An alternative treatment approach for patients with resistant otitis media with effusion and dysfunctional Eustachian tube: A pilot study with rapid maxillary expansion

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ABSTRACT

Objectives: To determine whether dysfunctional Eustachian tubes of children with resistant otitis media with effusion (OME), ventilation tube placement indication, and maxillary constriction will recover after rapid maxillary expansion (RME).

Materials and Methods: The RME group consisted of 15 children (mean age: 10.07 years) with maxillary constriction, Eustachian tube dysfunction (ETD), and resistant OME. The control group consisted of 11 healthy children (mean age: 8.34 years) with no orthodontic and/or rhinologic problems. Recovery of Eustachian tube dysfunction was evaluated by Williams’ test at three timepoints: before RME/at baseline (T0); after RME (T1); and after an observation period of 10 months (T2). The control group was matched to all these periods, except T1.

Results: In the control group, functioning Eustachian tubes were observed in all ears at baseline (T0), and tubes showed no worsening and no change during the observation period (T2) \((P > .05)\). In the RME group, functioning Eustachian tubes were observed in eight of 30 ears and ETD was observed in the remaining 22 ears at baseline (T0). The RME group showed significant improvements in tube functions after RME and the observation period \((P < .05)\). Fifteen of 22 dysfunctional ears recovered (68.2%) and started to exhibit normal Eustachian tube function after RME (T1) and the observation period (T2).

Conclusions: The findings suggest that ears having poorly functioning Eustachian tubes are restored and recovered after RME in most of children with maxillary constriction and resistant OME. Thus, RME should be preferred as a first therapy alternative for children with maxillary constriction and serous otitis media. (Angle Orthod. 2021;91:772–777.)

KEY WORDS: Rapid maxillary expansion; Eustachian tube; Otitis media with effusion

INTRODUCTION

Otitis media with effusion (OME) is defined as the presence of fluid in the middle ear without signs or symptoms of acute ear infection.\(^1\) OME is responsible for thousands of medical office visits each year and it is one of the most frequent conditions encountered in ear, nose, and throat clinics. About 80% of preschool children have experienced OME.\(^2\) The exact etiology of OME is uncertain, but it may result from several factors. The most likely explanations regarding the pathophysiology of OME seem to include Eustachian tube dysfunction as playing a major role for development of OME.\(^3\)

“Watchful waiting” has been recommended as the first line of treatment of OME.\(^2\) The second treatment option is prescription of medicine including antihistamines, decongestants, steroids, or antibiotics. The last treatment option may be surgery for insertion of a ventilation tube.\(^1,3\)

RME is a well-established technique for the correction of transverse discrepancies of the maxillary arch and it has been accepted as an effective treatment method in patients exhibiting transverse maxillary...
deficiency, posterior crossbites, and rhinologic and/or respiratory problems. The rationale for use of an RME appliance is approximately the same as for insertion of a ventilation tube for treatment of Eustachian tube dysfunction. Rapid maxillary expansion (RME) can stretch the tubal dilator muscles: tensor and levator veli palatini muscles. The stretched tubal dilator muscles open the pharyngeal orifice of the Eustachian tube and can recover Eustachian tube function. However, no previous study has evaluated the possible effects of RME on Eustachian tube function and tympanometric output in children with resistant OME in whom ventilation tube placement was indicated. Thus, this study aimed to determine whether dysfunctional Eustachian tubes of children with resistant OME, ventilation tube placement indications, and maxillary constriction would recover after RME.

**MATERIALS AND METHODS**

**Study Design**

This prospective study was a secondary outcome analysis based on a previous prospective study. Briefly, a sample of 26 children aged between 5 and 15 years old were enrolled in this study. This study was approved by the Ethics committee of Atatürk University, Faculty of Dentistry, and informed consent was obtained from the legal parents of each participant at the beginning of the study.

The sample size was computed with a power analysis. The sample size estimation was based on the assumption that 84% of dysfunctional ears would recover after RME (null hypothesis proportion, $p_0$) and 50% of dysfunctional ears would recover by spontaneous resolution during 3 months of watchful waiting (true proportion, $p$). To achieve 80% power with a significance level of .05, the minimum required number of dysfunctional ears was 18. To increase the power of the study and to compensate for possible dropouts during the study period, more patients with dysfunctional ears were included.

**Patients**

The RME group consisted of 15 children (mean age: 10.07 ± 2.72 years). All patients had maxillary constriction, Eustachian tube dysfunction, and resistant OME in one or both ears. To be included in the RME group, patients must have met the following criteria: (1) maxillary constriction, (2) deep palatal vault, (3) bilateral cross bite, (4) conductive hearing loss, (5) resistant OME lasting at least 3 months, (6) Eustachian tube dysfunction (ETD), (7) intact tympanic membrane with non-perforated eardrums, and (8) indication for ventilation tube placement. Patients were excluded as if they had previous adenectomy operation history, recurrent upper respiratory tract infections, perforated eardrums, allergy, chronic rhinitis, and cleft lip and palate, congenital or developmental deformity, and systemic disorder.

Using pneumatic otoscopy, if patients had a retracted tympanic membrane, they were diagnosed as having ETD. Sade’s and Ar’s four-grade classification system was used to grade retraction of the pars tensa:

Grade I: Slight retraction of the tympanic membrane (TM) over the annulus
Grade II: Severe retraction; TM touches the long process of the incus
Grade III: Atelectasis; TM touches the promontorium
Grade IV: Adhesive otitis; TM is adherent to the promontorium

Twenty-two dysfunctional ears of the children were included in this study.

The control group consisted of 11 children (nine females, two males) aged between 5 and 13 years with a mean age of 8.34 ± 2.46 years. All subjects in this group had no orthodontic nor rhinologic problems, congenital or developmental deformities, or systemic disorders.

The audiometric data obtained in the RME and control groups was published previously in a comparative study that included RME, control, and ventilation tube groups.

**RME Procedure**

The design and use of RME appliances used in the current study was described in the previous study. Patients were instructed to activate expansion screw two quarter turns (morning, evening) per day until adequate expansion was accomplished. After completion of adequate maxillary expansion, RME appliances were used as a retainer for 4 months. After this retention phase, patients stopped wearing all appliances and conventional orthodontic fixed appliance treatment was initiated for all subjects in the RME group. The patients in the RME group received no treatment for OME during the RME and observation periods.

**Tympanometry (Eustachian Tube Function Test)**

A Eustachian tube function test (Williams’ test) was carried out by using an impedance audiometer (AT235h middle ear analyzer, Interacoustics A/S, Assens, Denmark) under standard conditions in a quiet room. According to the manufacturer of this device, this model may be used to perform Eustachian tube function tests for non-perforated and perforated eardrums, so-called Williams’ and Toynbee tests.
respectively. In the current study, the Williams test was performed in all subjects having intact tympanic membrane with non-perforated eardrums (Figure 1). The same audiologist carried out all tympanometry tests. The applied pressure varied: -300 to -600 daPa.

In the Williams’ test, the impedance audiometer tested Eustachian tube function and middle ear pressure under three conditions:

1. The first test was used to obtain ambient pressure and normal tympanometric curve.
2. The second test was used to obtain decreased middle ear pressure during swallowing while closing the nose with two fingers.
3. The third test was used to make the patient increase middle ear pressure during the Valsalva procedure, which included softly blowing with the mouth and nose closed.

With these tests, three tympanometric sweeps were traced on the screen of the impedance audiometer device. A change in peak pressure graphically indicated different function of the Eustachian tube. Ears with dysfunctional Eustachian tubes showed the same three peak pressures, indicating temporary or permanent dysfunction of the Eustachian tube. Dysfunctional ears (Eustachian tubes) were rated as zero (“0”; no function), and functioning ears were rated as “1” for statistical analysis. Eustachian tube function was evaluated by Williams’ test at three timepoints: before RME (T0); after RME (T1); and after an observation period of 10 months (T2). The control group was matched to T0 and T2.

**Statistical Analysis**

All statistical analyses were carried out using SPSS 17.0 (IBM Corporation, Armonk, NY, USA). Mean ages of the groups were compared using Independent sample t-test. Intragroup comparisons were carried out using the Wilcoxon signed-rank test in both groups.

**RESULTS**

No statistically significant difference was found between the groups in terms of age ($P > .05$) (Table 1). The number of ears and subjects with Eustachian tube dysfunction or functioning Eustachian tubes at T0, T1, and T2 in each group are shown in Tables 2 and 3, respectively. Statistical results of between and within group comparisons are shown in Table 2.

In the control group, functioning Eustachian tubes were observed in all ears at baseline (T0) and the tubes showed no worsening and no change during the observation period (T2) ($P > .05$) (Table 2). In the RME group, functioning Eustachian tubes were observed in eight of 30 ears and Eustachian tube dysfunction was observed in the remaining 22 ears at baseline (T0). The RME group showed significant improvements in tube function after the RME and observation periods ($P < .05$) (Table 2).

Eustachian tube dysfunction was unchanged in seven of 22 dysfunctional ears (31.8%) after RME (T1). Grade 4 was registered in six of the seven dysfunctional ears and Grade 3 was found in one of the seven. However, the remaining 15 of 22 (68.2%) dysfunctional ears recovered and started to exhibit normal Eustachian tube function after RME (T1). Among the ears recovered, Grade 1 was in eight ears and Grade 2 was in seven ears.

During the observation period, Eustachian tube dysfunction reappeared in two ears that exhibited normal Eustachian tube function after RME, but the tube recovered in another two ears, which showed Eustachian tube dysfunction at baseline and after RME. Finally, 15 of 22 (68.2%) dysfunctional ears recovered and exhibited normal Eustachian tube function after the observation period (T2) (Tables 2 and 3).

**DISCUSSION**

OMC, the accumulation of fluid in the middle ear, is characterized by Eustachian tube dysfunction. Medical...
practitioners have been particularly concerned when fluid persists for a relatively long period of time, for example, 3 months or more and when the problem reduces hearing, because it may result in functional limitations and have long-term sequelae.

Eustachian tube dysfunction is an inability of the Eustachian tube to perform adequately in at least one of its three physiologic functions: pressure regulation, clearance drainage of secretions out of the Eustachian tube, and protection of the middle ear from nasopharyngeal secretions.\(^1\) Testing Eustachian tube function for functional assessment of the tube using impedance audiometry is an exact and useful technique for patients with perforated and non-perforated ear drums.\(^9\)

In the current study, the Williams' test was performed in all subjects that had intact tympanic membranes with non-perforated eardrums. In the Williams' test, the impedance audimeter automatically measured the middle ear pressure under three conditions. When the Eustachian tube functions properly, these three tests should meet the following conditions: (1) The first test was to obtain ambient pressure at or near the environmental pressure, that is, atmospheric air pressure showing "0" daPA and normal tympanometric curve. (2) The second was used to test the patency of the Eustachian tube in which swallowing induced decreased pressure in the middle ear, which normally should result in negative middle ear pressure. (3) The third test, Valsalva maneuver, was used to test patency of the Eustachian tube, which included softly blowing with the mouth and nose closed; under normal conditions, this test should result in positive middle-ear pressure.\(^1,10\) Any deviations from these conditions indicated complete or partial impairment of Eustachian tube function.

There are a number of treatment options to improve Eustachian tube function, but there is limited consensus about management of tube function. In this study, RME was used to treat impaired Eustachian tube function and resistant otitis media without any drug prescription or surgical intervention (that is, ventilation tube placement).

It would have been preferable to have a control group with maxillary constriction and Eustachian tube dysfunction and concomitant resistant OME without treatment or a group with just resistant OME without maxillary constriction and no treatment. In this way, spontaneous resolution of OME could also have been compared or taken into account. Ethical considerations did not allow postponement of treatment for patients with OME with or without maxillary constriction for scientific purposes, and subjects without orthodontic and/or rhinologic problems formed the control group.

Results of the current study showed that Eustachian tube dysfunction was observed in 22 of 30 ears in the RME group at baseline. Eustachian tube dysfunction was unchanged in seven of 22 dysfunctional ears (31.8%) after RME. However, the remaining 15 of 22 (68.2%) dysfunctional ears recovered and had functioning Eustachian tubes after RME and remained healed during the observation period of 10 months. These results suggested that the ears having poor tube function were restored and the tube recovered after RME in most of the children. This improvement remained relatively stable during the 10-month obser-

<table>
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<th>Group</th>
<th>N</th>
<th>Functioning Eustachian Tube</th>
<th>Eustachian Tube Dysfunction</th>
<th>Functioning Eustachian Tube</th>
<th>Eustachian Tube Dysfunction</th>
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<tr>
<td>RME 15 patients</td>
<td>0 (0%)</td>
<td>15 (100%)</td>
<td>4 (26.7%)</td>
<td>10 (66.7%)</td>
<td>5 (33.3%)</td>
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<tr>
<td>Control 11 patients</td>
<td>11 (100%)</td>
<td>0 (0%)</td>
<td>11 (100%)</td>
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vation period. On the other hand, Eustachian tube dysfunction was not fully recovered in the remaining seven ears after the observation period, but none of them underwent medical treatment (that is, surgical treatment, ventilation tube placement surgery).

The results of some clinical studies11 that assessed effects of RME on otitis media and Eustachian tube dysfunction of patients with maxillary constriction supported the findings of the current study. Other clinical studies reported significant improvements in Eustachian tube function and release of otitis media after RME.7 De Stefano et al.7 applied RME to 27 children with a mean age of 7 years suffering from recurrent otitis media in 54 ears with Eustachian tube dysfunction and adenoid hypertrophy, and they assessed the changes after RME and a retention period of 6 months. They reported approximately 83% (45/54 ears) improvement in Eustachian tube function, types of tympanograms, and middle ear pressure after RME, which indicated release of recurrent otitis media in most of the patients.

On the other hand, the findings of the present study were partially, but not completely, in disagreement with the findings of other studies.8,12 Micheletti et al.12 evaluated the effects of RME on middle ear function in 18 patients without otitis media, and found Type A normal tympanograms in all patients after 1 year follow-up. A short-term study was executed by Villano et al.8 on 25 children with a mean age of 7.24 years who had recurrent serous otitis media and abnormal tympanometric records (Type B or C), and they found normal tympanometric models (Type A), free of serous secretions at the entrance of the tube, in all patients after maxillary expansion. Their results indicated full recovery of Eustachian tube function in all patients.

These partial disagreements may have resulted from different patient selection criteria, types of otitis media, age of the subjects (that is, younger patients in other studies), and Eustachian tube function tests. The most striking difference of the present study from the others2,8,12 was that all of the patients in the RME group had resistant OME requiring ventilation tube placement. Another major difference of the present study was that Williams' test was used for assessing Eustachian tube function under three important conditions.

Villano et al.8 studied subjects with recurrent serous otitis media that were not drug resistant. However, the sample in the current study was composed of cases with drug resistant OME. In addition, all these authors8,12 tested only ambient pressure in the middle ear, but Eustachian tube function tests including three conditions were used in the current study.

In the current study, Eustachian tube dysfunction reappeared in only one ear of two patients during the observation period. Holm-Jensen et al.10 found that seasonal factors produced great variations in tympanometric conditions. This reappearance of tube dysfunction may be temporary in nature and it may result from seasonal factors such as upper airway infections, allergies, etc.

Findings of the current study might be explicable when dentomaxillofacial and surrounding soft tissue effects of RME are considered. The effects of RME were not limited to upper jaw because the maxilla is associated with 10 bones of the face by sutural connection.13 Thus, RME caused not only dentofacial, but also craniofacial, changes.14 These orthopedic changes could produce a new environment, not only promoting oro-nasal-pharyngeal function, but also normal Eustachian tube function.

The middle ear is part of a functional system composed of the nasopharynx, Eustachian tube anteriorly, and mastoid air cells posteriorly.1 Rapid expansion of the hard and soft tissues of the maxillary halves in opposite directions can potentially stretch the tubal dilators: tensor and levator veli palatini muscles due to the close anatomic relationships between them. This can cause normal functioning of the pharyngeal orifice of the Eustachian tube and improvement in Eustachian tube function15 since the tensor veli palatini (TVP) and levator veli palatini (LVP) muscles originate at or near the pharyngeal orifice of the Eustachian tube and end in the soft palate.16

The medial portion of the TVP muscle mainly accomplishes active opening of the Eustachian tube, and the LVP muscle may help to dilate the most anterior part of the tube.1 The relationship between the TVP muscle and middle ear aeration and tubal function was shown by several types of surgical alterations of this muscle.17

It has been well documented that RME widens the nasal airway dimensions.11 This widening will result in not only an improvement of nasal air flow and natural physiological function, but also a decrease in upper respiratory infections, nasal allergy, respiratory morbidity, otitis media,18 and the pathogenic aerobic and facultative anaerobic microflora in the oropharynx.19 These oro-rhinologic problems may be a causative factor for development of Eustachian tube dysfunction.15

This study had some limitations. First, sample size was limited with respect to the generalization of the findings. In the current study, the calculation of sample size based on the tympanometric data determined that 18 dysfunctional ears were needed for testing and the study was conducted on 22 dysfunctional ears. Therefore, due to this small sample size, this investigation should be considered a pilot study and findings should be confirmed in a larger group of children.
CONCLUSIONS

- Ears having poorly functioning Eustachian tubes were restored after RME in most of the children with maxillary constriction and resistant OME. Thus, RME should be preferred as a first therapy alternative for children with maxillary constriction and OME.

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REFERENCES