Research article

R.M.S. bite corrector: A novel appliance for the correction of mandibular prognathism in growing children-Part one: Skeletal and dental changes

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(Received: March 2022 Revised: August 2022 Accepted: September 2022)

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ABSTRACT

Introduction and Aim: Mandibular prognathism is one of the most challenging conditions in clinical dental practice. No appliance has yet been introduced to manage this strenuous condition. Hence, a modified appliance, R.M.S. (removable acrylic splint) bite corrector was fabricated combining the principles of three conventional appliances. The aim was to evaluate the skeletal and dental changes following R.M.S bite corrector in growing children with mandibular prognathism, using lateral cephalograms.

Materials and Methods: Twenty children between the age group 9 - 13 years, presenting with class III malocclusion with prognathic mandible were selected. R.M.S bite corrector was fabricated, which consist of reverse twin block with RME (Rapid Maxillary Expansion) incorporated in the upper block. Hooks integrated in the molar region of the upper block, and between the lateral incisors and canines in the lower block. A gradual increasing force was delivered by engaging intraoral intermaxillary elastics. After 10 months, skeletal, dental, and dentoalveolar parameters and linear measurements of jaw bases were compared using pre- and post-operative lateral cephalograms.

Results: After 10 months, skeletal changes included a significant retrusion of the mandible and maxillary protraction. Dental changes comprised of an increase in proclination of maxillary and mandibular incisors, which was not significant. A significant increase in the length of the maxillary base, non-significant change in the linear measurements of the mandibular base and ramal length leading to relocation of the mandible in a relatively new position with better esthetics.

Conclusion: Desirable skeletal and dental changes were observed following R.M.S. bite correction.

Keywords: Class III malocclusion; palatal expansion; reverse twin block; interceptive orthodontics.

INTRODUCTION

Mandibular prognathism was described by John Hunter as follows: "The mandible projecting too far forward so that the fore teeth pass before those of the maxilla, therefore two of the main facial characteristics are disfigurement and malocclusion". Incomplete closure of lip, deviation of the midline, and decreased labiomental fold are some of the distinguishing features of class III malocclusion. In such cases, surgical or orthodontic treatment alone cannot provide functional occlusal relationship and balanced facial harmony (1). No appliances have yet been introduced to correct mandibular prognathism.

Interceptive treatments for class III malocclusion at the early stages include Frankel III, reverse twin block, Protraction headgear, Tandem traction bow appliance (TTBA) and skeletal anchorage systems (2). The maxillary protraction facemask is one of the standard treatment protocols in the treatment of Class III growing patients, allowing the forward and downward growth of maxilla by orthopedic force (3). However, facemask often causes discomfort and is not easily accepted by the patients due to the heavy protracted force and unpleasant appearance, thereby reducing the patient's co-operation and compliance. Another, treatment protocol is the use of reverse twin block. The reverse occlusal planes are designed to encourage maxillary development and to drive the maxillary dentition forward by the occlusal forces and at the same time limit the growth of the mandible. The occlusal force exerted on the mandible is directed downwards and backward, However, the results are mainly dentoalveolar (4,5).

The bone anchorage maxillary protraction protocol (BAMP) was introduced recently for the correction of class III malocclusion by protraction of the maxilla. B.A.M.P. uses mini plates which are placed in the maxilla, above the first molar and in mandible between the laterals and the canines. A force is applied by placing intraoral elastics, engaged on to the maxillary and mandibular mini plates. This would thereby apply a continuous force for a longer duration. But the placement of mini- plates requires surgical intervention which makes the patient apprehensive (6).

Hence, the principles of B.A.M.P., reverse twin block and face mask have been employed to fabricate R.M.S.(removable acrylic splint) bite corrector, which consist of reverse twin block appliance with incorporation of hyrax screw and hooks substituted in place of miniplates with the placement of elastics joining the hooks for the management of mandibular prognathism. The appliance was registered for patency (Ref. No/Application No. 202141032032). The aim of the present study was to evaluate the skeletal and dental changes following the R.M.S bite corrector using lateral cephalogram.

MATERIALS AND METHODS

The subjects for this study were selected from the Department of Pediatric Dentistry, A B Shetty Memorial Institute of Dental Sciences, Mangalore. A total of 20 growing subjects having in the age group of 9-13 years with class III malocclusion were chosen for the study. Patients diagnosed with syndromes, gross facial asymmetry, systemic conditions, cleft lip and palate, temporomandibular joint disorders, mental retardation were not considered for the study.

Ten months follow up period was maintained after delivering the RMS bite corrector. A detailed case history, clinical examination and cephalometric analysis was done to confirm the skeletal pattern of the patients. Upper and lower alginate impressions were made, and bite registrations recorded. Reverse twin block with bonded RME was fabricated with hooks fixed on to the upper and the lower components at the region above the upper first molar region and between the lower laterals and the canines respectively (Fig. 1).

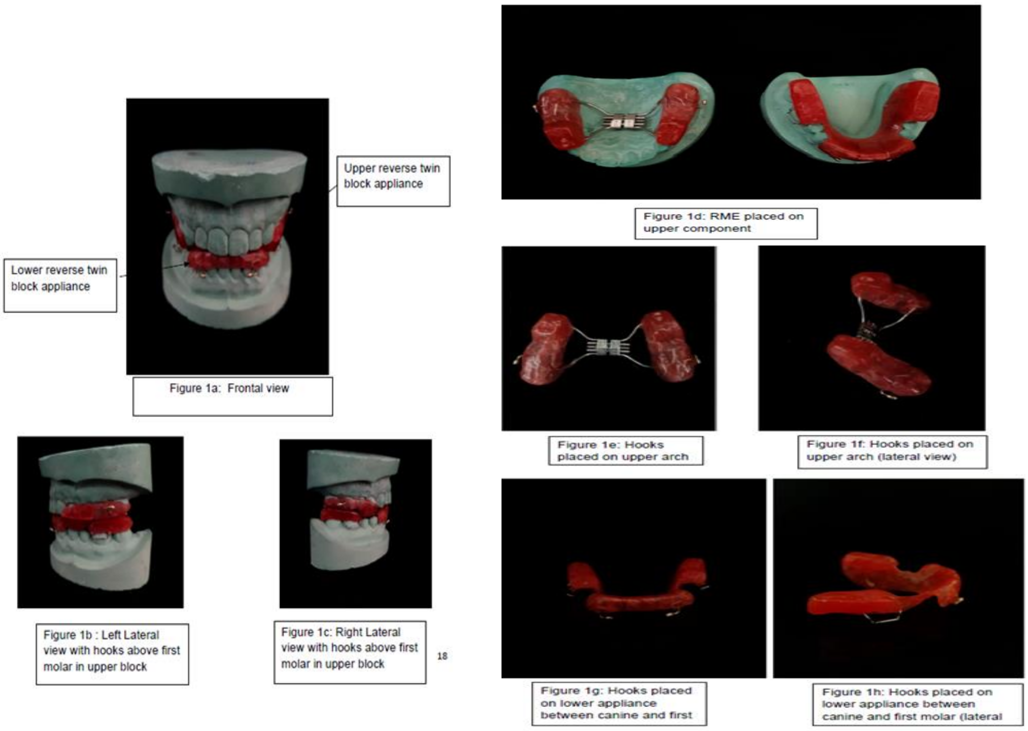


Fig.1: Model of RMS bite corrector

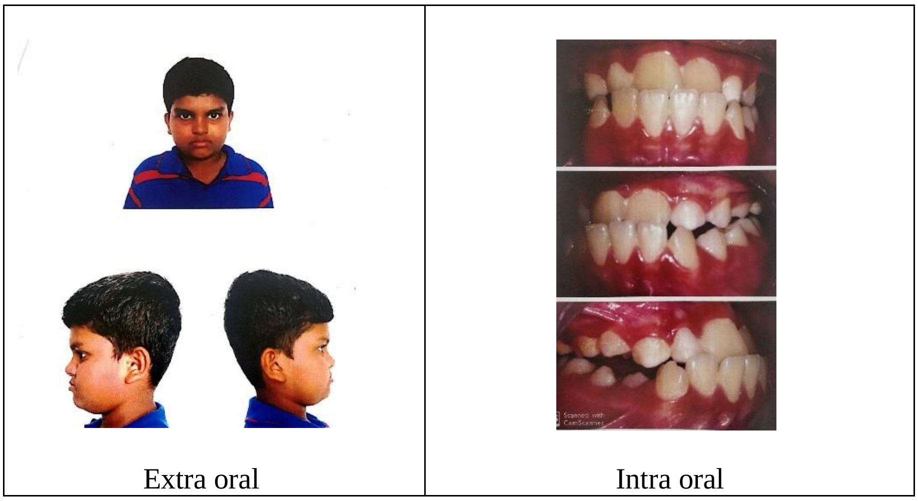


Fig.2: Pre-treatment images

The appliance was cemented on to the upper and lower arch. Gradual forces of 150-250 grams were applied on each side using intermaxillary elastics which were placed on to the hooks that are attached to the appliance (Fig. 2).

The appliance was delivered to the patient for 10 months period along with the intermaxillary elastics. The patient was advised to activate the RME twice daily for the first five days followed by one activation till the desired results are achieved. Patients were recalled once every 4 weeks for regular check-up. A post treatment lateral cephalogram and photographs were taken to assess the degree of maxillary protraction and mandibular retrusion and was compared with the pre-operative lateral cephalogram. For evaluation of the skeletal, dental and dentoalveolar changes that contributed the correction of class III malocclusion, Rakosi's analysis was used. Skeletal cephalometric measurement included SNA, SNB and ANB angle.

Dentoalveolar measurements included SNPr (o), which is measured as the angle between sella to nasion and the NPr (nasion to Prosthion) line. SNId(o), which is the angle between the anterior cranial base (sella to nasion) and the NId (nasion to Infradentale) line. Dental measurements included I-Pal(o), which is the angle formed between the upper incisor to the palatal plane, i-MP(o), which is the angle formed between the lower incisor to the mandibular plane and I-i(o) – Interincisal angle, formed by the angle between the upper and lower incisors. UI-SN (°) – The angle between long axis of maxillary central incisor to sella-nasion line. Linear cephalometric measurement included are Maxillary base (mm), measured as the distance between PNS and ANS in millimeters, Mandibular base (mm) measured as the distance between Go (Gonion) to Pog (pogonion) and ramal length(mm), measured from Go (Gonion) to Co (Condylion).

Statistical analysis

Estimates of mean and standard deviation was used to determine sample size, using the formula,

$$n = \frac{(Z_{\alpha} + Z_{\beta})^2 [s]^2}{d^2}$$

where Z_{α} is the z variate of alpha error i.e., a constant with value 1.96, Z_{β} is the z variate of beta error i.e., a constant with value 0.84 (7). Approximate estimates used were 80% power, Type I error to be 5%, Type II error to be 20%, True difference of at least 1.99 units between the time intervals and pooled standard deviation of 2.95

Substituting the values,

$$n = \frac{(2.8)^2 \ (2.95)^2}{(1.99)^2}$$

$$= 17.228$$

Approximately 18 to 20 subjects were involved in the study per time interval till the endpoint.

Statistical analysis of all the data was done using descriptive statistics. Pre and Post treatment values were compared using Paired 't' test

RESULTS

The results for all the measurements in Rakosi's analysis are shown in Table 1 and 2. Pre and Post treatment mean value, standard deviation, mean difference and t values are mentioned in the tables.

Skeletal changes

There was a mean forward movement of maxilla by 0.9 degrees post treatment, which was statistically highly significant ($P \leq 0.001$) (Table 1). There was a mean backward movement of mandible by 1.65 degrees post treatment, which was statistically significant ($P \leq 0.001$) (Table 2). The anteroposterior change in the relationship between the maxillary and mandibular base made a positive contribution following the treatment with RMS bite corrector. The ANB angle increased by 1.40 degrees which was statistically significant (P≤ 0.02).

Table 1: Pre-treatment and post treatment SNA, SNB and ANB values (n=20)

	Treatment	Mean value	SD	P value
SNA	Pre-Treatment	79.90	1.91	0.001*
	Post Treatment	80.80	1.99	0.001*
SNB	Pre-Treatment	81.30	3.43	0.001*
	Post Treatment	79.65	3.88	0.001*
ANB	Pre-Treatment	-0.70	3.65	0.02*
	Post Treatment	0.70	3.54	0.02*

Dentoalveolar changes

The upper incisor showed a forward inclination to the cranial base post treatment, SNPr angle increased by 1.20 degrees which was statistically significant (P<0.005) (Table 2). The lower incisor showed a backward inclination towards the cranial base as SNId angle decreased by 2 degrees which was significant statistically (P<0.001) (Table 2).

Table 2: Pre-treatment and post treatment SNPr, SNId values (n=20)

		Mean Value	S.D.	P value
SNPr	Pre-Treatment	83.90	2.64	0.005*
	Post Treatment	85.10	3.04	0.005*
SNId	Pre-Treatment	85.30	3.65	0.001*
	Post Treatment	83.30	4.11	0.001*

Dental changes

There was proclination of the upper incisors following the use of RMS bite corrector. I-Pal angle increased by 2.05 degrees; However, it was not significant statistically (P<0.08) (Table 3). A decrease in the proclination of mandibular incisor to mandibular plane angle was noted. I-MP angle increased by 1.1 degree; However, it was not statistically significant (P≤0.31) (Table 3). The I-i(o) angle increased by 1.1 degree was not statistically significant (P≤0.29) (Table 3).

Table 3: Pre and post treatment I-Pal, i-MP, Interincisal angle values (n=20)

		Mean value	S.D.	P value
I-Pal	Pretreatment	66.10	9.22	0.08
	Post treatment	66.15	10.92	0.08
i-MP	Pre-treatment	94.40	9.05	0.31
	Post treatment	95.50	9.51	0.31
Interincisal Angle	Pre-treatment	125.60	8.09	0.29
	Post-treatment	126.70	7.62	0.29

Changes in linear measurements

The Post treatment linear changes in the subjects following the use of RMS bite corrector showed a mean forward movement of point ANS by 0.65mm, which was significant statistically (P≤ 0.04), point Pog moved backward by 0.25mm, which was not statistically significant (P≤ 0.24) (Table 4). The mean decrease of ramal length was by 0.50mm. However, it was not statistically significant (P≤ 0.09) (Table 4).

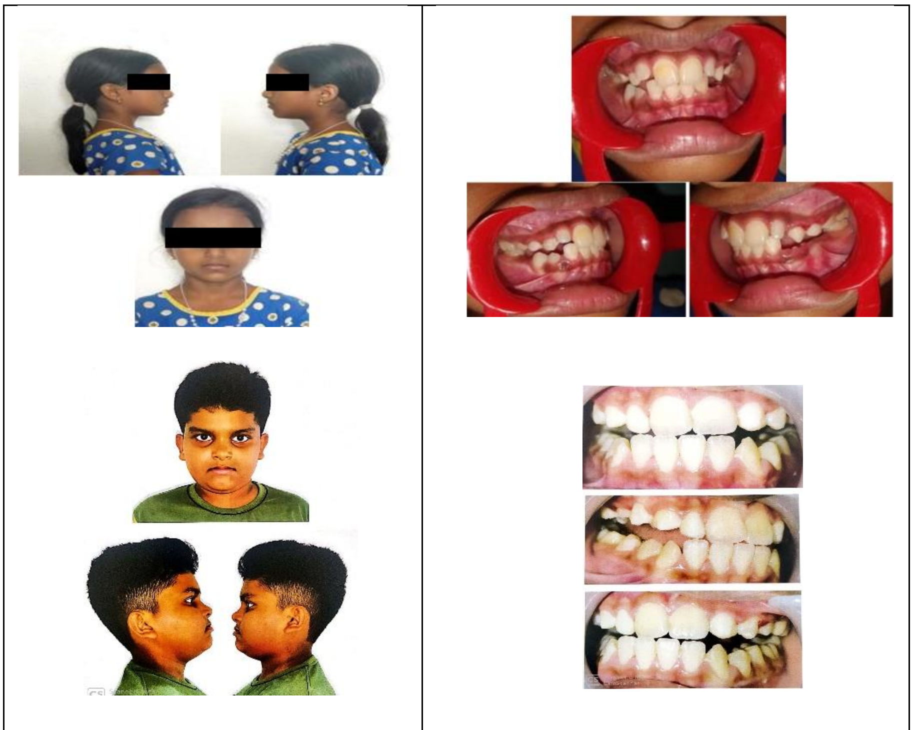
Table 4: Pre and post treatment maxillary base, mandibular base and ramal length values (n=20)

		Mean value	S.D.	P value
Maxillary base (mm)	Pre-treatment	46.40	4.53	0.04*
	Post treatment	47.05	4.13	0.04*
Mandibular base (mm)	Pre-treatment	61.15	3.48	0.24
	Post-treatment	60.90	3.53	0.24
Ramal length	Pre-treatment	36.80	4.11	0.09
	Post- treatment	36.30	3.58	0.09

DISCUSSION

The decision to commence early or to delayed treatment is based on the severity of malocclusion for class III individuals. An appropriate treatment plan can be formulated after diagnosing the extent of skeletal disharmony (8). In this study, young class III malocclusion patients with mandibular prognathism received treatment with a modified appliance to observe orthopedic response with more of skeletal effect and minimal dentoalveolar effects. The conventional use of reverse twin block for the early treatment of class III produces more of the dentoalveolar effect. This treatment modality is often combined with the use of facemask therapy where extraoral elastics are used bringing about maxillary protraction. Reverse twin blocks are designed with the reversal occlusal planes inclined at 70° angle thereby encouraging maxillary development. The forces of occlusion drive the upper teeth and the maxilla forward and at the same time restrict mandibular development. The force vector thus passes through the mandible from the mandibular molar towards the gonial angle (4). The prognosis of the treatment using Reverse Twin block for correction is determined by the ease with which the patient can achieve an anterior edge to edge bite. The appliance must be worn 24 hours a day for a visible maxillary advancement which can be appreciated within 4 weeks. Kidner *et al.,* evaluated the action of reverse twin block and found that most of the changes following the use of the appliance are mainly dentoalveolar with minimal skeletal changes limited to the backward and downward rotation of the mandible thereby increasing the vertical height. Dentoalveolar changes are due to upper incisor pro-clination and lower incisor retroclination (5). Hence in the present study, to minimize the dentoalveolar effects using reverse twin block, the appliance was modified and fabricated thereby to bring about more of skeletal changes. In the BAMP protocol, mini-plates are inserted, which would require surgical interventions during the initial placement and removal of the mini-plates. Moreover, irritation in the buccal region and potential healing complications can take place due to failure in the placement of miniplates (8). Due to the drawbacks of all the above-mentioned appliances, R.M.S bite corrector was introduced, which consisted reverse twin block with hooks placed like the placement of mini plates in the BAMP. This modified appliance was stable and was well tolerated by patients as there was no need for surgical intervention when compared to the BAMP protocol. The placement of hooks in the modified appliance is such that they lie above the molar region in the upper block and between the lower lateral incisor and the canine on each side of the lower block. For the protraction of maxilla, RME is commonly used as an adjunct to other treatment modalities in the correction of class III, which was also accommodated in this appliance to facilitate the opening of circum-maxillary sutures for expansion of the maxilla thereby correcting the posterior crossbite due to constricted maxilla. Since the patients in this study were all in the growing stages, the activation schedule of RME was selected accordingly. Activation schedule followed was two times daily for the first five days followed by once a day till the desired results was achieved (9). In the present study, the hooks on the upper and lower blocks were engaged with Class III elastics. About 150g of initial force was applied on either side, which was increased to 250g after 2 months. Dontrix gauge was used to measure the force and maintained accordingly. To ensure a constant application of force, the patient was asked to replace the elastics every 24 hours. In facemask therapy, RME is bonded to the upper block. Two hooks are present in the region above the first premolar to engage elastics for the application of an orthopedic force of 400g per side. This force element is directed 30˚ downward and forward from the occlusal plane to act through the center of resistance of the dentomaxillary complex. This is expected to bring about protraction of the maxilla by its anterior and inferior rotation. The choice of direction of force in the present study was made based up on the same principle to bring about the desired results. In contrast to facemask therapy wherein the appliance is worn for only 14 hours a day thereby resulting in an intermittent orthopedic force delivery, the R.M.S bite corrector used in our study facilitates a continuous orthopedic force, delivered over a period of 24 hours, because it is cemented intraorally. In addition, the facemask is bulky and less esthetic, thus reducing the overall patient compliance. Thus. Combining the principles of BAMP, facemask, RME and reverse twin block, the R.M.S bite corrector was fabricated. A bonded RME hyrax screw and hooks in the molar region have been incorporated in the upper block. These hooks are incorporated such that they lie between the lower lateral incisor and the canine on each side of the lower block. A gradual continuous force was directed 30˚ downward and forward from the occlusal plane to act through the center of resistance of the dentomaxillary complex by engaging elastics between the hooks and has shown to retrude the mandible and at the same time protrude the maxilla. The design of the appliance, anchorage device, treatment duration, force magnitude, and direction were standardized to minimize the number of variables to be interpreted when reviewing the data.

RMS bite corrector was made to be worn by the selected group of children with class III malocclusion. Following a period of ten months there was an overall improvement in the facial profile of all the children. One of the major skeletal changes observed was a shift in ANB from -7˚ to 7˚. This finding agrees with the study done by Minase *et al.*, where an increase in ANB angulation was observed in the facemask-RME group (10). The change in ANB in our study is attributed mostly due to mandibular setback and a minor forward placement of maxilla. There was an increase in the maxillary protraction in this study as SNA angle has increased by 0.90˚. This observation is in accordance with the study done by Kidner *et al.,* on class III twin block wherein an increase in SNA of 0.1790˚ was noted (5). SNB angle in this study has decreased by 1.65˚. suggestive of mandibular retrusion due to the downward and backward rotation. This decrease in the SNB value was found to be statistically significant. This observation is in accordance with the study done by Cha *et al.,* wherein a decrease in SNB of 1.08˚. was noted in patients with facemask with a surgical miniplate placed as anchorage (11). Ngan *et al.,* did a study on maxillary expansion and protraction with facemask, on Class III growing children where the SNB angulation decreased with a changeof 1.7˚ which has been attributed to the chin cup effect of the face mask (12). The dentoalveolar measurements were assessed by the change in the angulation of SNPr and SNId. SNPr and SNId are both reflective of the angular change of the dentoalveolar component of the premaxilla and the mandible respectively. SNPr in combination with SNA and SNId in combination with SNB is expected to reflect the difference between the skeletal and the dentoalveolar corrections better than SNI and Sni alone which measures only the incisal inclinations. Thus, for the angular measurements of both the skeletal and the dental components, SNA in combination with SNPr and SNB in combination with SNId were thought to be more reliable and was thus used in this study There was an increase in the SNPr angulation by 1.20˚. In this present study which reflects that there has been an increase in the dentoavleolar component of the premaxilla. A significant decrease in the SNId angulation of 2˚ was noted which reflects the decrease in the dentoalveolar component of the mandible. Upper incisor to the palatal plane angulation in our study increased by 2.05˚, this change in I-Pal angulation suggests that there has been protrusion of the upper incisors. Findings of this study are on par with the study done by, Ağlarci *et al.,* result showed that a significant protrusion of maxillary incisors was found in both the facemask and skeletal anchorage groups, but in the facemask group all maxillary incisor measurements were at least double than those of skeletal anchorage group (13). In a study done by Shetty *et al.*, upper incisor angulation increased following the use of modified maxillary protraction appliance, which was like our study (14). The lower incisor angulation was checked in this study, which increased by 1.1°., which was not statistically significant. The inter-incisal angulation in the present study showed an increase of 1.1° which was statistically not significant. However, the present finding contradicts the findings observed in the study done by Lee *et al.*, where there was a decrease in the inter incisal angulation by around 1.02° in the facemask-miniplate group (14). The length of the maxillary base, mandibular base, and ramal length was measured in the study. There was statistically significant increase in the maxillary base by 0.65mm stating that the point ANS moved forward. This finding is be attributed to the use of RME in the present study, which is supported by the study, where there was a comparative increase in the maxillary length in the facemask- RME group when compared to the facemask-miniplate group (15). The mandibular base measurements showed that there was a decrease of 0.25mm, which was statistically not significant. The ramal length measurements showed similar results with a decrease of about 0.50mm which was not statistically significant. These findings contradict the findings in the study done by Ge *et al.*, where a significant increase of 2mm was noted in the overall mandibular length in the facemask-RME group (8).



Extra oral	Intra oral

Fig. 3. Post-treatment images

Results thus show that RMS bite corrector has produced significant mandibular retrusion along with maxillary protraction with a greater change in the mandibular setback (Fig. 3), which could be due to the backward force acting on mandible by means of intraoral elastics passing through the center of resistance.

However, long term follow-up of these children until the completion of growth spurts is required before arriving at a definitive conclusion. One of the major disadvantages of any appliance is the bulkiness which result in compromised patient compliance and cooperation. However, in our study patient compliance and cooperation were addressed successfully following the use of RMS bite corrector. Long term follow-up of these children until the completion of growth spurts is required before arriving at a definitive conclusion. Skeletal, dentoalveolar and dental changes of maxilla and mandible was evaluated in our study, using modified appliance. However, changes in the nasomaxillary complex and assessment of airway changes, if any, are required to further investigate the effects of the appliance. A two-dimensional imaging technique was employed for the assessment of skeletal changes, but a three - dimensional imaging technique such as Cone Beam Computed Tomography (CBCT) would be much more accurate in analyzing the changes that have occurred due to the use of this appliance. Hence, the second article on this study will report the dimensional changes of nasomaxillary complex following RMS bite corrector using C.B.C.T.

CONCLUSION

On comparison of the pre-treatment and post treatment values of various angles as measured on lateral cephalograms of growing children with skeletal class III malocclusion who were treated with R.M.S bite corrector, the following conclusions were made:

- Skeletal changes such as retrusion of the mandible and protraction of maxilla were observed as denoted by the angular measurements which led to a visible improvement in the facial profile of all the children.
- Dentoalveolar changes in terms of angulation of the alveolar portion showed an increase in the premaxilla and a decrease in the mandible.
- Dental changes comprised of an increase in proclination of maxillary and mandibular incisors, which was not statistically significant.
- Linear measurement changes were observed in the maxillary base as indicated by the increase in length of the same whereas no significant change in the linear measurements of the mandibular base and ramal length were noted.

CONFLICT OF INTEREST

Authors have no conflict of interest to declare.

REFERENCES

1. Park, C.G., Yoo, J.W., Park, I.C. Surgical treatment of mandibular prognathism in collaboration with orthodontic treatment in Korea. Aesthetic Plast Surg. 1994 Fall;18(4):407-412.
2. Azamian, Z., Shirban, F. Treatment options for class III malocclusion in growing patients with emphasis on maxillary protraction. Scientifica, 2016.
3. Kim, J. H., Viana, M. A., Graber, T. M., Omerza, F. F., BeGole, E. A. The effectiveness of protraction face mask therapy: a meta-analysis. American Journal of Orthodontics and Dentofacial Orthopedics. 1999; 115(6): 675-685.
4. Sargod, S. S., Shetty, N., Shabbir, A. Early class III management in deciduous dentition using reverse twin block. Journal of Indian Society of Pedodontics and Preventive Dentistry. 2013; 31(1): 56.
5. Kinder, G., DiBiase, A., DiBiase, D. Class III twin blocks: a case series. Journal of orthodontics. 2003; 30(3): 197-201.
6. Sar, C., Arman-Ozcirpici, A., Uckan, S., Yazici, A. C. Comparative evaluation of maxillary protraction with or without skeletal anchorage. American Journal of Orthodontics and Dentofacial Orthopedics. 2011; 139(5): 636-649.
7. Charan, J., Biswas, T. How to calculate sample size for different study designs in medical research? Indian Journal of Psychological Medicine. 2013; 35(2):121-126.
8. Ge, Y. S., Liu, J., Chen, L., Han, J. L., Guo, X. Dentofacial effects of two facemask therapies for maxillary protraction: Miniscrew implants versus rapid maxillary expanders. The Angle Orthodontist. 2012; 82(6):1083-1091.
9. Isaacson, R. J., Ingram, A. H. Forces produced by rapid maxillary expansion: II. Forces present during treatment. The Angle Orthodontist. 1964; 34(4): 261-270.
10. Minase, R. A., Bhad, W. A., Doshi, U. H. Effectiveness of reverse twin block with lip pads-RME and face mask with RME in the early treatment of class III malocclusion. Progress in Orthodontics. 2019; 20(1): 1-12.
11. Cha, B. K., Ngan, P. W. Skeletal anchorage for orthopedic correction of growing class III patients. In Seminars in Orthodontics. 2011; 17(2): 124-137.
12. Ngan, P., Hagg, U., Yiu, C., Merwin, D., Wei, S. H. Treatment response to maxillary expansion and protraction. European Journal of Orthodontics. 1996; 18(2): 151-168.
13. Aglarci, C., Esenlik, E., Findik, Y. Comparison of short-term effects between face mask and skeletal anchorage therapy with intermaxillary elastics in patients with maxillary retrognathia. European Journal of Orthodontics. 2016; 38(3): 313-323.
14. Shetty, R., Hegde, A. M., Unais, M. Correction of Class III Malocclusion Using Modified Maxillary Protraction Appliance. Journal of Advanced Medical and Dental Sciences Research. 2019; 7(3): 46-54.
15. Lee, N. K., Yang, I. H., Baek, S. H. The short-term treatment effects of face mask therapy in Class III patients based on the anchorage device: miniplates vs rapid maxillary expansion. The Angle Orthodontist. 2012; 82(5): 846-852.