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POSTURAL CHANGES IN PATIENTS UNDERGOING HYOID SURGERY FOR OSAS

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ABSTRACT

The hyoid bone is the only "suspended bone" in our body, and its suspension system has an important role in posture maintenance. We studied postural modification in a group of patients affected by Obstructive Sleep Apnea Syndromewho had undergone surgical treatment including hyoid suspension. The surgical procedure performed was section of supra- and infrahyoid muscle and mobilization of the hyoid bone through its suspension to the thyroid cartilage. We studied the postural changes with stabilometric tests. In the early post-operative (one week) follow-up, we performed a posturography test with closed eyes and occlusal disjunction, and saw a worsening of the average parameter of the centre of pressure with antero-posterior oscillations. However, we would like to highlight that by the time of the one year follow up, a compensatory mechanism had been established which allowed for a return to normal hyoid bone kinematics.

1. Introduction

The hyoid bone is the only "suspended bone" in our body, as it has no joints with other bone surfaces. It is connected indirectly through muscular connection, tendon and fasciae with structures such as the skull, jaw, sternum, scapula, larynx and pharynx. Is a central point of convergence of all the muscular forces in the anterior midline of the neck and the place where muscular chains intersect, thus is has a strategic role in postural alignment. Due to its importance and complexity, the hyoid bone suspension system, has been compared by Goodheart (1) to a gyroscope in a driving system. Therefore, over the last two decades, considerable attention has been given to the position of the hyoid bone in relation to posture. The position of the hyoid bone is affected by the biomechanical influences of the supra- and infrahyoid muscles, and by the elastic membranes of the larynx and the trachea. They are part of the closed kinematic chain of the stomatognathic system, in which there are complex interactions with mandibular movement, speech, swallowing and balancing activities. In addition, there is a close connection between craniomandibular structures, the rachis, shoulder girdle, pelvic girdle and limbs through direct or indirect connections; the so-called body chains. Therefore, any alteration to one of these elements can lead to the onset of postural alterations. Previous studies have shown that changes in mandibular position are related to hyoid bone changes and that hyoid bone position adapts to anteroposterior changes in head posture (2, 3). In our study, we treat patients suffering from Obstructive Sleep Apnea Syndrome (OSAS), which affects both adults and children. This syndrome causes impaired sleep quality associated with daytime sleepiness, cardiovascular, endocrine, nervous and vestibular system disorders (4). Obstructive respiratory disease in children is mainly due to severe adenotonsillar hypertrophy and adenotonsillectomy, and is curable in most subjects (5). In adults, the surgical treatment of OSAS has seen a succession of techniques for the management of oropharyngeal obstruction (6-8), but for the treatment of obstructions at hypopharyngeal level, the technique which has been used most widely for many years is hyoid bone suspension surgery (HBSS).

HBSS has routinely been used to manage hypopharyngeal lateral collapse. This technique, in which the bone hyoid is suspended to the chin, was first developed in 1986 by Riley (9). Due to its complexity and invasiveness, this technique was later abandoned, for the more simple suspension to the upper margin of the thyroid cartilage which we also use (10). Posture adaptation after hyoid bone surgery has not been establised, therefore, the

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aim of the present study is to investigate postural changes in patients suffering from OSAS and submitted to HBSS.
A stabilometric evaluation was performed before surgery and in the immediate post-operative follow-up, in order to evaluate postural alteration. This assessment was repeated a year later in order to assess the possible appearance of compensation phenomena.

2. Material and Methods

All patients in this study were adults.
The selection protocol included:
- Preoperative polisomnography
- Preoperative ENT evaluation
- Preoperative endoscopic evaluation including Müller Manoeuvre and Drug Induced Sleep Endoscopy
- Preoperative lateral cephalometric imaging
- Preoperative stabilometry performed with closed eyes, and with closed eyes with occlusal disjunction (using a wooden tongue depressor)

The records of 30 OSAS patients were evaluated between June 2014 and June 2016. 11 patients met the inclusion criteria and were selected to be part of the study.
The inclusion criteria were:
- Mild to severe OSAS, not or poorly compliant to CPAP
- Absence of craniofacial abnormalities
- Presence of a cross-sectional collapse at hypopharyngeal level with Müller Manoeuvre and Drug Induced Sleep Endoscopy (11) such as to indicate the intervention of HBSS.
- At lateral cephalometric imaging, an ioido-mental distance of between 15 and 30 mm
- Absence of preoperative postural alteration

The subjects underwent multilevel surgery with expansion sphincter pharyngoplasty, radiofrequency turbinate reduction and hyoid suspension.
Postoperative ENT evaluation and postoperative stabilometry were performed in these patients, with closed eyes and with closed eyes with occlusal disjunction (using a wooden tongue depressor) one week after surgery and again one year after surgery.
The tool used was the free Med platform, a pressure platform built with resistive sensors of conductive rubber. This type of platform communicates with a computer through the USB port. It develops a sampling frequency up to 400 Hz in real time. Sensors coated with 24 K gold guarantee repeatability and reliability of the instrument. In conjunction with the free Step program, it was possible to make a postural evaluation and biomechanical analysis.
The execution time of each test was the standard 51.2 seconds.
The relevant parameters for the purpose of our evaluation were:
- Length of the skein (expressed in mm): the value of the total distance covered by the centre of pressure (CoP).
- Ellipse area (expressed in mm^2): evaluates the dispersion of the CoP oscillations of 95% of the sampled positions.
- Mean X (expressed in mm): indicates the midpoint of the CoP oscillations in the frontal plane (lateral side).
- Mean Y (expressed in mm): indicates the midpoint of the CoP oscillations on the sagittal plane (anterior-posterior).

Comparisons between groups were assessed by paired t-test at a significance level of $p < 0.05$. Statistical analysis was performed using Microsoft Excel 2003.

3. Results

The study cohort was composed of10 male and 1 female suffering from moderate to severe OSAS, with average AHI 40.9 ± 22.7 events / hour of sleep, with mean age: 47,5 ± 9,30 years , mean BMI 28,7 ± 2,78.
Examining our cohort, the preoperative stabilometric parameters related to the test with closed eyes were within the normal range. The same test was performed with closed eyes one week after surgery with no significant changes compared to the pre-operative evaluation (T no significant test) (Table 1).

	CE Pre	CE Post	*p*
Length of the skein (mm)	804,23 ±301,73	744,65 ± 241,72	Ns
Ellipse area(mm^2)	382,68±589,36	236,67±267,82	Ns
Mean X (mm)	-0,39 ± 11,80	1,49 ± 16,36	Ns
Mean Y (mm)	-11,87 ± 23,38	-6,81 ± 28,73	Ns

Table 1 - Closed eyes T test before and one week after surgery

Preoperative data for the Closed Eyes test with occlusal disjunction were within the normal range.
After surgery the same test showed normal parameters relative to the length of the oscillations, the surface of the ellipse and the mean X, showing no significant changes (T-test).
However, in the post-operative assessment, a variation in terms of deterioration of mean Y parameter of the CoP position along the sagittal plane, with significant fluctuations in the anterior-posterior direction was highlighted.
The t-test analysis, performed between the mean Y values with closed eyes and occlusal disjunction in pre and postoperative conditions, highlights a statistically significant variability in the data ($p = 0.021$) (Table 2).
We compared the values obtained preoperatively from closed eyes test without occlusal disjunction with those obtained preoperatively with occlusal disjunction, without obtaining a statistically significant difference for any of the parameters.

When we Compared the data obtained from the one year follow-up post-operative tests with the preoperative data we highlighted the absence of significant changes in all parameters, revealing postural compensation mechanisms on the Y plane.

	CE Disjunction		*p*
	(Pre)	(Post)	
Length of the skein (mm)	846,05 ± 352,07	795,74 ±239,15	ns
Ellipse area(mm^2)	399,69 ± 675,34	199 ± 215,27	ns
Mean X (mm)	1,62 ± 10,06	1,74 ± 11,59	ns
Mean Y (mm)	-12,65 ± 20,04	-19,97 ± 21,75	0,021

Table 2 - Closed eyes T test whit mandibular disjunction before and one week after surgery

4. Discussion

This study is the first to deal with the evaluation of possible consequential postural alterations of hyoid bone suspension surgery. We wanted to examine this aspect because every supra- and infra-hyoidal muscle has a definite role in hyoid bone kinematics, and it is exactly these dynamics that are altered in HBSS.

The HBSS technique, provides for section of the mylohyoid muscle, important in the dynamics of stomatognathic apparatus, since the contraction of this muscle causes the lifting of the hyoid bone and lowering of the jaw, and at the same time may result in a lifting of the floor of the mouth and of the tongue.

In addition, the sternohyoid muscle that connects the sternum and clavicle to the hyoid bone is sectioned which on contraction lowers the hyoid bone; the tyrohyoid muscle is sectioned, which links the thyroid cartilage to the hyoid bone, and on contraction lowers and raises the hyoid cartilage.

The action of these muscles reflects the important role of the hyoid bone in the stomatognathic system of connections with the jaw, tongue and larynx, which have important functions in the field of mastication, eating and phonation. It also has a key role in the redistribution of forces projected towards the skull and into the shoulder girdle, which regulate the postural asset.

The surgery can cause postural alteration, because by dissecting both sovrahyoid and infrahyoid muscles, there is a reduction in muscular tension and forward mobilization of the hyoid bone which causes a shift in its kinematics in the sagittal plane.

These alterations should be evaluated using computerized static stabilometry; the test used to evaluate postural control in a subject, in the standing position, through a quantitative study of the postural oscillations of the patient, assessing the contribution of the various components involved in postural control. Subjects should be tested in an upright position, recording the reflex activity that underpins it, and highlighting how the position relates to earth from the centre of gravity. The movement of the latter, and the consequential effects related to dynamic acceleration resulting from the activity of the muscles which prevent fall should be reported.

The data we obtained confirm this. In all patients, the only highlighted postural variation was that linked to Y mean parameter. We found a worsening of the average parameter of the center of pressure oscillations in the posturographic test with closed eyes and occlusal disjunction. This corresponds to the point of application of the result of the forces exchanged between the foot and the ground, along the cartesian Y axis, and then along the sagittal plane in the anterior to posterior direction.

The modification was obtained only in the test with closed eyes and occlusal disjunction, as by maintaining the occlusal bond the stomatognathic system continues to perform its physiological functions, being able to compensate the disequilibrium. However, when the apparatus is freed from the bonds it is unable to compensate the disequilibrium arising as a result of the forward mobilization of the hyoid bone, which causes an interference along the sagittal plane.

Zheng e coll. (13) found that X- and Y-positions of the hyoid bone should be related to the angular positions of jaw, head and C1–C4 and to the more global head and neck angular posture. From our data, it is clear that over time compensatory mechanisms are established that lead to are turn to normal kinematics of the hyoid bone for posturographic control after one year. The dynamics of change in posture and the position of the hyoid bone have been extensively studied in the postoperative evaluation of patients undergoing jaw surgery, and especially in mandibular setback surgery for prognathism. Many authors reported in early studies that surgical correction of mandibular prognathism alters the position of the hyoid bone by downward repositioning, carrying the root of the tongue downwards immediately postoperatively, followed with a tendency to return to its original position (13-16). However, other authors (17-18)have stated that the hyoid bone never regains its original position. Post-operative alteration in position of the hyoid bone may cause relaxation of the suprahyoidal musculature. The possible decreased tension of suprahyoidal musculature may change the balance within the head and neck musculature, and this can result in an increase in anteriorly directed force caused by the neck muscles, pulling the mandible forward again (15,18).

In conclusion, our study shows that the section of supra- and infra-hyoidal muscle and the mobilization of the hyoid bone through its suspension to the thyroid cartilage can result in a worsening of the hyoid bone kinematics along the Y axis, producing oscillations in an antero-posterior direction. However, at one year follow up it became evident that there was an establishment of compensatory mechanisms probably due to central and peripheral mechanisms related to scarring which allow are turn to normal hyoid bone kinematics.

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