International Journal of Pediatric Otorhinolaryngology 105 (2018) 138–145

Contents lists available at ScienceDirect

International Journal of Pediatric Otorhinolaryngology

journal homepage: www.elsevier.com/locate/ijporl

Review Article

Effects of maxillary protraction appliances on airway dimensions in growing class III maxillary retrognathic patients: A systematic review and meta-analysis

Ye Ming[a,b,c], Yun Hu[a,b,c], Yuyue Li[a,b,c], Jinfeng Yu[a,b,c], Haojue He[a,b,c], Leilei Zheng[a,b,c,*]

[a] The Affiliated Stomatology Hospital, Chongqing Medical University, Chongqing, 401147, China
[b] Chongqing Key Laboratory of Oral Diseases and Biomedical Sciences, Chongqing, 401147, China
[c] Chongqing Municipal Key Laboratory of Oral Biomedical Engineering of Higher Education, Chongqing, 401147, China

ARTICLE INFO

Keywords:
Maxillary protraction appliances
Airway
Growing patients
Maxillary retrusion
Systematic review
Meta-analysis

ABSTRACT

Objectives: The purpose of this study was to assess, through a systematic review and meta-analysis, the efficacy of maxillary protraction appliances (MPAs) on improving pharyngeal airway dimensions in growing class III patients with maxillary retrognathism.

Methods: An electronic search in PubMed, Cochrane Library, Web of Science, and EMBASE was until September 2nd, 2017. The assessments of methodological quality of the selected articles were performed using the Newcastle-Ottawa Scale. Review Manager 5.3 (provided by the Cochrane Collaboration) was used to synthesize the effects of MPAs on pharyngeal airway dimensions.

Results: Following full-text articles evaluation for eligibility, 6 studies (168 treated subjects and 140 untreated controls) were included in final quantitative synthesis and they were all high-quality. Compared to untreated control groups, the treatment groups had increased significantly nasopharyngeal airway dimensions with the following measurements: PNS-AD1 (fixed: mean difference, 1.33 mm, 95% CI, 0.48mm-2.19 mm, P = .002), PNS-AD2 (random: mean difference, 1.91 mm, 95% CI, 0.02mm-3.81 mm, P = .05), aerial nasopharyngeal area (fixed: mean difference, 121.91 mm^2, 95% CI, 88.70 mm^2-155.11 mm^2, P < .00001) and total nasopharyngeal area (fixed: mean difference, 142.73 mm^2, 95% CI, 107.90 mm^2-177.56 mm^2, P < .00001). Meanwhile, McNamara's upper pharynx dimension (fixed: mean difference, 0.96 mm, 95% CI, 0.29mm-1.63 mm, P = .005), which was highly related to post-palatal airway dimension, was also improved significantly. However, no statistically significant differences in adenoidal nasopharyngeal area (P > .05) and McNamara's lower pharynx dimension (P > .05) existed.

Conclusions: MPAs can increase post-palatal and nasopharyngeal airway dimensions in growing skeletal class III subjects with maxillary retrusion. It may be suggested that MPAs have the potential to reduce the risk of obstructive sleep apnea syndrome in children with maxillary retrusion by enlarging airway space.

1. Introduction

Obstructive sleep apnea syndrome (OSAS), which is featured by recurrent episodes of obstruction of the upper airway during sleeping, is a common respiratory problem in children and youths. Occurring in all childhood age ranges (younger than 18 years old), pediatric OSAS is mainly predisposed by tonsil and adenoid hypertrophy, with other conditions including obesity, craniofacial malformations and so on [1]. Preliminary studies have demonstrated that craniofacial malformations, such as retrusive maxilla and mandible, narrow maxillary arch, inferiorly positioned hyoid and long lower face [2,3], play a vital role in the pathological mechanics of pediatric OSAS. Skeletal class III malocclusions are especially characterized by a retruded maxilla or a combination of maxillary retrusion and mandibular prognathism [4]. Handler and Hui [5,6] described that skeletal class III malocclusions with severe maxillary hypoplasia, in craniofacial discrepancies like Apert's syndrome or Crouzon's disease, may contribute to constrict the upper airway, including the nasal cavity and velopharynx.

There are multisystem symptoms and related complications in pediatric OSAS such as agitated sleep, abnormal daytime behaviors, learning difficulties, some chronic disease, or even death under the oxygen deficit condition [7–10]. Thus, the OSAS in childhood must be treated as soon as possible for fear of degrading patients' quality of life and delaying their growth and development. Tonsillectomy and

* Corresponding author. The Affiliated Stomatology Hospital, Chongqing Medical University, No.426 Songshibei Road, Yubei District, Chongqing, 401147, China.
E-mail address: zhengleilei@cqdent.com (L. Zheng).

https://doi.org/10.1016/j.ijporl.2017.12.013
Received 15 October 2017; Received in revised form 10 December 2017; Accepted 12 December 2017
Available online 14 December 2017
0165-5876/

adenoidectomy have already become two major therapies for OSAS in children. However, they are not available for those who have unobvious tonsil and adenoid hypertrophy [11]. Bi-level positive airway pressure and continuous positive airway pressure are used to avoid sleep apnea for severe cases. But Marcus reported children could not adhere to using the devices for a long time [12]. Recently, a growing number of scholars have suggested that orthopedic treatments of craniofacial structure deficiencies, especially including mandibular sagittal growth stimulation, transverse maxillary palatal expansion and maxillary protraction, may be effective in decreasing potential risk of sleep-disordered breathing like OSAS for children [2,13,14].

Maxillary protraction appliances (MPAs) using facemask have been used to treat maxillary hypoplasia in growing skeletal class III patients since 1960 [15]. And there is evidence that one of the skeletal effects induced by maxillary protraction is forward displacement of maxilla in growing patients [16]. Considering that mandible advancement via functional-orthopedic devices for children with mandibular retrognathism can obviously widen oropharyngeal airway dimensions [14], one may speculate that maxillary advancement should have similar effects on the upper airway. Interestingly, there is no consensus about changes in airway dimensions induced by MPAs. Improvements on nasopharyngeal and oropharyngeal airway dimensions, according to most previous studies, were found in subjects treated by MPAs [17–26]. However, Mucedero [27] and Baccetti [28] concluded that no significant changes on the sagittal airway dimensions were produced by MPAs in subjects compared with untreated control groups.

The purpose of this study was to elucidate, through a systematic review and meta-analysis, changes of upper airway dimensions after MPAs therapy in growing class III maxillary retrognathic patients with untreated control groups.

2. Materials and methods

2.1. Search strategy

This systematic review and meta-analysis was performed in accordance with the statement of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [29]. An electronic search in PubMed, Cochrane Library, Web of Science, and EMBASE was until September 2nd, 2017. No language restrictions were applied. We used the complete search terms for PubMed: [((((facemask OR (facemask not face mask) OR “reversehead gear” OR “reverse headgear” OR “maxillary protraction” or “extraoral traction appliances”)) AND ((((((((((((pharyngeal) OR “upper airway total volume”) OR “upper pharynx”) OR “lower pharynx”) OR “adenoidal ") OR “aerial ") OR airway)) OR (((((((“nasopharynx"[Mesh]) OR nasopharynxes) OR rhinopharynx) OR rhinopharynxes) OR nasopharynges) OR rhinopharynges) OR choanae)) OR ((((((hypopharynxes) OR laryngopharynx) OR laryngopharynges) OR laryngopharynxes) OR hypopharynges) OR “hypopharynx” [Mesh])) OR “oropharynx” [Mesh]))]. All electronic search strategies shared similar combinations of MESH terms and texts. References in the full-text article selected were manually searched additionally. Two independent authors (Ye Ming and Yun Hu) screened initially titles and abstracts to find any potentially eligible studies, and then their full-texts were retrieved carefully according to inclusion criteria and exclusion criteria. Any disagreements were resolved after discussion. If necessary, the third author (Leilei Zheng) was consulted.

2.2. Selection criteria

According to the PICOS (patient; intervention; comparison; outcome; study design) criteria, the inclusion criteria were worked out.

2.2.1. Population

All subjects before initiating treatment had skeletal class III malocclusion with retrusive maxilla in the period from mixed dentitions to early permanent dentitions and their ages ranged from six to fourteen years old [30,31]. At least two high-quality cephalograms or CBCTs existed, one at the pre-treatment phase and the other at the post-treatment phase.

2.2.2. Intervention

MPAs.

2.2.3. Comparison

Between MPAs-treated patients and untreated control groups.

2.2.4. Outcome

Measurements of sagittal pharyngeal dimensions.

2.2.5. Study design

Clinical controlled trials, randomized controlled trials, and cohort studies.

2.2.6. Exclusion criteria

(1) Study type: case reports, reviews, abstracts, conference papers, letters, animal studies; (2) Subjects: children with previous orthodontic treatment, cleft palate, other congenital anomalies, temporomandibular joint disorders, OSAS due to tonsil and adenoid hypertrophy or nasal obstructive problems.

2.3. Data extraction

The data we extracted from the included studies were as follow: the first author's name, year of publication, type of study, characteristics of subjects, interventions, sample size and gender of subjects, age of subjects, treatment/observation time, image examination and outcome. But only the data of MPAs-treated groups and untreated groups were considered. Unless the same parameters were originated from at least two of the selected studies, the relevant data could only be described but not synthesized.

2.4. Quality assessment

The assessments of methodological quality of the selected articles were performed using the Newcastle-Ottawa Scale [32] independently by two authors (Ye Ming and Yun Hu). This scale involves 8 items, the first four items designed for the selection of the study groups, the fifth item for the comparability of the groups and the remaining three items for the ascertainment of the outcome of interest. Each item was marked as at most 1 star, except for the fifth item with at most 2 stars. The total number of 0–5 was regarded as low-quality, 6 to 9 as high-quality. When the two authors (Ye Ming and Yun Hu) disagreed, the third investigator (Leilei Zheng) was on demand and a final reasonable conclusion was drawn subsequently.

2.5. Statistical analysis

Review Manager 5.3 (provided by the Cochrane Collaboration) was employed in the data analyses according to the methods in the Cochrane Handbook for Systematic Reviews of Interventions (version5.1.0). All the evaluated cephalometric parameters we extracted from the included studies were continuous data. The mean difference with 95% confidence intervals (CI) was used to construct forest plots of continuous data. The significance level for the hypothesis test was set at $p < .05$. Cochrane Q test was used to assess the heterogeneity between studies and Cochrane's test (statistic) was to evaluate the magnitude of heterogeneity. If heterogeneity was low ($P > .10$, $I^2 < 50\%$), we presented results with fixed-effects model; Otherwise, the random-effects model was adopted for the meta-analysis. And if $I^2 > 75\%$, sensitivity analyses were conducted by removing each study individually to confirm the effect of the relevant study on the overall mean difference.