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Pharyngeal airway effects of Herbst and skeletal anchored Forsus FRD EZ appliances

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ABSTRACT

Background and objective: To evaluate the skeletal and pharyngeal airway effects of skeletal anchored Forsus FRD EZ appliance using bilateral miniplates inserted on mandibular symphyses and to compare the findings with a well matched control group treated using a Herbst appliance.
Methods: Thirty patients with skeletal Class II malocclusion due to mandibular retrusion were divided into two groups. Group 1 consisted of 15 patients (8 females and 7 males; mean age: 13.11 ± 1.29 years) treated using the Herbst appliance and Group 2 consisted of 15 patients (9 females and 7 males; 12.84 ± 1.27 years) treated using the skeletal anchored Forsus FRD EZ appliance. Treatment changes were assessed by means of linear, angular, and area measurements.
Results: The groups were well matched regarding to the chronological ages, gender distribution and initial cephalometric values ($P > 0.05$). In both groups, skeletal Class II malocclusion was corrected by decrease in SNA and increase in SNB, Co-Gn, VRL-B and VRL-Pog measurements. Those changes caused a significant correction in the maxillo-mandibular relationship. Upper and lower pharyngeal airway dimensions were increased in both group, while the increase in the lower pharyngeal dimension was found to be statistically significant in the skeletal anchored Forsus FRD EZ group ($P < 0.05$). Oropharyngeal area measurements significantly increased in both groups ($P < 0.001$ and $P < 0.01$, respectively). Comparison of the groups showed that both groups had similar changes with no statistically significant differences ($P > 0.05$).
Conclusion: Skeletal changes produced by both appliances caused significant pharyngeal airway changes.

1. Introduction

Patients with skeletal Class II malocclusions are characterized by maxillary protrusion, mandibular retrusion, or both, together with abnormal dental relationships and profile discrepancy [1]. The majority of the patients with this malocclusion were reported to be attributed to mandibular retrusion rather than maxillary protrusion [2–4], and removable or fixed functional appliances have been the main treatment options for the correction of mandibular retrusion in growing patients. Although numerous studies [5–14] have investigated the dentofacial effects of those appliances, a limited number of them [15–18] reported about the effects of those appliances on pharyngeal airway dimensions. Previous studies reported that these appliances improved the mandibular position relative to the maxilla, improved the facial profile, and caused an increase in oropharyngeal dimensions [15,16].

Since the need for patient cooperation limits the use removable appliances [19,20], orthodontists developed different fixed functional appliances which do not need patient cooperation during improving the position of the mandible. Herbst appliance is a fixed bite jumping device that is one of the most commonly used fixed appliances [8]. Few studies [17,18] evaluated the effects of Herbst appliance on pharyngeal airway and the studies showed that the appliance increased the oropharyngeal and hypopharyngeal airway dimensions [18] and volumes [17] compared to the untreated patients.

On the other hand, Herbst appliance as well as the other fixed functional appliances cause some adverse effects such as

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protrusion of mandibular incisors that inhibits the protrusion of the mandible. Thus, clinicians attempt new approaches to eliminate the protrusion of the mandibular incisors and to increase the amount of mandibular protrusion. Celikoglu et al. [21] described a new approach for the correction of mandibular retrusion using a Forsus FRD EZ appliance combined with skeletal anchor by means of two miniplates inserted at mandibular symphysis. This new approach was shown to be very successful for the correction of mandibular retrusion without protruding the mandibular incisors [9,22]. However, the effects of this new approach for the correction of the mandibular retrusion on pharyngeal airway dimensions have not been investigated yet.

Therefore, the aim of this study was to evaluate the skeletal and pharyngeal effects of skeletal anchored Forsus FRD EZ appliance and to compare the findings with a well matched control group treated using a Herbst appliance.

2. Material and methods

The present retrospective study was approved by the local ethics committee. Informed consent was obtained from the parents of the patients included to the study.

Sample calculation of the study was based on a formula described by Pandis [23], using a significance level of 0.05, and a power of 80% to detect a difference of 1.5 mm (±1.4 mm) for the upper pharyngeal dimension between the groups using the findings of Bavbek et al. [16] The power analysis showed that 14 patients were needed in each group.

The study materials for this retrospective study were selected from the archives of the Departments of Orthodontics, XXXX and XXXX Universities. According to the inclusion (Group 1, patients with skeletal class II malocclusion due to mandibular retrusion and treated by means of Herbst appliance; Group 2, patients with skeletal class II malocclusion due to mandibular retrusion and treated by means of skeletal anchored Forsus FRD EZ appliance. Patients in both groups had ANB > 4°, SNB <78°, overjet > 5 mm, dental class II division 1 malocclusion, low or normal vertical growth pattern determined by SN-MP angle [24], good quality of cephalometric radiographs taken just before and after the fixed functional treatment) and exclusion criteria (presence of congenital anomalies, medical history and/or airway surgery that affect the respiratory system) [16]. Based on the above criteria and matching the groups according to age and gender distribution, Group 1 consisted of 15 patients (8 females and 7 males; mean age: 13.11 ± 1.29 years) treated using a Herbst appliance (Fig. 1). Group 2 consisted of 15 patients (9 females and 6 males; mean age: 12.84 ± 1.27 years) treated using the skeletal anchored Forsus FRD EZ appliance. After the maxillary arch was aligned using MBT brackets (0.022 inch slot size prescription), in patients included to Group 2, 0.019 × 0.025-inch stainless steel archwire was inserted and cinched back. Two miniplates (Stryker, Leibinger, GmbH&Co.KG, Freiburg, Germany) were placed bilaterally on mandibular symphysis using three miniscrews (diameter: 2 mm and length: 7 mm) made of titanium and then the appliance was adjusted to the miniplates without leveling of the mandibular arch (Fig. 2).

Fig. 1. The Herbst appliance used in the study.

All cephalometric radiographs were taken under standard positions just before and immediately after the fixed functional treatment using either a Herbst appliance or skeletal anchored Forsus FRD EZ appliance by means of the cephalostats (Planmeca Proline, Planmeca Co Ltd, Helsinki, Finland and the Siemens Nanodor 2, Siemens AG, Munich, Germany, respectively). After the calibration was done, an experienced maxillofacial radiologist (A.E.S) blindly performed the measurements using NemoCeph NX 2006 (Nemo Tec, Madrid, Spain) without knowing the group of the patients. The linear, angular, and area measurements used in this study are shown in Figs. 3 and 4. Pterygomaxillary vertical (VRL) passing through ethmoid registration point and pterygomaxillary fissure inferior was used as the anterior border of the nasopharyngeal airway, and the ANS-PNS plane as the lower border. The ANS-PNS plane and the hy-cv3ia line were accepted as the upper and lower borders of the oropharyngeal air passage [25].

2.1. Statistical analysis

The same radiologist examined 20 randomly selected radiographs three weeks after the first examination and performed all measurements again without knowing the name and the group of the patients. Intra-class correlation coefficients were performed to assess the reliability of the measurements as described by Houston [26].

A Kolmogorov-Smirnov test showed normal distribution of the data and thus parametric tests were applied for data analysis. Gender distribution in each group was tested by means of a Pearson chi-square test. Chronological ages, treatment durations, and initial cephalometric values were compared between the groups using a Student's t-test. The mean changes observed in each group were evaluated using a Paired t-test, and then they were compared between the groups using the Student's t-test. In addition, Pearson correlation coefficients were calculated between the statistically significant pharyngeal changes and those of craniofacial measurements to evaluate their relationships. All statistical analyses were performed using the SPSS software Package program (SPSS for Windows 98, version 10.0, SPSS Inc, Chicago, Ill). The significance level was set at $P < 0.05$ for all tests.

3. Results

The results of Houston test showed that the coefficients of reliability for all measurements were above 0.875 (0.875–0.916), confirming the measurement reliability.

The comparisons of the chronological ages, observation periods and gender distribution between the groups showed that the groups were well matched as tested by Student's t- and Pearson chi-square tests, respectively (Table 1).

The results of the Student's t-test comparing the initial measurements between the groups were shown in Table 2. No statistically significant differences were observed between the groups ($P > 0.05$). The patients in both groups had skeletal class II malocclusions due to mandibular retrusion and normal vertical growth patterns. Initial pharyngeal airway dimensions and area measurements showed similar values for both groups.

Changes occurred during the skeletally anchored Herbst and