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# MAXILLARY SKELETAL CHANGES CONCOMITANT WITH DIFFERENT LEVELS OF FORCE APPLICATION FOR MAXILLARY PROTRACTION IN GROWING CLASS III PATIENTS

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## *ABSTRACT*

**Objective:** to evaluate maxillary skeletal changes concomitant with different three levels of force application for maxillary protraction in growing orthodontivc patients with skeletal Class III malocclusion. **Subjects and Methods:** The current study was conducted on 30 Class III patients (19 boys and 11 girls) with maxillary difficieny. The age of the recrutted sample ranged from 7-10 years. The patients were randomely allocated into three equal groups. The point of protraction force application varied among the three groups; (Group A) at the occlusal plane level, (Group B) 20 mm above the occlusal plane and (Group C) at the infraorbital foramen level. The duration of the maxillary protraction was 8 months, the patients were instructed to wear the appliance 16 hour/day with the applied 550gs protraction force. CBCT images were taken before and after maxillary protraction to evaluate the different treatment effects. **Results:** The average amount of maxillary advancement in the three groups was 2.5 mm with non-significant difference. The pattern of maxillary rotation accompanied with the maxillary advancement, as demonstrated by PP-TVP, varied among the three groups; in (Group A) it was a counterclockwise rotation (2.8°) while in (Group B) it was a negligible (0.35 °) rotation. On the otherhand, in (Group C) the maxillary rotation was in a clockwise direction (-1.8°). **Conclusions:** Varying the point of force application was an efficient tool to control the rotation of the maxilla during protraction facemask therapy without affecting the amount of maxillary advancement.


**KEY WORDS:** Protraction facemask, Multilevels protraction system, Class III malocclusion

## INTRODUCTION

Skeletal Class III malocclusion is one of the most difficult conditions to correct in daily orthodontic practice. The continued posttreatment craniofacial growth is adding to the difficulty of this condition, especially when the mandible is diagnosed as the primary offending jaw. According to the literature, there is a great variability regarding the prevalence of Class III malocclusions across and within different populations[(1)].The incidence of Class III malocclusion among Egyptian population is at the rate of 11.8%[(2)].

Class III malocclusion may result from: (1) maxillary retrusion, (2) mandibular prognathism, or (3) combined maxillary retrusion and mandibular prognathism. According to Ellis and McNamara, they found in their sample that 65% to 67% of the observed Class III malocclusions were characterized by maxillary retrusion. Class III as considered a malocclusion in the sagittal dimension, it might also be associated with vertical as well as transverse discrepancies[(3)].

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There are several factors that should be considered when treating such cases; among them family history and genetics; severity of the problem; whether the problem is diagnosed in the midface, mandible, or combination; the age of the patient; patient compliance; in addition to the growth status of the patient[4] .

In the late 1960s, the Delaire protraction facemask was popularized to protract the maxilla. This appliance consists of a forehead cap and a chin cap that are connected together with bilateral square framework. There is a horizontal bar running in front of the mouth for elastic attachment. In 1983, Petit modified the Delaire mask by replacing the bilateral connecting square wire frame with a single vertical midline connecting bar. The horizontal running bar for elastic attachment is vertically adjustable in both designs to facilitate varying the point and direction of force application [5].

It has been proven that the effects of the protraction facemask on the facial structures include; maxillary skeletal advancement, forward maxillary dentoalveolar movement, restraining the expected mandibular growth during the period of treatment, retrusion of the mandibular dentoalveolar segment as well as the increase in the lower anterior face height due to the counter clockwise rotation of maxilla as well as the downward and backward rotation of mandible[6–8] .

The widespread use of the protraction facemask appliance has however, unveiled some of its major demerits such as the increase of the vertical dimension, due to the counterclockwise (CCW) rotation of the maxilla with the open bite tendency. This CCW is one of the major undesirable side effects in average and high angle cases [9-11].

According to Nanda, successful maxillary protraction could be done by controlling the protraction force variables such as the point of force application as well as the magnitude of the applied force. It was reported that the relationship between the point of protraction force application and the estimated center of resistance of the maxillary complex determines the direction of the maxillary rotation concomitant with forward maxillary displacement[12].

It was reporte that conventional tooth borne maxillary protraction headgears cause extrusion and anterior rotation of the anchor teeth, and upward and forward rotation of the maxilla[13-16].

According to Tanne et al the location of the center of resistance of maxilla is between the first and the second upper premolar root apexes [17].

Until recently, only few studies[18-20] have investigated the dentoskeletal effects of varying the point of protraction force application. To our best knowledge, none of these studies has used Cone Beam Computed Tomography (CBCT) to evaluate their outcomes nor applied the protraction force at a higher level above the nasal floor.

Therefore, the trigger was to conduct this study aiming to increase the utility and versatility of the protraction facemask therapy to suit different clinical situations by varying the points of force application and evaluating their associated maxillary skeletal changes using CBCT.

## PATIENTS AND METHODS

This randomized clinical trial was conducted on a sample of 30 Class III patients (19 boys and 11 girls) with age range from 7-10 years old. The sample size calculation was based data derived from previous studies[7,20] , For a standard deviation of 1.49 mm and a minimal intergroup difference of 2.14 mm to be detected, a sample of 27 patients was required to provide statistical power of 80% with an alpha of 0.05.

The included patients met the following criteria: skeletal Class III malocclusion due to retruded maxilla and/or combined maxillary retrusion with mild mandibular prognathism (ANB≤1, Wits appraisal <-2), concave profile with either edge to edge or anterior crossbite, no significant skeletal asymmetry, and no systemic diseases or congenital deformities. Only those subjects manifesting features of pre-pubertal cervical vertebrae maturational stages 1 and 2 (initiation and acceleration) were included.

This study was reviewed and approved from Department Ethics Committee, Faculty of Medicine for Boys, Al-Azhar University, Cairo, Egypt with registration number: *orthod._10Med.Research_Class III Malocclusion.Maxillary. Protraction. Growing.Pts._0000010* Additionally, the protocol of this study was registered in the ClinicalTrials.gov with the identifier: NCT04310267

After informed consent was signed, the patients were randomly assigned into three equal groups according to the point of force application (Figures 1&2); Group A: occlusal level, where the point of force application was at the level of the occlusal plane with 30° inclination[6,8]. Group B: nasal floor level, where the point of force application was at 20 mm [20] above the occlusal plane. Group C: infraorbital level, where the point of protraction force application was approximately at the level of infraorbital foramen.

In order to relocate the point of force application in a higher positions as in groups B and C an Intraoral to Extraoral Connecting Device (IECD) was used to overcome the anatomical limitations. This device is amodification of the standard headgear face bow (Denturum Company, Vogelberg 21BCH-4614 Hägendorf, Switzerland.)

Maxillary protraction was preceded by a rapid maxillary expansion for 10 days; 2 turns /day using bonded Hyrax rapid palatal expander (RPE) (Hyrax, GH Wire Company, Hanover, Germany). Extraoral Petit face mask (American Orthodontics 3524 Washington Avenue North America), used for extraoral anchorage, was linked to the intraoral RPE via extra oral elastics. 550 g per side[10] were measured using force gauge to assure adequate orthopedic effect. Patients were instructed to wear the appliance at least 16 hour/ day for 8 months[6].

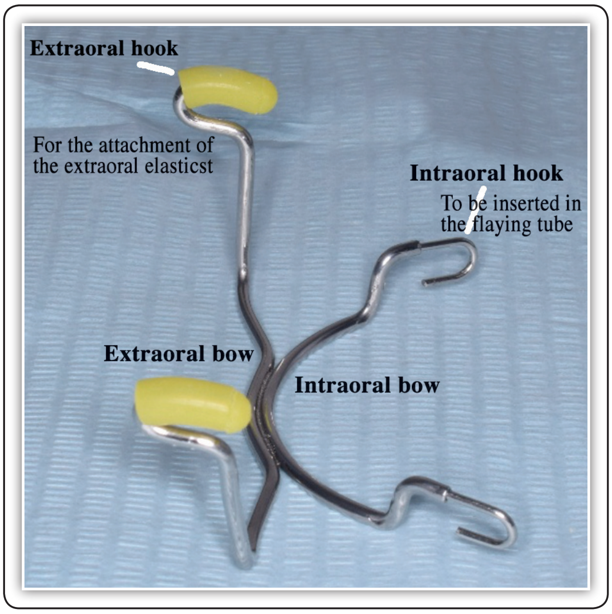


FIG (1) Intraoral to Extraoral Connecting Device (IECD) was used to relocate the point of protraction force application to be in a higher level.

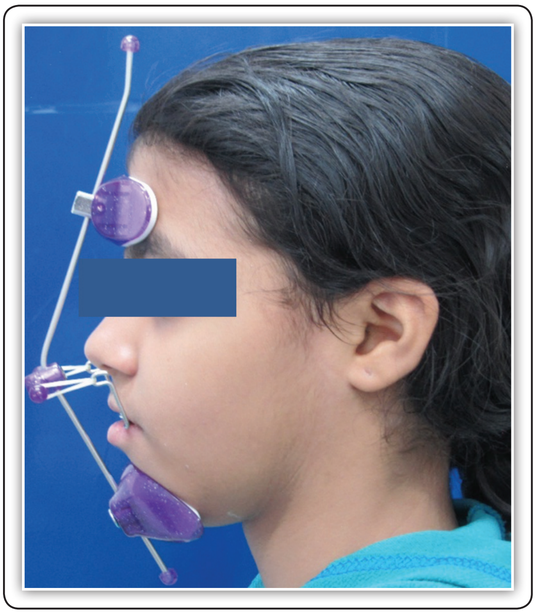

FIG (2) The installed maxillary protraction system

**Three dimensional assessment:**

The before and after maxillary protraction CBCT datasets (Figure 3) were imported to the 3D On Demand Software (Cybermed co., Seoul, Korea) , where 3D Ceph module was utilized for the analysis. Registration of both datasets was done

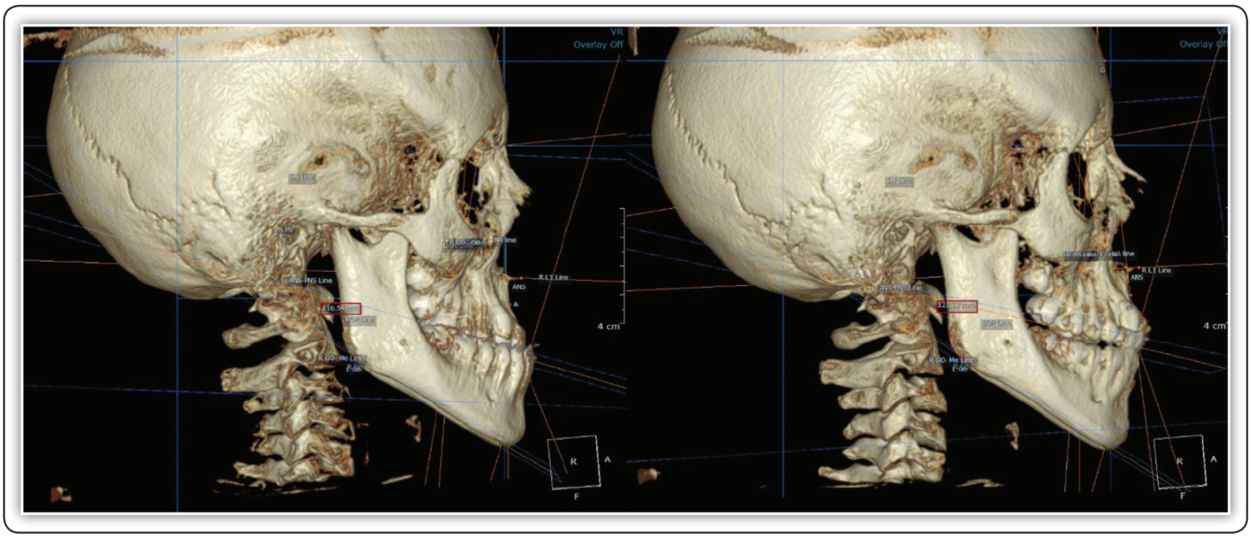


FIG (3) Sample of the linear and angular measurements using CBCT images

using automatic registration, where certain area was identified as area with minimum anatomical changes at both scans, and then the software matches both volume accordingly. Due to unavoidable discrepancy in positioning patients at the CBCT machine, another reorientation is made to ensure that both datasets are now aligned to reference planes (Frankfurt horizontal and midsagittal planes).

After registration, and reorientation, the preprotraction dataset (volume 1) was the only activated at the tracing function, where the assigned landmarks were identified at the three planes. The software automatically calculated the linear and angular measurements (table 1) as previously fed at the database. After this step, the postprotraction data set was then activated at the same volume configuration, two major tasks were then performed, the first one was identifying the previously located landmarks at certain coordinates in volume 1, then moving each landmark from that coordinate to the new position in volume 2 according to the change in its anatomical position (treatment effect). For the postprotraction data set, the repositioning of landmarks was again manually verified, and corrected at the three reconstructed planes if needed. The software again calculated the linear and angular measurements. Both measurement values were then extracted from the software in excel format.

**TABLE (1):** Linear and angular measurements used to evaluate maxillary changes

| Outcome measurement | | Definitions |
|---|---|---|
| **Maxillary Skeletal Measurements** | | |
| Vertical Position | ANS-THP (mm) | The perpendicular linear distance between ANS point and THP |
| | PNS-THP (mm) | The perpendicular linear distance between PNS point and THP |
| | A-THP (mm) | The perpendicular linear distance between ANS and THP |
| Sagittal position | ANS-TVP (mm) | The perpendicular linear distance between ANS and TVP |
| | PNS-TVP (mm) | The perpendicular linear distance between PNS and TVP |
| | A-TVP (mm) | The perpendicular linear distance between A and TVP |
| Rotation | PP-TVP (°) | The anterior inferior angle between PP and TVP |
| | OP-TVP (°) | The anterior inferior angle between OP and TVP |
| Length | ANS –PNS (mm) | The linear distance between ANS and PNS |

### Statistical Analysis

Descriptive statistics were calculated for all measurements at T1 and T2 by using the Statistical Package for Social Science (version 23, SPSS, Chicago, Ill). Paired samples t-tests were used to determine the statistical significance of skeletal measurements between T1 and T2 for each group. T1–T2 changes among the three studied groups were assessed with one way ANOVA test. Statistical significance was tested at $P < .05$.

## RESULTS

The comparison of the baseline characteristics revealed non-significant differences among the three groups. Since the data sets of the studied outcomes were normally distributed, paired t-test was used to evaluate the treatment effect within each group. One way ANOVA test was used to evaluate the treatment among the three studied groups. The results of this study (Table 2) revealed significant difference among the three studied groups regarding the rotational tendency of the maxilla after protraction facemask therapy. PP-TVP and OP-TVP revealed counterclockwise rotation of the maxilla (2.8 ˚, 1.78˚) in Group A, nearly bodily movement in Group B (0.35˚, -0.20°) and clockwise rotation of the maxilla in group C (-1.8 ˚, -3.459°). the skeletal changes of the maxilla in the sagittal dimension among the three studied groups revealed non-significant difference. Changes in the A-TVP showed average improvement of 2.62 mm, 2.66 mm and 2.82 mm for groups A, B and C respectively. T2-T1 within each group revealed statistically significant treatment effec

**TABLE (2)** Comparison of the maxillary skeletal changes among the different studied groups.

| Parameter (variable) | | Group A ($T_{2-}T_1$) | | Group B ($T_{2-}T_1$) | | Group C ($T_{2-}T_1$) | | Value | Sig. | Sig. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **Mean** | **SD** | **Mean** | **SD** | **Mean** | **SD** | | | |
| Vertical Position | ANS-THP (mm) | -1.54 | 1.01 | -0.13 | 1.11 | 1.56 | 0.812 | 2.029 | 0.021 | * |
| | PNS-THP (mm) | 1.03 | 0.91 | 0.11 | 0.61 | -1.88 | 1.240 | 3.666 | 0.028 | * |
| | A-THP (mm) | -1.56 | 0.71 | -0.03 | 0.82 | 1.453 | 0.706 | 2.220 | 0.031 | * |
| Sagittal | ANS-TVP (mm) | 2.39 | 1.16 | 2.60 | 1.18 | 2.716 | 1.018 | 0.217 | 0.806 | NS |
| | PNS-TVP (mm) | 0.99 | 0.71 | 0.92 | 0.62 | 1.036 | 0.819 | 0.066 | 0.937 | NS |
| | A-TVP (mm) | 2.62 | 1.43 | 2.66 | 1.14 | 2.822 | 1.556 | 0.060 | 0.942 | NS |
| Rotation | PP-TVP (˚) | 2.8 | 1.05 | 0.35 | 0.85 | -1.8 | 0.793 | 3.109 | 0.025 | * |
| | OP-TVP (˚) | +1.78 | 3.96 | -0.20 | 4.31 | -3.459 | 5.041 | 4.038 | 0.001 | * |
| Length | ANS-PNS (mm) | 0.934 | 1.087 | 1.383 | 1.196 | 1.808 | 1.242 | 1.379 | 0.269 | NS |

*$T_1$: before protraction, $T_{2:}$ after protraction, P value: Probability value, Sig. Significance, NS: None significant, *: significant*

## DISCUSSION

Tooth borne protraction facemask appliance is considered as the prime choice for the correction of Class III malocclusion with maxillary deficiency. The protraction facemask applies an anterior force on the circum maxillary sutures and stimulates bone formation at the sutural areas. It assists to correct the maxillary skeletal retrusion, maxillary dentoalveolar retrusion as well as the decrease in the lower face height.

There are some effects concomitant with the use of protraction facemask that might be undesrirable in certain clinical situations. One of these undesirabl effects,especially in cases of Class III with normal and openbite tendencies, is the counterclockwise rotation of the maxilla. So, the aim of the this study was directed toward testing the hypothesis of varying the point of forceapplication in order to overcome this side effect.

The protocol fro this study was published online in order to avoid selective reporting or reporting bias. The current study included 30 Egyptian children of both genders with age range from 7-10 years old. The early treatment at this age according to literature will help to achieve the maximum skeletal changes with minimum dental compensations(21). It was reported that there is no existing significant sexual dimorphism in Class III malocclusion before age of 13 years old therefore, no gender restriction in the selection of children was applied in this study(22).

The selected patients were randomly allocated into three equal groups using online software by the secretary of the Orthodontic Department. Randomizations was done in order to equally distribute the eligible patients among the three groups without bias. The comparison of the baseline characteristics of the subjects among the three groups revealed a non-significant differences in the all studied outcomes, assuring the adequate method of randomization.

Allocation concealment was done by using white opaque envelopes, each envelope contained the random number and its allocation group. These envelopes were kept in a box at the orthodontic department secretary's office. The secretary of the department used to deliver the allocation envelop for each enrolled patient to the operator.

Blinding during intervention procedures for both the operator and the patient was impossible. Meanwhile, blinding during data collection and analysis was possible. Data collection from patients' record (CBCT analysis) and statistical analysis was done by two persons other than the two supervisors and the principle operator in order to minimize data collection and management bias.

The maxillary protraction system set up in this study included the use of a Petit facemask attached to a fixed intra-oral bonded rapid palatal expander, Hyrax type (McNamara's expander design). Petit type facemask was chosen as it is relatively small in size which makes it more appealing to the child in the view of the esthetic concerns.

The treatment was started with 10 days of RME before protraction in all groups to mechanically disarticulate the surrounding sutures and to release the inflammatory mediators that are important for facilitating maxillary displacement. It was also reported by Hass that maxillary expansion by itself can cause anterior maxillary displacement and slight increase in the vertical dimension that might help in the correction of mild class three cases.(15) The occlusal coverage (splint) was incorporated in the design of the RPE for three reasons; first to disarticulate the occlusion that facilitates protraction and removes interferences, second is to counteract the extrusive effects of expansion and protraction and finally to help in splinting the maximum number of teeth as one unit that would increase the skeletal effect.

The maxillary skeletal effects of each point of force application were analyzed using CBCT due to its high accuracy and precision, sensitivity and specificity, as well as absence of image magnification. The comparison of the treatment effects in each group was made in a way previously described by several investigators[23].

The results of this study, demonstrated a significant ($P<0.05$) positive response to facemask therapy at different levels of the force application with non-significant differences among the three studied groups regarding the amount of anterior maxillary displacement. This finding is in accordance with what have been previously reported in the literature.[5–7, 20]

The patterns of maxillary rotation demonstrated a significant ($P<0.05$) difference among the three studied groups, this might be attributed to relationship between the applied force and the estimated center of resistance (CRE) of the maxillary complex.

In group A, since the point of force application was below the CRE there was a counter clockwise rotation of the maxilla. These findings are in agreement with what have been reported previously in the literature[5–7]. The observed nearly bodily maxillary advancement with minimal rotation in group B confirms the previous findings of Keles et al [20] with the conclusion that this point is the closest point to the maxillary CRE. The observed clockwise rotation of the maxillary group C was due to the application of the protraction force above the maxillary CRE.

## CONCLUSION

Varying the point of force application is an efficient method to control maxillary rotation during protraction facemask therapy without affecting the amount of maxillary advancement .

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