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Comparison of Volumetric Dimensions of Orofacial Airway in Subjects with Class I and Class II Malocclusion – A CBCT Study

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ABSTRACT

OBJECTIVE: To compare the 3-D dimensions of tongue space and nasopharyngeal airway space in subjects with class I and class II skeletal malocclusion.

MATERIALS AND METHODS: Cone beamed computer tomographies of 20 class I skeletal pattern subjects and 20 class II skeletal pattern subjects (mean age- 24±4years) were examined. Tongue space and nasopharyngeal airway space volume were evaluated in mm^3. Group was divided into two skeletal patterns according to ANB, beta angle and wits AO/BO. Group comparison was done using independent Student paired test/ Mann-Whitney test at the $P < .05$ level.

RESULTS:

According to independent Student paired test/ Mann-Whitney test, statistical significance was seen in both tongue space and nasopharyngeal airway space volume. The tongue space volume and nasopharyngeal airway volume was found to be decreased in class II skeletal pattern when compared to class I skeletal pattern individual. Sexual dimorphism was also noticed.

CONCLUSIONS:

Significant differences in orofacial airway volume of Class I and class II subjects were identified.

KEY WORDS: Tongue space; nasopharyngeal airway; CBCT; 3D; volumetric analysis.

INTRODUCTION

Malocclusions can be classified as skeletal or dentoalveolar in origin. Etiology of vertical malocclusions during growing child can be development of dentoalveolar component, maxilla, mandible, soft tissue, tooth eruption.[1]Since 19th century, various investigations is focused on the relationship between morphology of craniofacial and respiratory component. [2]

Majority of the studies on the relationship of facial pattern and pharyngeal airway have been performed on cephalograms which has an limitation of being a 2D imaging thus volumetric calculation of airway was not possible. [2] 3D CBCT enables accurate volumetric assessment of airway by the software option which is associated with it. This gives essential clinical and diagnostic information in patients with obstructive sleep apnea. Further studies may be required to determine reliability in airway volumes and areas analysis.[3]

3D CBCT is accurate and reliable in measuring the volume of oropharyngeal airway and the airway volume at the most constricted part of oropharynx which gives important information during orthodontic treatment of the patient.[3] Sagittal skeletal pattern of patients has shown significant difference in dimensions of pharyngeal airway[2]but volumetric analysis of tongue space and nasopharynx has not been done in subjects with class I and class II malocclusion using CBCT.

The aim of the present study was to evaluate the orofacial airway volumes, that is, tongue space volume and nasopharyngeal airway volume of patients presenting with class I and class II malocclusion using 3D analysis on CBCT.

MATERIALS AND METHODS

The sample size was estimated using the software GPower v. 3.1.9.2

Considering the effect size to be measured (d) at 80% for Two-tailed hypothesis, power of the study at 80% and the margin of the error at 5%, the total sample size was decided upon 40. Each study group will comprise of 20 samples. Statistical Package for Social Sciences [SPSS] for Windows Version 22.0 Released 2013. Armonk, NY: IBM Corp., WAS used to perform statistical analyses. The level of significance will be set at P<0.05.

Records namely pre-treatment CBCT head scans were collected of 40 patients from the Oral Medicine and Radiology department. CBCT head scans were obtained from NewTom cone beam imaging machine. The exposure parameter included 110 kVp tube voltage, 5 mA tube current. The data were obtained as DICOM format files. The DICOM files are transferred to InVesalius software for volume estimation of tongue space and nasopharynx. The manual segmentation tool in the software was used to measure the volume.

Inclusion criteria were all permanent teeth should be present in each arch (third molar may or may not be included) , age group – 18 to 40 years and acceptable quality of CBCT head scans. Exclusion criteria were previous orthodontic treatment, craniofacial anomalies like cleft lip and palate and syndromes, trauma to dentofacial region, orthognathic surgery of maxilla and mandible and cervical spine which was not upright. Parameters used for assessing facial skeletal type were ANB, Beta angle and Wits AO/BO by lateral cephalogram acquired by CBCT. The volume of the spaces is assessed through the CBCT obtained.

Area of interest for tongue space (mm^3)(Figure 1): formed by Hard palate, T which is the most anterior part of the hard palate behind maxillary incisors, Me which is the menton and H which is the most anterior part of the hyoid bone.

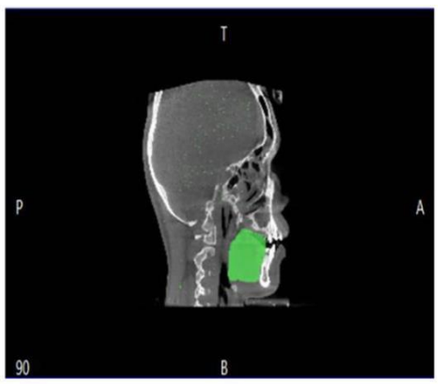

FIGURE 1 Limits of area of interest – tongue space

Area of interest for nasopharyngeal airway space volume (mm^3) (Figure 2): formed by Pt PNS line anteriorly, posterior pharyngeal wall posteriorly, palatal plane inferiorly and lateral pharyngeal wall laterally.

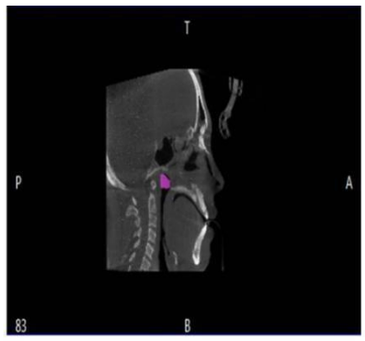

FIGURE 2 Limits of area of interest -nasopharynx

RESULTS

When tongue space volume was compared between class I and class II skeletal subjects, the comparative value was significant where the tongue space in class I skeletal pattern was found to be 90,211 ± 11307mm^3 whereas class II skeletal pattern was found to be 76,625 ±9369mm^3 which inferred that the tongue space is significantly smaller in class II skeletal pattern compared to class I skeletal pattern as shown in Table 1. Comparison of nasopharyngeal airway volume was also significantly smaller in class II individual, that is, 2,231 ± 937 mm^3 when compared to class I skeletal pattern which was 3,402 ± 1305mm^3 as shown in Table 1.

Table 1 – Comparison of mean tongue space and nasopharyngeal airway between class I and class II skeletal malocclusion using Mann-Whitney test.

Variable	Group	N	Mean	SD	Mean Diff	P-Value
Tongue Space (mm^3)	Class I	20	90211.90	11307.98	13586.25	0.001*
	Class II	20	76625.65	9369.40		
Nasopharyngeal Airway Space (mm^3)	Class I	20	3402.70	1305.59	1171.20	0.001*
	Class II	20	2231.50	937.41		

In male patients, comparison of tongue space volume in class I and class II skeletal pattern as shown in Table 2 showed a significant difference where tongue space is smaller in class II skeletal pattern than class I skeletal pattern subjects. There was no significant difference seen in nasopharyngeal airway volume as shown in Table 2.

Table 2 - Comparison of mean tongue space and nasopharyngeal airway volumes between class I and class II skeletal malocclusion among males using Mann-Whitney test

Variable	Group	N	Mean	SD	Mean Diff	P-Value
Tongue Space (mm^3)	Class I	11	87830.00	9627.52	10048.71	0.03*
	Class II	14	77781.29	8039.16		
Nasopharyngeal Airway Space (mm^3)	Class I	11	3071.45	1335.47	546.31	0.24
	Class II	14	2525.14	977.84		

In female patients, comparison of class I and class II skeletal pattern also showed a significant difference in both tongue space and nasopharyngeal airway volumes as shown in Table 3. The tongue space as well as nasopharyngeal airway volume was smaller in class II skeletal pattern when compared with class I skeletal pattern among females.

Table 3 - Comparison of mean tongue space and nasopharyngeal airway volumes between class I and class II skeletal malocclusion among females using Mann-Whitney test

Variable	Group	N	Mean	SD	Mean Diff	P-Value
Tongue Space (mm^3)	Class I	9	93123.11	13057.39	19193.94	0.01*
	Class II	6	73929.17	12372.85		
Nasopharyngeal Airway Space (mm^3)	Class I	9	3807.56	1218.10	2261.23	0.001*
	Class II	6	1546.33	220.05		

When gender wise comparison in females and males subject on class I group was done as shown in Table 4, there was no significant difference seen.

TABLE 4- Genderwise comparison of mean tongue space and nasopharyngeal airway volume among class I group.

Variable	Gender	N	Mean	SD	Mean Diff	P-Value
Tongue Space (mm^3)	Males	11	87830.00	9627.52	-5293.11	0.21
	Females	9	93123.11	13057.39		
Nasopharyngeal Airway Space (mm^3)	Males	11	3071.45	1335.47	-736.11	0.16
	Females	9	3807.56	1218.10		

When gender wise comparison was done within the male and female of class II group as shown in table 5, it was found that class II females had a significantly smaller nasopharyngeal airway volume, that is, 1,546 ± 220 mm^3 when compared to class II males which was 2525± 977 mm^3.

Table 5 – Gender wise comparison of mean tongue space and nasopharyngeal airway volume among class II group.

Variable	Group	N	Mean	SD	Mean Diff	P-Value
Tongue Space (mm^3)	Males	14	77781.29	8039.16	3852.12	0.93
	Females	6	73929.17	12372.85		
Nasopharyngeal Airway Space (mm^3)	Males	14	2525.14	977.84	978.81	0.01*
	Females	6	1546.33	220.05		

DISCUSSION

The tongue is an area of interest for different professions.

Alterations in the tongue muscle properties are associated with different pathological conditions. Systemic disorders may involve the tongue secondarily, or local tongue alterations can cause systemic diseases like scleroderma, local tongue dysfunction, tumors, old age, obstructive sleep apnea syndrome, and emotional disorders.[4]

Gorgulu et al stated that in class III individual, there is decreased contact between tongue tip and palatal rugae, also the posterior portion and root of the tongue is more inferiorly positioned when compared with class I individuals.[5] In the present study it was confirmed that the tongue space volume is larger in class I skeletal pattern subjects compared to class II subjects.

MRI measurement of airway and tongue volume was done in 45 patients in a study by Sharma et al. The study concluded a significant correlation of mandibular length in normodivergent class I, hyperdivergent class II and obstructive sleep apnea group. Thus tongue volume can be a predictor for oropharyngeal and nasopharyngeal glossomandibular area.[6]A study done by Ucar et al where they cephalometrically evaluated 104 patients showed a significant difference in orofacial airway that is the nasopharyngeal airway and tongue space volume in different growth pattern. The study concluded that high angle class I patients have reduced nasopharyngeal airway space compared to low angle individuals. Palatal tongue space and tongue gap were reduced in low angle subjects than in high angle subjects.[1]In the present study, male patients showed a significant difference where tongue space is smaller in class II skeletal pattern than class I skeletal pattern subjects whereas in female patients, comparison of class I and class II skeletal pattern also showed a significant difference in tongue space volume. The tongue space was smaller in class II skeletal pattern when compared with class I skeletal pattern among females.

Pharynx comprises of three parts – nasopharynx, oropharynx and hypopharynx. The nasopharynx is outlined by skull base to pharyngeal roof. Pharyngeal isthmus separates the nasopharynx and the oropharynx which is demarcated by the soft palate anteriorly.[7]Airway volume can be influenced by obstructive sleep apnea, surgeries, orthodontic therapy and chemotherapy. The mean value of upper airway volume is smaller in the Obstructive sleep apnea group.[8]A study done by Wang concluded that extraction patients have significantly reduced pharyngeal airway space. Incisor retraction after premolar extraction has found to reduce the pharyngeal space and also alter the hyoid bone position.[9]

Study by Paul et al have stated that a strong association of skeletal pattern and airway.[10] whereas De frieta et al in their study concluded that there is no association between skeletal pattern and pharyngeal airway space.[11]Our study gave a similar

result as Paul et al where the nasopharyngeal airway is reduced in class II skeletal pattern compared to class I skeletal pattern. This contradicted the normal anatomy as maxilla in class II skeletal pattern is placed anteriorly or normal which should result in increased nasopharyngeal space.[7]

In the present study, male patients had no significant difference seen in nasopharyngeal airway volume whereas in female patients, comparison of class I and class II skeletal pattern also showed a significant difference in nasopharyngeal airway volumes. The nasopharyngeal airway volume was smaller in class II skeletal pattern when compared with class I skeletal pattern among females.

A cephalometric study was done by Martin et al to assess nasopharyngeal soft-tissue patterns in patients with ideal occlusion. Nasopharyngeal soft- tissue patterns were different in men and women. Nasal fossa, cranial base, and adenoidal tissue were larger in men. Nasal fossa length was statistically correlated with upper airway thickness showing sexual dimorphism.[12] This was confirmed in our CBCT study that class II male subjects had a larger nasopharyngeal airway compared to class II female subjects. There was no significant difference between class I males and females.

A study of Ghoneima et al suggested that the CBCT digital measurements of the airway volume and the most constricted area of the airway are reliable and accurate. CBCT imaging for the airway assessment can provide clinically useful in the field of orthodontics.[3]

In a study by Savoldi, reliability of lateral cephalograms were evaluated for assessment of upper airway in children where the method reliability and the inter-assessor reliability for soft palate and tongue was less favorable and soft palate area and thickness were the most critical parameters.[12]Thus, the limited reliability in the assessment of tongue and soft palate area may compromise the diagnostic application of cephalograms.[13]In the present study we have compared the orofacial airway volume using CBCT for better accuracy.

CONCLUSION

- There is a significant difference in 3-D dimensions of tongue pace and nasopharyngeal airway between subjects with class I and class II skeletal pattern.
- The tongue space volume is significantly smaller in class II skeletal pattern compared to class I skeletal pattern.
- The nasopharyngeal airway volume is significantly smaller in class II skeletal pattern compared to class I skeletal pattern.
- In male patients, tongue space volume is significantly smaller in class II skeletal pattern than class I skeletal pattern subjects.
- In female patients, tongue space volume as well as the nasopharyngeal airway volume is significantly smaller in class II skeletal pattern when compared with class I skeletal pattern subjects.
- There is sexual dimorphism seen where class II females had a significantly smaller nasopharyngeal airway volume, when compared to class II males.

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