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Prediction of 3-dimensional pharyngeal airway changes after orthognathic surgery: A preliminary study

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Introduction: Recent studies have shown some contradictory results when evaluating the consequences of orthodontic-surgical treatments on the pharyngeal airway. Therefore, the purpose of this study was to correlate the amount of jaw displacement with the volume variation and the minimal cross-sectional area of the pharyngeal airway. A comparison was made between the correlations with the percentage and the absolute values of the measurement variations. **Methods:** Forty-two patients were divided into 2 groups according to the kind of orthognathic surgery that they had undergone. Group 1 had 22 subjects who had undergone maxillary advancement associated with mandibular setback, and group 2 had 20 patients who had undergone maxillomandibular advancement. The pharyngeal airway was divided into the upper segment and the lower segment, and the sum of these volumetric measures resulted in the total volume. The maxillary and mandibular displacements were assessed using closest point iteration after a voxel-wise cone-beam computed tomography superimposition. Hence, jaw displacements were correlated, using Pearson's correlation and linear regression analysis, to the volume variations of the pharyngeal airway (first time separately and then both groups together) and to the minimal cross-sectional area variation. **Results:** The strongest correlation found was between maxillary displacement and the upper segment in group 2 ($r = 0.898$, $R^2 = 0.888$; $P \leq 0.001$). With the groups' data combined, the variables mandibular displacement and the lower segment showed a linear correlation ($r = 0.921$, $R^2 = 0.914$; $P \leq 0.001$). Maxillary displacement showed a strong positive correlation with the minimal cross-sectional area variation in group 2 ($r = 0.710$, $R^2 = 0.604$; $P \leq 0.01$). **Conclusions:** Correlations with the percentage values were substantially stronger than the correlations with the absolute values. Stronger positive correlations were found between the jaw's displacement and the volume variation of the volume segment that was closer to it in both kinds of surgeries. Only the maxillary displacement is a reliable predictor of the minimal cross-sectional area variation after maxillomandibular advancement. (Am J Orthod Dentofacial Orthop 2014;146:299-309)

Alterations of the dimensions of the pharyngeal airway (PA) after surgical-orthodontic treatment have been the subject of numerous studies confirming the importance of the dimensions of the PA to a good quality of life. A recent systematic review elucidated the importance of craniofacial and PA morphologies on the etiology of obstructive sleep apnea.[1] Nevertheless, there is still sparse evidence of the type and severity of these alterations, especially regarding the 3-dimensional (3D) measurements.[2,3] This is true primarily because most of the studies assessing these changes had used cephalometric radiographs[2,4,5] that provided only 2-dimensional (2D) measurements in a lateral view, worsened by structure superimpositions.[6] In addition, those that actually had used 3D images adopted different methodologies, compromising comparisons between them and weakening the evidence.[2,7]

Cone-beam computed tomography (CBCT) has given a greater power of analysis to orthodontists and oral surgeons, providing accurate 2D and 3D measurements of the PA—for example, cross-sectional area and volume, respectively.[8] Although with the current technology the patient might be exposed to a higher level of

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radiation than customary orthodontic digital records,[9] the benefits for surgical-orthodontic patients are evident: a more comprehensive sagittal and lateral analysis; the possibility of multiple 2D or 3D virtual planning simulations of the surgical movements; and prototyping of a surgical guide—in association with digital models—for more predictable surgical results.[10] Moreover, current imaging technology allows a voxel-wise computed cranial base superimposition of the preoperative and postoperative CBCT scans,[11] permitting a reliable assessment of jaw displacement after the orthognathic surgery.[12]

Few studies have tried to correlate the surgical displacement of the jaws with the PA's dimension alterations, and most used 2D cephalometric radiographs in their evaluations.[13,14] The studies that used 3D assessment had correlated the jaw displacements with the absolute values of the volume variation[15]; this seems not to be a reliable correlation concerning the wide variation of the PA volume according to face morphology and other factors.[16]

Therefore, the purpose of this study was to correlate the degrees of maxillary and mandibular displacement arising from surgical-orthodontic treatment with the volume and the minimal cross-sectional area variation of the PA and compare the strength of these correlations between absolute and percentage assessments of the measurement variations.

MATERIAL AND METHODS

The project was approved by the research ethics committee of the Institute of Collective Health Studies from the Federal University of Rio de Janeiro. A sample calculation, based on previous studies, showed that at least 17 subjects would be necessary in each group to detect differences of 65 mm^2 in the minimal cross-sectional area and 2500 mm^3 in the PA volume, with a power of 0.8 and a significance level of 0.05.[17,18]

All the patients were selected from the archives of Hospital da Face (São Paulo, SP, Brazil) from a pool of 338 operated patients. None had a documented diagnosis of obstructive sleep apnea. The selection process was carried out in 2 phases. In the first phase, these inclusion criteria were applied: (1) patients from 18 to 30 years of age, (2) preoperative and postoperative CBCT scans taken with the same machine, (3) the postoperative scan taken from 5 to 8 months after surgery (immediately after bracket debonding), and (4) craniocervical inclination between 90° and 110°.[19] Exclusion criteria applied were (1) important maxillary and mandibular transverse asymmetry,[20] (2) chin augmentation,[21] (3) syndromic patients, and (4) evident airway pathology. The second phase comprised 2 specific steps: preoperative (T1) and postoperative (T2) scans of the eligible patients were loaded into Dolphin Imaging software (version 11.5; Dolphin Imaging & Management Solutions, Chatsworth, Calif). The head orientation was performed by an experienced operator (D.P.B.): the horizontal reference was the Frankfort horizontal plane (FHP), defined bilaterally by porion and right orbitale landmarks, parallel to the floor; the midsagittal plane (MSP), vertically oriented and defined by nasion, anterior nasal spine, and basion; and the transporionic plane, defined by bilateral porion landmarks and oriented perpendicular to the FHP and the MSP.[22]

On step 1 of the second phase, 5 points were used on the MSP: S point, posterior nasal spine (PNS), A-point, B-point, and menton. S point served as a reference for the delineation of the horizontal reference line (parallel to the FHP) and the vertical reference line (perpendicular to the FHP). A vertical analysis (Fig 1, *A*) and a horizontal analysis (Fig 1, *B*) were performed on the T1 and T2 scans. The purpose of the vertical analysis was to exclude patients with substantial vertical variations (greater than 2 mm for any point between T1 and T2) from the sample. The horizontal analysis excluded patients with anteroposterior variations of less than 3 mm for either A-point or B-point, to ensure that only patients with significant anteroposterior jaw displacement would be selected.

In the second step, 2 customary cephalometric measurements were performed on the T1 and T2 scans as well. If the palatal plane or the occlusal plane had a variation greater than 5° (either clockwise or counterclockwise), the patient was eliminated from the study. This criterion was applied to better visualize the PA modifications after isolated anteroposterior jaw movements.

At the end of the selection, 42 subjects were selected, of which 22 (10 male, 12 female) had undergone maxillary advancement associated with mandibular setback and were allocated to group 1. The other 20 (8 male, 12 female) had undergone maxillomandibular advancement and constituted group 2 (Table 1).

All CBCT scans were taken with an i-CAT machine (Imaging Sciences International, Hatfield, Pa) by the same radiology technician. The scanning protocol was 120 kV, 5 mA, 13 × 17 cm field of view, 0.4 mm voxel, and scanning time of 20 seconds. The patients had been told to maintain natural head position, to keep the teeth in occlusion, to not swallow, and to breathe smoothly during the examination. All scans were requested as a part of the initial or final records of the orthodontic treatment. The same oral surgeon (L.V.) was responsible for all the surgical procedures, performing a LeFort 1 osteotomy for the maxilla and a bilateral sagittal split osteotomy for the mandible. Titanium plates were used for rigid fixation of the jaws.