Effects of Combined Rapid Maxillary Expansion and Facemask Therapy on the Mandibular Dental Arch in Mixed Dentition

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Objective: *The aim of this study was to evaluate changes in the mandibular dental arch and incisor alignment induced by combined bonded Rapid Maxillary Expansion (RME) and Face Mask (FM) therapy in the mixed dentition stage in which leeway space was used throughout the treatment.* ***Study Design:*** *This retrospective study evaluates pretreatment (T0) and posttreatment (T1) cephalometric radiographs and orthodontic models of 25 patients (mean age: 10.75±2.64), in mixed dentition, having skeletal Class 3 anomaly (ANB<0) with maxillary retrognatism (SNA=77.2±0.68) and bilateral posterior crossbite treated with bonded Hyrax RME-FM. Mean treatment duration was 10.4 months. Dental model measurements were performed using the 3Shape OrthoAnalyzer™ 2013-1 program. Changes in the mandibular incisor and first molar positions were determined on cephalometric radiographs. Statistical evaluation was done with a paired t-test.* ***Results:*** *A significant increase of 1.2 mm was found in intermolar width (p<0.001) in the mandibular dental arch. There was a significant decrease (1.4 mm) (p<0.001) in arch depth and an increase in arch length discrepancy (1.7mm)(p<0.01). There was a significant increase (0.8mm) (p<0.05) in the incisors' irregularity score (LII). IMPA showed a significant decrease (p<0.05).* ***Conclusion:*** *Clinicians should be aware that mandibular crowding tends to increase during this type of combined therapy.*

Keywords: *Angle Class III, crowding, reverse headgear, dental arch length, dental arch depth*

INTRODUCTION

Combined rapid maxillary expansion (RME) and facemask (FM) therapy are the most preferred treatment protocols for patients who have Class III malocclusion with maxillary transverse and sagittal deficiencies.[1-6] The effects of RME and FM therapy alone[7-13] and in combination[3-6] were studied.

In the studies evaluating the effect of RME-FM, anterior movement of both maxilla and maxillary dentoalveolar structures were observed with the mandible showing posterior rotation.[3-6,14] However, few studies have evaluated dentoalveolar changes, including changes in arch depth and length, induced by combined RME and FM therapy.[3,4,15-17] These limited studies mostly assessed the maxillary dental arch rather than mandibular arch.[15,16] When studies on the effects of RME-FM on the mandibular dental arch were evaluated, their main focus was the changes in the sagittal position of incisors, and their results mainly indicated lingual tipping.

Maxillary protraction with or without RME is predominantly used in transitional dentiton.[18-20] During this stage, a certain amount of shortening in the mandibular arch length occurs due to the loss of leeway space and a slight uprighting of the incisors.[21] Together with these physiological changes, lingual tipping of the mandibular incisors due to FM may cause incisor crowding or exacerbate an existing problem.

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In a previous study that evaluated the effect of RME-FM therapy in permanent dentition, a significant increase in mandibular incisor crowding was reported.[22] However, to our knowledge there is no study that considers the result of this combined treatment on the mandibular dental arch, especially on mandibular incisor alignment during mixed dentition with the leeway space.

Gaining further knowledge about the extent of the potential incisor crowding will help deciding whether preventive precautions should be taken during the treatment process. So, being aware of changes in the dentoalveolar arch as well as skeletal changes can be helpful in taking a more appropriate approach to orthopaedic and orthodontic treatment.

The aim of this retrospective study was to evaluate changes in the mandibular dental arch and incisor alignment induced by combined bonded RME and FM therapy in the mixed dentition stage in which leeway space was used throughout. The hypothesis tested was that combined RME and FM therapy causes arch length loss and increases incisor crowding in the mandibular dental arch during the mixed dentition stage.

MATERIALS AND METHOD

In this retrospective study, in order to access the orthodontic department's archives, approval was obtained from the Ethical Committee of the University (77082166-604.01.02). Sample size was determined by the G-Power 3.1.9.2 program (Düsseldorf University, Düsseldorf, Germany). It was calculated according to the results of a previous study[23] in which the mean change of 0.54 mm in Little's irregularity index with 0.43 mm standard deviation was found to be statistically significant. Although a minimum sample size of 21 patients at α=0.05 yields a statistical power of 80%, the sample size was increased to 25 patients, which in turn, increases this statistical power.

Clinical records, pretreatment (T1) and posttreatment (T2) lateral cephalograms and dental casts of 25 children (17 girls and 8 boys) with a mean age of 10.75±2 who were treated with combined application of bonded Hyrax RME and FM and who met the following inclusion criteria were used in the study: (1) a mixed dentition stage in which mandibular second deciduous molars were lost throughout the treatment, (2) permanent mandibular canines present at T1, (3) skeletal Class III (ANB<0) with maxillary retrognatism (SNA=77.2 ± 0.68), (4) bilateral posterior crossbite, and (5) Go-Gn to SN angle between 26° and 37° (Go-Gn=31.6 ± 2.6). Patients with missing/supernumerary teeth, congenital anomalies, craniofacial deformities, and a history of previous orthodontic treatment were not included.

This study used a modified Hyrax appliance with an acrylic cap splint, which is in contact with all existing mandibular teeth. The appliance was activated once a day (0.25 mm per activation). Expansion continued until maxillary 1. molars' palatal cusps were in contact with buccal cusps of mandibular 1. molars. The appliance was used as the intraoral part of a Petit FM. Protraction hooks were placed between the deciduous canine and first premolar, and a protraction force of 350-400 g per side was used with an antero-inferior force vector of 20°-30° to the occlusal plane. Patients were instructed to wear the FM for at least 16 hours each day. Treatment was terminated when a positive overjet was achieved. The mean duration of RME and FM combination therapy was 10.4±3.7 months.

All pre- and posttreatment dental casts were digitized by R700 scanner (3Shape Trios A/D, Copenhagen, Denmark) and 3D images obtained. Nine measurements were done on the digital models with 3Shape Ortho Analyzer™ 2013-1 (Copenhagen, Denmark) software program (Figure 1).

On pre- and posttreatment cephalograms IMPA was measured. Subsequently, the mandible tracings were superimposed on the natural reference structures as described by Björk and Skieller.[24] On superimpositions, two linear parameters defining the sagittal movement of incisors and first molars were measured directly on millimetric grid paper with reference to the Go-Gn line (Figure 2). The 8% magnification of the cephalograms that may have affected the measurements was disregarded.

All measurements were done by the same orthodontist. To analyze the intra-observer repeatability, 15 digital models and lateral cephalograms were selected randomly, and both the tracing and measurements were repeated after a 2-week interval.

Figure 1: 3D dental models and the measurements; a) inter-molar width, b) inter-canine width, c) arch depth, d) arch length, e) measurements for Little's irregularity index[31]

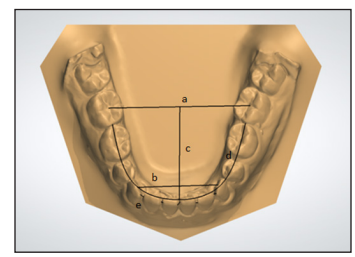
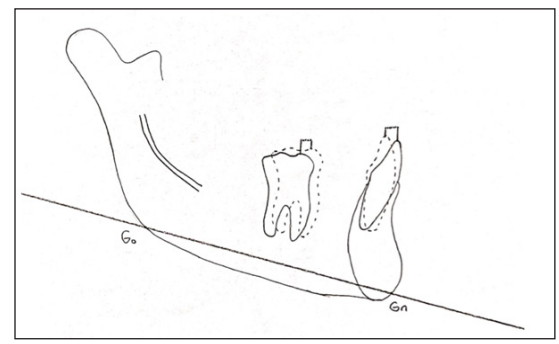


Figure 2: Measurements of mandibular molar and incisor's sagittal movements on mandibular superimpositions.



Statistical Analysis

Intra-observer repeatability analysis was performed on a set of 15 digital models and lateral cephalograms randomly chosen and assessed at two different points in time. The intraclass correlation coefficient (ICC) was used for the analysis. All statistical analyses were performed using SPSS-15 (15.0, Chicago, IL, USA). The data were tested for normality using the Shapiro-Wilk test. Because the data were normally distributed, paired t-tests were used to evaluate the significance of differences between T1 and T2. A p-value of <0.05 was considered statistically significant.

RESULTS

ICCs for the intra-observer repeatability were excellent: between 0.89 and 0.98 with a mean of 0.92.

The statistical evaluation of the measurements on 3D dental models and IMPA can be found in Table 1. In the upper dental arch, intermolar and intercanine widths increased significantly by 3.8 and 3.2 mm, respectively ($p<0.001$), and arch depth decreased significantly by 1.2 mm ($p<0.001$).

In the mandibular dental arch, there was a significant increase in the intermolar width (1.2 mm, $p<0.001$) while intercanine width showed no significant difference between T1 and T2 (0.5 mm, $p>0.05$). Arch depth and arch length decreased significantly by 1.4 and 1.7 mm, respectively ($p<0.001$). LII and arch discrepancy significantly increased by 0.83 mm ($p<0.5$) and 1.7 mm ($p<0.001$), respectively. There was a significant decrease in IMPA from T1 to T2 (2.1°, $p<0.05$).

Mandibular superimposition revealed a mean molar mesialization of 1.4 mm (±1.05) and a retraction of 1.1 mm (±1.19).

DISCUSSION

Even though spontaneous mandibular response after palatal expansion[25-29] and lingual tipping of mandibular incisors with RME+facemask treatment has been reported in several studies,[5,13] the combined effects of these two alterations on mandibular arch length discrepancy have not been addressed in any published studies. Given the fact that maxillary protraction is most effective in the full primary or early transitional dentition,[18-19] predicting its effects on the developing dentition, and taking preventive measures is crucial. This study is the first to evaluate the changes in mandibular dental arch and anterior crowding due to the combined application of RME and FM in mixed dentition with a study sample in which mandibular leeway space was used throughout the treatment.

In the present study, statistically significant increases were observed in maxillary intermolar and intercanine widths (3.8 mm and 3.2 mm, respectively). These values were much lower than the ones reported in other studies on the use of RPE in the mixed dentition.[29-33] While considering maxillary expansion values in previous studies that evaluated combined use of RME and FM, the results of the present study were in accordance with Uzuner *et al* [15] and Lione *et al* [16]

In this study, mandibular intermolar width increased significantly (1.2 mm, $p<0.001$) whereas intercanine width increased slightly; however, this increase was not statistically significant (0.5mm, $p>0.05$). The increase in molar width might be attributed to the lowered position of the tongue due to the palatal position of the RME appliances.[10] While Ngan *et al* [17] attributed this change to the altered forces of occlusion, in previous studies that evaluated spontaneous mandibular arch changes after rapid maxillary expansion in the mixed dentition, varying increases in arch widths were reported. Lima *et al* [29] reported 1.47 mm of intermolar and 0.39 mm of intercanine width increases. Despite the fact that their measurement method was different and that their study sample consisted of Class I patients, the results were similar to ours.

In the study Geran *et al* ,[33] mean increases in the intermolar and intercanine widths were 1.7 mm and 1.5 mm. Although RME appliance, activation protocol, and reference points used for measurements were similar to the present study, in Geran *et al* ,[33] at T1, subjects were in early mixed dentition, only some of them had a posterior crossbite, and T2 measurements were obtained after the fixed appliance therapy. In the only available study on the effects of RME and the maxillary protraction combination on mandibular dental arch width, Ngan *et al* [17] reported a 2.28 mm and 0.62 mm increase in mandibular intermolar and intercanine widths, respectively, after six months of treatment. As stated in the previous paragraphs, differences in measurement method, treatment duration, and study sample characteristics might have contributed to different results.

In the present study, both a significant decrease in IMPA (2.1°; $p<0.05$) and a 1.1 mm retraction of incisors measured on cephalometric superimpositions indicated lingual tipping of mandibular incisors probably due to the positioning of the chin-cup part of the FM. Physiological uprighting of the incisors during the transitional dentition stage may have also contributed to this but was considered less likely, as the treatment duration was only 10.5 months. Although the result of this study was in accordance with several previous studies[14,17,34-36] it conflicted with Williams *et al* ,[37] which reported no significant change in the sagittal position of mandibular incisors and in another, Nartallo-Turley and Turley,[38] which reported 0.33 mm forward movement. Conflicting results between our study's findings with those of the aforementioned studies may be due to the fact that patients were in different stages of dentition. In these two studies patients with deciduous dentition were included in the study groups.

Moorrees[39] stated that the mandibular dental arch could shorten 2-3 mm during the transition from primary to permanent dentition, and according to Bishara[40] mandibular arch length decreased significantly (2.4-3.2 mm) between 8 and 13 years. In accordance with these studies, our study finds 1.4 mm mesialization of mandibular first molars, most likely due to the exfoliation of the second primary molars and their replacement with the smaller second premolars, led to significant decreases in both arch length and arch depth. Changes in the incisor positions could have also contributed to this. Ngan *et al* 's[17] findings supported our results, reporting a significant decrease in lower arch perimeter during RME-FM treatment.

Changes in the incisors' positon and a decrease in the arch depth resulted in a significant increase of 1.7 mm in the arch length discrepancy. Additionally, the former led to a 0.8 mm increase in LII. In a previous study considering the RME-FM combined therapy in permanent dentition, the LII increase was reported as 1.46 mm, which was a bigger increase than our study reported.[22] The development of anterior misalignment in the current study seems to be less than it was in permanent dentition, which might be due to the use of the leeway space reserves in the mixed dentition stage.

According to a mathematical model developed by Germane *et al* ,[41] a 1 mm increase in the lower intermolar distance creates a gain of 0.27 mm in arch perimeter (arch perimeter in Germane *et al* 's study corresponds to the arch length in the present study) and the combination of 1 mm intermolar and 1 mm intercanine distance resulted in an increase of 0.93 mm in perimeter. With reference to Germane *et al* 's study, 1.2 mm and 0.5 mm intermolar and intercanine width increases found in the present study would improve arch length by less than 0.93mm. This amount of arch length gain can be considered insufficient to solve an arch length problem that would occur as an unwanted but anticipated effect of FM in patients with no arch

length deficiency before treatment. In a like manner, any existing incisor crowding or arch length deficiency will likely increase.

One limitation of this study was the lack of a control group due to ethical reasons that made it impossible to differentiate treatment effects from normal growth. To overcome this problem, growth data from previous studies were used.

The results of this study confirm the hypothesis that RME and FM cause significant changes in the mandibular dental arch and increase the arch length discrepancy, especially incisor crowding. As increasing space in the mandibular arch with incisor protrusion is not an option in Class III patients, maintaining the leeway space should be a part of the treatment plan, especially if there is an already existing arch length deficiency.

CONCLUSIONS

During RME-FM therapy, although statistically significant increase in the mandibular intermolar width is achieved, the resultant arch length increase is not sufficient to overcome the effects of a tooth size–arch length discrepancy that increased as a result of molar mesialization and incisor retraction. Therefore, clinicians should be conscious of the tendency toward increases in mandibular arch length discrepancy and anterior crowding during this type of combined therapy. Clinicians should consider maintaining leeway space with a lingual arch in late mixed dentition stage, also expanding the mandibular arch with a Schwarz or bi-helix appliance if patients are in early mixed dentition and mandibular primary canines are present.

Conflicts of interest

None to declare

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