Pakistan Oral & Dent. Jr. 24 (2) Dec 2004

RAPID PALATAL EXPANSION IN MIXED DENTITION STAGE WITH CUSTOM MADE MODIFIED EXPANSION DEVICE

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ABSTRACT

The aim of this study was to determine the sagittal, transverse and vertical effects of a custom made Modified Expansion Device on dentofacial structures in patients with severe crowding and narrow upper arches in the mixed dentition. A total of 20 patients (13 females and 7 males) with an age range of 8-11 years were selected without regard to their skeletal class and gender. All subjects had mixed dentition (mean age 9.8 years) and needed maxillary expansion. Lateral and frontal cephalometric radiographs, maxillary and mandibular plaster models and occlusal radiographs were obtained from each patients at pre-expansion (T1), post-expansion (T2) and at the end of retention period (T3). Occlusal radiographs were used to demonstrate changes in the midpalatal suture. The measurements were made on the patients' cephalometric films and plaster models. The means and standard deviations for independent and dependent variables were analyzed statistically and evaluated by paired-t test using SPSS 10.1 for windows. In the transverse plane, a significant increase in intercanine width (ICW), interpremolar width (IPW) and intermolar width (IMW) was found. Sagitally, 2mm of maxillary protraotion and significant increase in arch length was noted. Mesial tip was more marked than distal although both were statistically insignificant Extrusion, buccal tipping and other cephalometric variables used for vertical analysis showed insignificant values. We conclude that the custom made modified expansion device with rapid maxillary expansion is an effective appliance for correction of crowding and constricted upper arches as phase I treatment.

Key words: *Rapid palatal expanion, Mixed dentition, Modified expansion device.*

INTRODUCTION

Severe crowding and narrow upper arches may affect the smile and facial profile adversely. There are many ways to treat such a crowded arch. One of the treatment modalities is expanding the upper arch at its proper time which can be attained by various means such as ordinary removable screw plates or fixed expanders in the form of Quad helix, soldered Hyrax or Hyrax with acrylic splint and Haas screw appliance.

Removable screw plates can serve the purpose in the early mixed dentition stage when the midpalatal suture is less tortuous and their added advantage is simple laboratory procedures and cost effectiveness. However, main problem with the use of plates is non-compliance on the part of the patients as most of the patients fail to apply them regularly.

Fixed expanders being rigid and fixed to the teeth produce excellent effect in the form of palatal expansion but their disadvantage is that of cost and extensive laboratory procedures. The introduction of Modified Expansion Device (MED)1 properly addresses the disadvantages of both removable and fixed expanders.

Modified expansion device is a fixed expander designed by A. Ij az . The appliance comprises an acrylic plate with a midline screw. This plate covers the palate

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and also extends to the occlusal and buccal surfaces of teeth up to the cervical margins. This appliance being rigid and fixed is independent of patient's compliance, as well as cost effective and easy to fabricate. Fig. 1.

MATERIALS AND METHODS

This prospective and interventional study was carried out at the orthodontic department of Children's Hospital and Institute of Child Health, Lahore. Twenty patients, (13 Females and 7 Males) were included in the study. Age of these patients ranged from 8-11 years with the mean age of 9.8 years. The inclusion criteria was mixed dentition stage, constricted upper arches with or without bilateral cross bite. Patients with cleft palate or any other congenital deformity were excluded from the study.

Brief history, intra and extra oral examination, cast analysis, Cephalometric analyses were done to evaluate the patients. Intra oral photographs, lateral cephalogram, occlusal radiographs, frontal cephalogram and dental casts were obtained at the start of treatment, at the end of expansion and at the end of retention. Mid line screw of MED was opened, twice a day, with two turns per activation for ten days. After the expansion, the MED was replaced by trans e palatal arch (TPA) with extended arms as a retainer for six months.

LATERAL CEPHALOMETRIC ANALYSIS

Conventional lateral cephalometric radiographs were taken before cementation and after removal of the appliance. To analyze parameters related to the maxillary dental changes, most of the time it is difficult to identify the inclination of the right and left molars and premolars on cephalometric radiographs because of the superimposition of the right side to the left side. To solve this problem, we used 0.7mm size wire markers. These markers were oriented vertically and retained in the acrylic caps, which were made for maxillary first molars, deciduous second molars and deciduous cuspids.

On the right side the tip of the wires were bent mesially into a helix and on the left side the tip of the wires were bent in a distal helix. On the right side the markers were oriented vertically from the mesial and on the left side the wires were oriented vertically from the distal in order to prevent superimposition of these markers on the cephalograms. The markers were cemented temporarily to the first permanent molars, deciduous second molars and deciduous canines on both sides and lateral cephalometric radiographs were taken and analyzed before and after expansion.

The reference plane used in the cephalometric analysis was the sella nasion (S-N) plane. The sella nasion correction due to posture was made at 7° and true horizontal was thus drawn to the patient's existing S-N plane and then true vertical was drawn at right angle to the constructed true horizontal. The sella nasion was registered and superimposed on to the post treatment lateral head film.

The following two cephalometric measurements were recorded:

1. Linear measurements. Fig. 2. The linear measurements were made from the wire markers to the true vertical and true horizontal to assess dental protraction and extrusion of the teeth. Skeletal protraction was recorded by measuring the distance from point A to the true vertical.

   Extrusion of the teeth caused by the appliance was recorded by measuring the distance in millimeters from the true horizontal to the angle formed by intersection of horizontal and vertical arm of the wire markers.

2. Angular measurements Fig. 3. The angular measurements were made at the anterior angle formed by the intersection of the true horizontal and the long axis of the wire markers to evaluate mesial or distal tip of teeth.

FRONTAL CEPHALOMETRIC ANALYSIS

Frontal cephalometric radiographs were taken before cementation and after removal of expansion device with the same wire markers in position to assess degree of buccal inclination of these teeth after active expansion procedure.

MODEL PHOTOCOPIES

Immediately before appliance insertion and at the end of active expansion, standardized occlusal radiographs and maxillary casts were taken, and suture separation and expansion was interpreted from the occlusal radiograph. Measurements were made on the photocopies of study models taken before expansion, on completion of expansion and retention. The following reference points were marked with thin and soft pencil. Fig. 4.

- Cusp tips of deciduous canines.
- Mid central points of second deciduous molar or second permanent premolar.
- Mid central points of first permanent molars.

The marked models were photocopied 1/1 with maximum contrast and teeth touching the glass (Mita DC-1435).

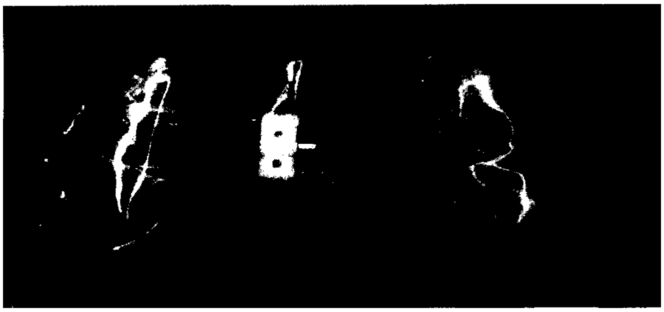

Fig 1. Modified expansion device

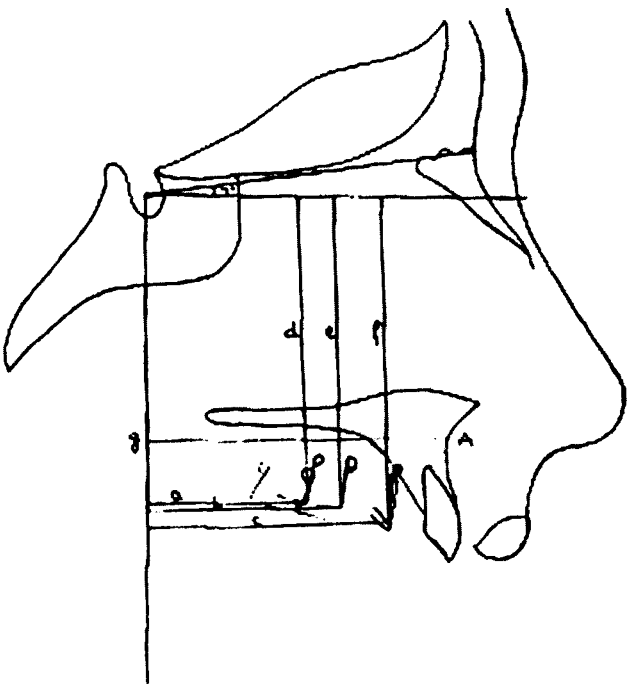

Fig 2. Cephalometric analysis for linear measurements

PARAMETERS USED FOR LINEAR MEASUREMENTS

a)	Distance from the wire marker on right maxillary first molar to true vertical.
b)	Distance from the wire marker on the right maxillary deciduous second molar to true vertical.
c)	Distance from the wire marker on the right maxillary deciduous canine to the true vertical.
d)	Distance from the wire marker on the right maxillary first molar to true horizontal
e)	Distance from the wire marker on the right maxillary second deciduous molar to true horizontal.
f)	Distance from the wire marker on the right maxillary canine to the true horizontal.
g)	Distance from point A to the true vertical

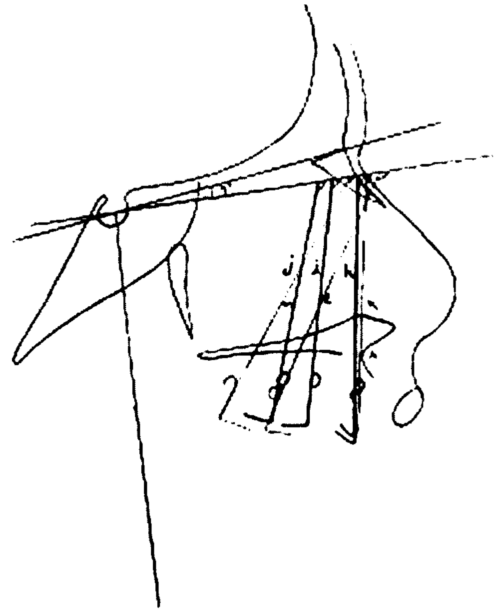

Fig 3. Cephalometric analysis for angular measurements

PARAMETERS USED FOR ANGULAR MEASUREMENTS

h)	Angle between Right deciduous canine and the true horizontal.
i)	Angle between Right deciduous second molar and the true horizontal.
j)	Angle between Right permanent first molar and the true horizontal.
k)	Angle between Left deciduous canine and the true horizontal.
1)	Angle between left deciduous second molar and the true horizontal.
m)	Angle between Left first permanent molar and the true horizontal

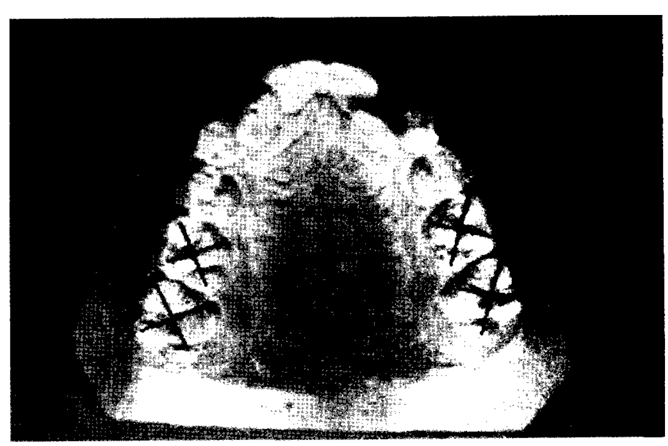

Fig 4. Model photocopy showing mid central points on deciduous second molars and first permanent molars

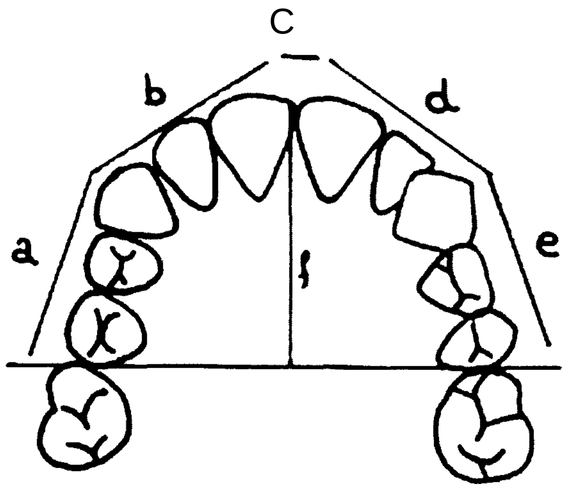

Fig 5. Arch perimeter and arch length

Following measurements were made on the photocopies of the models

- I.C.W (Intercanine width) the distance between cusp tips of the maxillary cuspids.
- I.P.W (Interpremolar width) the distance between mid central point of deciduous second molars or second premolars.
- I.M.W (Intermolar width) the distance between mid central points of first permanent molars.
- D.W (Maxillary diastema width) the distance between the mesial aspects of the maxillary permanent central incisors.

ARCH PERIMETER

The maxillary arch perimeter as calculated from summing the following 5 measurements. Fig. 5.

a. The mesial contact point of the left permanent first molar to the cusp tip of the left canine. Fig. 5, Line (a).

b. The left canine cusp tip to the mesial contact point of the left central incisor. Fig. 5, Line (b).

c. The space between mesial contact points of the central incisors. Fig. 5, Line (c).

d. The mesial contact point ofthe right central incisor to the cusp tip of the right canine. Fig. 5, Line (d).

e. The cusp tip of the right canine to the mesial contact point of the right first molar. Fig. 5, Line (e).

ARCH LENGTH

The distance from a line perpendicular to the mesial surface of the permanent first molars to the central incisors. Fig. 5, Line (f).

Effects of expansion on the lower arch were recorded in the same manner as for the upper arch by making model photocopies.

STATISTICAL ANALYSIS

Kolmogorov-Smirnov test is applied to test the assumption of normality which is necessary to justify before applying t-Test. Values were higher, making the study eligible to apply paired t-Test. Values of Mean, Standard Deviation, Standard Error and Paired t-Test were calculated and analyzed using statistical package of SPSS 10.

VARIABLES

Independent Variables

Intercanine width, Interpremolar width and Intermolar width.

Dependent Variables

Arch Perimeter, Arch Length, Skeletal protraction, Dental Protraction, Mesial and Distal Tipping, Buccal Tipping and Extrusion.

RESULTS

Results were compiled after the completion of the study and the arithmetic mean and standard deviation were calculated for the different variables. Paired t Test was used to evaluate the significance of intragroup treatment changes.

- Model photocopies evaluation showed that there was significant increase in ICW, IPW and IMW after expansion ($P<0.0001$). There was insignificant change in measurements of model photocopies after retention which shows the maintenance of expansion achieved ($P>0.05$). Table 1 (a) and (b).
- Although the lower arch followed the upper arch in expansion but the values were insignificant $P>0.05$.
- Measurement showed significant increase in arch length after expansion, ($P<0.005$) and there was insignificant decrease in this variable after retention, showing that the gain in arch length is almost maintained. Table 2 (a) and (b).
- Skeletal protraction was insignificant after expansion but there was 2mm forward movement of point A after retention, although which was statistically insignificant. Table 2 (b) and (c).
- There was significant increase in arch perimeter after expansion ($P<0.005$) but there was significant decrease in arch perimeter after retention ($P<0.005$) which shows almost complete relapse of this variable. Table 2 (a), (b) and (c).

TABLE 1 (a): INDEPENDENT VARIABLES

Measurements	Pre Expansion (T1)		Post Expansion (T 2)		Difference T2-T1		P.Value	Paird t-Test
	Mean	SD	Mean	SD	Mean	SD		
1CW	29.33	4.36	32.87	4.68	3.54	2.07	0.000	S
IPW	34.95	3.31	39.83	3.17	4.87	2.63	0.000	S
IMW	41.29	3.39	45.62	4.54	4.33	2.14	0.000	S

Measurements from model photocopies at T_1 and T_2.
ICW: Intercanine width
IPW: Interpremolar width
IMW: Intermolar width

TABLE 1(b): INDEPENDENT VARIABLES

Measurements	Post Expansion (12)		Post Retention (T 3)		Difference (T3-T2)		P.Value	Paird t-Test
	Mean	SD	Mean	SD	Mean	SD		
1CW	32.87	4.68	35.62	2.15	2.75	5.27	0.098	NS
IPW	39.83	3.17	40.29	2.86	0.45	5.28	0.769	NS
IMW	45.62	4.54	47.67	3.04	2.04	6.16	0.275	NS

MeasuremeT2s from model photocopies at T_2 and T_3.

TABLE 2 (a): DEPENDENT VARIABLES

Measurements	Pre Expansion (T1)		Post Expansion (T2)		Difference (T2-T1)		P.Value	Paird t-Test
	Mean	SD	Mean	SD	Mean	SD		
Arch Perimeter	76.37	5.11	79.89	5.84	3.52	1.60	0.000	S
Arch Length	29.58	3.05	31.00	3.68	1.41	0.84	0.000	S
Skeletal Protraction	64.41	3.60	64.45	3.85	0.04	0.75	0.851	NS

Measurements at T_1 and T_2.

TABLE 2 (b)

Measurements	Post Expansion (T2)		Post Retention (T3)		Difference (T3-T2)		P.Value	Paird t-Test
	Mean	SD	Mean	SD	Mean	SD		
Arch Perimeter	79.89	5.84	75.83	6.57	-4.06	1.91	0.000	S
Arch Length	31.00	3.68	30.37	3.58	-0.62	1.43	0.159	NS
Skeletal Protraction	64.45	3.85	66.45	4.17	2.00	2.12	0.008	S

Measurements at T_2 and T_3.

TABLE 2 (c)

Measurements	Pre Expansion (T1)		Post Retention (T3)		Difference (T3-T1)		P.Value	Paird t-Test
	Mean	SD	Mean	SD	Mean	SD		
Arch Perimeter	76.37	5.11	75.83	6.57	-0.79	1.42	0.08	NS
Arch Length	29.58	3.05	30.37	3.58	0.54	2.26	0.42	NS
Skeletal Protraction	64.41	3.60	66.45	4.17	2.04	1.98	0.004	S

Measurements at T_1 and T_3.

TABLE 3: CEPHALOMETRIC VARIABLES

Measurements	Pre Expansion (T1)		Post Retention (T3)		Difference		P.Value	Paird t-Test
	Mean	SD	Mean	SD	Mean	SD		
<SNA	79.58	3.14	80.91	4.14	1.33	2.60	0.104	NS
<SNB	75.08	0.82	76.50	5.50	1.41	2.93	0.123	NS
<ANB	4.50	1.78	4.50	2.64	0	1.70	1	NS
<SN-Man line	37.58	6.08	37.66	6.77	0.08	1.83	0.87	NS
<SN-Palatal line	7.95	4.03	8.91	3.89	0.95	3.79	0.4	NS
Sum of Posterior Angles	396	6.75	395	8.00	0.91	7.02	0.66	NS
PFH/TAFH %	62.75	4.68	63.43	4.63	0.68	1.76	0.206	NS
LAFH/TAFH %	58.09	3.04	58.72	2.86	0.63	2.11	0.341	NS
<UI-SN	104.83	6.57	108.00	6.11	3.25	8.24	0.2	NS
<UI-Palatal	107.33	13.88	113.41	8.17	6.08	14.24	0.167	NS
<IMPA	95.08	9.99	94.58	5.97	-0.50	10.82	0.876	NS
<11A	124	11.9	121.4	13.11	-2.58	9.54	0.369	NS
<FMA	32.41	6.68	31.75	7.3	-0.66	4.11	0.586	NS
<MHA	57.83	4.32	58.29	2.64	0.45	4.76	0.745	NS

Level of significance = 0.05
NS (Non-Significant)

- Skeletal protraction was insignificant after expansion but there was 2mm forward movement of point A after retention, which was statistically significant ($P<0.05$) Table 2 (b) and (c).
- Lateral and frontal cephalograms with wire markers were analyzed before and immediately after expansion to see the buccal tipping, mesial and distal tipping, extrusion and dental protraction. The results from these measurements, however, showed insignificant values. ($P>0.05$), demonstrating that undesirable dental movements are almost prevented.
- Pre-expansion and post retention lateral cephalometric measurements without using wire markers were compared to evaluate different cephalometric variables. Results of all of these variables are insignificant. Table 3. So this appliance can be used in almost all kind patients.

DISCUSSION

Malocclusion is a constant source of threat to the facial appearance. Dental crowding and narrow upper arches adversely affect the smile and consequently patient becomes handicapped socially as well as psychologically. Maxillary expansion has been used in resolving the problems of crowding and constricted arches. The objective of maxillary expansion is to widen the maxilla rather than to expand the dental arch by just moving the teeth relative to the bone. The technique of Rapid Maxillary Expansion can play a vital role for adequate transverse expansion. Rapid palatal expansion produces larger forces at the sutural site over a short period of time[2]. These heavy forces maximize skeletal expansion of midpalatal suture before any dental movement or physiological sutural adjustment can occur. However, traumatic separation of the midpalatal suture may induce discomfort and needs more patient or parent cooperation. Slow expansion devices allow more physiological adjustment during sutural separation. This in turn produces greater stability and less relapse potential [3]. The proportion of skeletal and dental movement is dependent on the rate of expansion with rigid expander and age of the patient during treatment [4,5].

According to many investigators, skeletal and dental effects are easy to achieve and relapse is rare when RME is performed in the prepubertal period or during puberty [6-14]. This study agrees with all these reports as the mean age in our sample was 9.8 years.

Adkin, Aras and Surucu, Erverdi, Hass, Memikoglu and Seri, Reed, and Hazar reported significant increase in Inter canine width and Inter molaIIAidth after Rapid maxillary expansion but many others noted increases in Inter molar width after Rapid maxillary expansion6,15-18.

Adkins used splinted hyrax expander on 21 patients with age range of 11.5 years to 17 years[19]. Expansion was done at the rate of 0.5mm /day and then stabilized for 3.5 months. The increase in ICW was (2.9mm), in IPW (6.1mm) and IMW (6.5mm) respectively. An increase of 4.27 mm was observed in arch perimeter whereas the arch length showed a decrease of 2.9 mm. The study suggested that this decrease in arch length might be due to the palatal movement of incisors. The mesial tip of incisors was reported to be due to the elastic recoil of transseptal fibers which generally takes four months. The maxillary central incisors tend to extrude relative to the cranial base and mostly upright or tip lingualy. This movement helps to close diastema and also shortens the arch length.[6, 9].

In the current study, the arch length showed an increase of 1.42 mm, unlike the decrease reported in the earlier studies. The reason for this increase is probably due to the fact that impression was recorded immediately on completion of expansion, before closure of the resultant median diastema. On completion of retention for 6 months, arch length was measured and a slight decrease was calculated which was statistically insignificant and was probably due to elastic recoil.

In this study, expansion attained in the canine, premolar and molar region was 3.54 mm, 4.88 mm and 4.42 mm respectively. Increase intercanine width in our study may be due to the expression of growth spurt because the study was conducted in the mixed dentition stage.

On completion of retention stage (6 months) an increase of 2.75 mm in canine region, 2.04 mm in the molar region and 0.04 mm in the premolar region was found. This may be an affect of some activation induced in the Transpalatal arch with extended arm and partly because of the growth changes as most of the patients were females and it was high time for pubertal growth spurt.

Yine Germanne and Friends described that increase in intercanine width is more effective in gaining arch perimeter than the increase in the intermolar width[20,21].

Toygar in his case report, used rigid acrylic bonded RME appliance very similar to MED, in a 13 year old girl with (GoGn-SN=37) and concluded that the rigid acrylic bonded RME prevented upper molar extrusion and provided more parallel expansion, with less tipping of the posterior teeth, than could have been achieved with conventional banded expanders[22]. During expansion, there was little change in vertical dimension with only a slight posterior rotation of the mandible. He used the same appliance for retention purpose.

In this study the extrusion and buccal tipping of the teeth produced in the MED appliance was found negligible. These variables were measured with the use of wire markers used on deciduous canine, second premolar or deciduous second molar and the first permanent molar before and after expansion. The measurements were recorded by taking lateral and frontal cephalograms. 1.14° buccal tipping was measured in molars, 0.72° in premolars and 0.89° in the canines which are clinically and statistically non significant. These angles were calculated between midsagittal plane and wire markers on tracing of pre and post frontal cephalogram.

Extrusion of the teeth involved in the study was measured as a linear distance from the true horizontal to the line angle of the wire markers and the values found were 0.44mm in molars, 0.33mm in premolars and 0.73mm in canines, respectively.

Mesial tipping was more marked after RME with MED than the distal tip, and is suggestive of dental proclination followed by RME and consequent increase in the arch length. It is difficult to comment about this variable because insufficient details are available in the literature.

Dental protraction was also measured from the wire markers on teeth to the true vertical but it was not significant (mean= 0.65mm).

Various cephalometric variables were measured before expansion and after retention without using wire markers and the results of all of these variables were found to be insignificant. These insignificant differences in the variables of the vertical dimension suggest the use of this appliance with rapid palatal expansion in all types of faces, particularly those with high angle tendencies.

It is evident from the results that with the use of acrylic bonded MED, extrusion and buccal tipping, that were considered as the dependent variables were found clinically and statistically insignificant.

Many studies have concluded that maxilla moves forward and downward with RME[7,8,27]. But there are many other studies that report of opposite findings[9,13,28.29]. According to Carreno and Menendez, Bishara and Slatey the final position of the upper jaw is unpredictable[1]0

Wertz found, return of point A to its initial position in 50 % of cases after three months of retention [9]. Paloma found no change in anteroposterior position of the maxilla three years following treatment"'.

In this study, 2 mm of maxillary protraction was observed after six months of retention. This may be due to the cumulative effect of growth as well as expansion. The result of this variable suggests that a further study should be conducted with a control, to determine the contribution of growth in the advancement of point A.

During the course of this study some of the complications were also observed. These included mild inflammation of the palatal mucosa during the expansion phase, loosening of the appliances during expansion and maintenance phase. In one patient, there was moderate inflammation of the palatal mucosa which healed on removal of appliance at the end of expansion phase.

CONCLUSIONS

The modified expansion device was given as phase-1 treatment modality in patients who were in their mixed dentition stage. Successful results were seen by the use of this device.

1. MED being rigid and fixed produced significant expansion at the midpalatal suture.
2. The appliance produced protraction of the maxilla.
3. The device being fixed, involves minimal degree of patient compliance.
4. The appliance being cost effective and easy to fabricate, can be used as a substitute for Hyrax or Haas expanders.

A further study is suggested with control to note the contribution of growth in advancement of point A.

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