | Post Treatment | Mean Difference | t Value | P Value, sig* |
|------------|---------------|----------------|-----------------|---------|---------------|
| SNA *      | 79.67         | 84.21          | 4.54            | 14.6    | P<0.001 HS    |
| SNB*       | 82.83         | 82.58          | 0.25            | 0.9     | P>0.05 NS     |
| ANB*       | -3.25         | 1.63           | 4.88            | 16.1    | P<0.001 HS    |
| SNPg*      | 83.58         | 82.17          | 1.42            | 2.4     | P<0.05 S      |
| SNGoMe*    | 30.67         | 33.67          | 3.00            | 6.8     | P<0.001 HS    |
| N-ANS      | 48.00         | 48.75          | 0.75            | 2.7     | P<0.05 S      |
| ANS-Me     | 54.92         | 61.25          | 6.33            | 5.4     | P<0.001 HS    |
| N-Me       | 102.92        | 110.00         | 7.08            | 6.0     | P<0.001 HS    |

Table 1: Skeletal Parameters

*Student’s paired t test.
### Dental parameters

| Parameters | Pre Treatment | Post Treatment | Mean Difference | t Value | P Value, sig* |
|------------|---------------|----------------|-----------------|---------|--------------|
|            | Mean | SD | Mean | SD |               |               |
| Is-NA      | 5.92 | 2.39 | 6.58 | 2.50 | 0.67          | 1.2           | P>0.05 NS     |
| Is/NA*     | 31.17 | 7.33 | 30.83 | 8.10 | 0.33          | 0.5           | P>0.05 NS     |
| Ii-NB      | 5.67 | 2.50 | 4.83 | 2.86 | 0.83          | 1.8           | P>0.05 NS     |
| Ii/NB*     | 25.33 | 5.48 | 25.17 | 6.10 | 0.17          | 0.1           | P>0.05 NS     |

Table 2: Dental Parameters

### Soft tissue

| Parameter           | Pre Treatment | Post Treatment | Mean Difference | t Value | P Value, sig* |
|---------------------|---------------|----------------|-----------------|---------|--------------|
|                     | Mean | SD | Mean | SD |               |               |
| facial angle        | 92.42 | 5.20 | 90.67 | 4.70 | 1.75          | 5.74          | P<0.001 HS    |
| nose prom           | 8.58 | 2.50 | 8.33 | 3.47 | 0.25          | 0.45          | P>0.05 NS     |
| supr sul dep        | 4.13 | 1.65 | 4.25 | 1.42 | 0.13          | 0.43          | P>0.05 NS     |
| subnasal-Hline      | 5.29 | 2.01 | 7.63 | 2.38 | 2.33          | 4.84          | P<0.001 HS    |
| sk convex           | -3.00 | 3.07 | 1.13 | 2.61 | 4.13          | 13.65         | P<0.001 HS    |
| ULthk-Ss            | 13.50 | 1.78 | 13.58 | 2.57 | 0.08          | 0.19          | P>0.05 NS     |
| Ulthk-verm          | 13.33 | 2.06 | 13.17 | 2.29 | 0.17          | 0.28          | P>0.05 NS     |
| Ulstrn              | 1.17 | 0.94 | 1.08 | 0.90 | 0.08          | 0.27          | P>0.05 NS     |
| H-angle             | 11.17 | 2.86 | 16.67 | 2.93 | 5.50          | 6.85          | P<0.001 HS    |
| Si-H Line           | 1.63 | 1.40 | 2.79 | 1.64 | 1.17          | 3.44          | P<0.05 S      |
| chn thk             | 10.75 | 1.91 | 11.00 | 1.91 | 0.25          | 1.91          | P>0.05 NS     |
| nas-lab ang         | 95.83 | 17.79 | 98.33 | 10.57 | 2.50          | 0.9           | P>0.05 NS     |
| chn-lab ang         | 122.00 | 14.55 | 117.67 | 17.26 | 4.33          | 1.3           | P>0.05 NS     |
| Ls-S-line           | 0.71 | 1.68 | 2.46 | 1.80 | 1.75          | 7.7           | P<0.001 HS    |
| Li-S-line           | 5.42 | 1.83 | 4.75 | 2.49 | 0.67          | 1             | P>0.05 NS     |
| Ns-Sn_Pgs           | 171.92 | 4.64 | 164.33 | 5.91 | 7.58          | 6.2           | P<0.001 HS    |

Table 3: Soft tissue parameters

### Horizontal

| Parameter | Pre Treatment | Post Treatment | Mean Difference | t Value | P Value, sig* |
|-----------|---------------|----------------|-----------------|---------|--------------|
|           | Mean | SD | Mean | SD |               |               |
| A-VL      | 70.00 | 4.09 | 73.75 | 4.16 | 3.75          | 17.2          | P<0.001 HS    |
| B-VL      | 76.38 | 6.23 | 76.75 | 5.48 | 0.38          | 0.4           | P>0.05 NS     |
Table 1: Skeletal parameters

Table 2: Dental Parameters

Table 4: Horizontal parameters
DISCUSSION: The treatment group comprised a sample of 12 patients (8 males and 4 females) whose Class III malocclusions were successfully treated with the maxillary protraction appliance. Our major intent was to evaluate the reflection of Class III orthopedic treatment on the hard and soft tissues. Previous clinical studies\(^{(5,6)}\) have suggested that activation of circummaxillary sutures at an early phase of growth can provide favorable treatment results.

The effects derived by the appliance were determined cephalometrically by comparing the pre-treatment and post treatment effects on the hard and soft tissues. At end of treatment, comparison with the pre-treatment group revealed that the midfacial complex was displaced anteriorly and there was highly significant forward movement of point A and SNA angle increased significantly. Forward migration of both point B and pogonion points was restricted, and the mandible exhibited a downward and backward rotation. Accordingly,
improvement in skeletal profile convexity was obtained but at the expense of vertical dimension, this shows that patients treated at acceleration and transition stage responded well to the MPA and affected in significant skeletal changes. Clinical studies\(^{(5-7)}\) reflecting the effect of maxillary protraction devices support these results. Also, experimental studies\(^{(8-9)}\) have shown anterior displacement of the maxilla by sutural modification of the circummaxillary sutures.

Dentally, the Class III incisor relationship was corrected by anterior displacement of the maxillary complex, with no significant change in the axial inclination of anterior teeth. The study of Kilcoglu and Kirlic\(^{(10)}\) showed a significant forward movement of the anterior teeth thereby contributing to the skeletal change. We were able to effectively control the dental changes and maximize the skeletal changes.

Dentoskeletal changes were mirrored by alterations in soft tissue behavior. Soft tissue facial angle and the facial convexity angle as determined by NS-Sn-PgS decreased significantly. An increase in Holdaway’s H angle was attained to a greater extent. These results correlate well with those of Atallah\(^{(11)}\) who, in his study of Class III malocclusions treated with the Delaire mask, reported a statistically significant increase in the convexity of the soft tissue profile.\(^{(12-13)}\) The upper lip was protracted due to anterior displacement of the maxillary complex. The lower lip moved posteriorly to lie behind the Steiner S line, but compared with the pre-treatment group, this movement was not statistically significant. Additionally, when the lower lip position was examined with respect to sella-vertical, inhibition of forward migration could be recorded at labrale and sulcus inferior. It seems that the lower lip could not be entirely influenced by changes induced on underlying hard tissues. It must be remembered that after the correction of the crossbite in Class III cases, the lower lip most often contacts both lower and upper incisors and would therefore be influenced not only by the retraction of the lower incisors but by protraction of the upper incisors as well. Significant retraction of the lower lip when using a chin-cup alone was reported by Allen et al.\(^{(14)}\) Our findings are fairly similar to those reported by Battagel and Orton,\(^{(15)}\) who recorded significant forward movement of the upper lip after upper incisor protraction in females treated with a modified facemask.

CONCLUSIONS:

1. The maxillary protraction appliance treatment can provide orthopedic effects on dentofacial morphologic features of growing skeletal Class III patients.
2. Treatment tended to reduce the concavity of the profile. This was characterized by a forward movement of the upper lip, backward repositioning of the pogonion soft, and slight inhibition of anterior migration of the lower lip.
3. The effect of the treatment was found to be more marked on the upper lip area.

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Date of Submission: 13/07/2015.
Date of Peer Review: 14/07/2015.
Date of Acceptance: 17/07/2015.
Date of Publishing: 24/07/2015.