ORIGINAL RESEARCH

Assessment of the Oropharyngeal Space Using CBCT and Its Impact on Volume of Airway Prior and after Denture Placement: *In Vivo* Study

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Abstract

Aim: The current study aimed to assess the oropharyngeal space using cone-beam computed tomography (CBCT) and its effect on airway volume both before and after denture placement.

Materials and methods: For this investigation, a total of 15 individuals with fully edentulous upper and lower ridges, ranging in age from 40 to 70, were taken into consideration. A recording of the pulmonary function test was made both prior to and following full denture recovery. Prior to finishing denture therapy, the patient underwent a CBCT scan while standing erect and wearing a cephalostat. For one patient, two tomographs were recorded. The initial skull tomography was obtained prior to the rehabilitation of prosthetic limbs. After receiving prosthetic rehabilitation, the second tomograph was taken. On Demand 3D and CS 3D imaging software were used to take the measurements. The maxillary and mandibular complete dentures were fabricated using standardized techniques. Following prosthesis insertion, a CBCT scan of the skull was performed, and the results were recorded and analyzed.

Results: The mean oropharyngeal space measurement before and after complete denture rehabilitation was 9.18 mm and 10.20 mm, respectively. It was discovered that there was a statistically significant difference ($p = 0.001$). The oropharynx's mean volume before complete denture rehabilitation was 5533.50 mm^3, and it was 6562.39 mm^3 after denture rehabilitation was finished. A statistically significant difference was discovered ($p = 0.028$).

Conclusion: On conclusion, a statistically significant difference was found between the airway volume and oropharyngeal space prior to and following denture rehabilitation. Reducing apnea-hypopnea episodes can be achieved by minimizing pharyngeal collapsibility in patients by providing complete dentures that are created with acceptable and potentially improved vertical dimension of occlusion within the limits of permissible tissues.

Clinical significance: The CBCT image enables it to be simple to distinguish between empty space and soft tissues. One benefit of wearing a denture while sleeping for edentulous patients with obstructive sleep apnea is that it helps decrease apnea-hypopnea episodes. This happens because wearing a denture causes changes to the soft tissue, pharyngeal airway space, jaw, and tongue positions.

Keywords: Airway volume, Cone-beam computed tomography, Denture, Oropharyngeal space.

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Introduction

Edentulism is a significant risk factor for obstructive sleep apnea (OSA) and causes a decrease in the size and tone of the pharyngeal musculature. A study of the literature shows that when all of a patient's teeth were extracted for obstructive sleep apnea, the patient's cardiorespiratory symptoms worsened, and the frequency of apnea/hypopnea episodes nearly doubled per hour.[1] It could be anatomical in nature because of diseases such as soft tissue hyperplasia, retrognathia, micrognathia, and macroglossia that cause the airway lumen to shrink, or it could be functional in origin because of muscle hypotonicity.[2]

Obstructive sleep apnea can result from a number of situations, including rotation of the mandible and loss of the vertical dimension of occlusion, which reduces the height of the lower face. When lung function tests are performed on edentulous patients without dentures, there is a slight but notable drop-in inspiratory airflow rates. This could indicate that the upper airway's patency is at risk.[3]

Prosthodontic appliances, such as tongue and mandibular repositioning devices, can be used as a therapy option for patients who pose a risk of surgery or who have not responded well to previous surgical treatments. Because the lack of teeth reduces

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Fig. 1: Patient position on CBCT machine

Fig. 2: Patient performing spirometry

the vertical dimension and is linked to morphological changes in the upper airway, a reduction in the retropharyngeal space, and a decrease in the size and tone of the pharyngeal musculature, OSA is more common in edentulous people. There are few therapeutic options available for edentulous OSA patients, with continuous positive airway pressure therapy (CPAP) continuing to be the recommended course of action.[4]

Particularly for the craniofacial region, cone-beam computed tomography (CBCT) technologies have recently been developed. More people can benefit from CBCT scans since they require less radiation because they employ a different style of acquisition than a typical multislice CT. A sophisticated procedure, including the use of specifically created computer programs, is required to convert two-dimensional slices of CBCT into three-dimensional pictures and volumes.[5]

One of the most important processes is respiration, which is the exchange of gases between an organism and its environment to support the body's metabolic needs. Oral tissues and preexisting dentures are the first structures that come into contact with the air as it passes through the upper airways during oral respiration.[6] Therefore, the aim of the current study was to evaluate the oropharyngeal space using CBCT and its effect on airway volume both before and after complete denture insertion.

Materials and Methods

The current *in vivo* research was conducted in the department of prosthodontics. For this investigation, a total of 15 individuals with fully edentulous upper and lower ridges, ranging in age from 40 to 70, were taken into consideration. Prior to the study's start, institutional ethical committee approval was obtained. Additionally, the patients' informed consent was obtained. The study comprised subjects with well-formed or average ridges, no history of denture wear, and total edentulous status for at least 6 months. The study excluded any patient displaying joint sounds, restricted motions, respiratory disorders, or deep neck infections in addition to muscle discomfort.

Approximate residual ridges on the mandible and maxilla before prosthesis rehabilitation. Furthermore, following prosthetic rehabilitation using a centric occlusion complete denture for the mandible and maxilla. The airway space and oropharyngeal space were next radiographically examined using CBCT (Fig. 1).

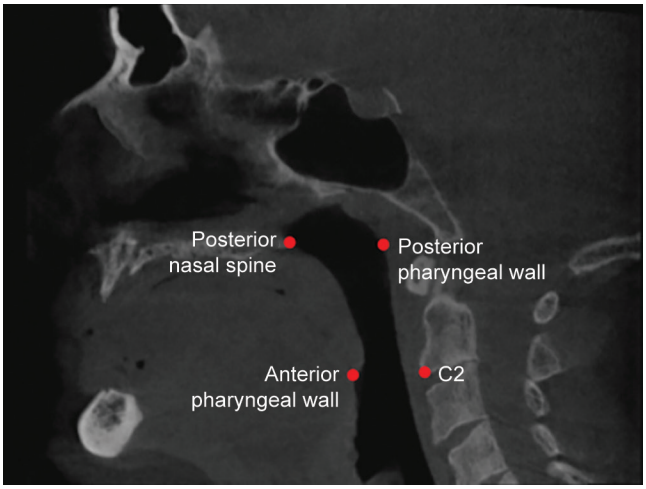

Fig. 3: Landmarks used for the volume of upper airway

Pulmonary Function Test (Fig. 2)

The patient was instructed to breathe normally for a few seconds, take a deep breath, hold it for a few seconds, and then exhale as forcefully as possible into the breathing mask. The pulmonary function test was recorded both before and after the patient underwent complete denture rehabilitation. The patient was seated upright. A clip was placed on the nose to keep both nostrils closed. Spirograms with adequate origins, extrapolated volumes <5% of FVC or 0.15 liters, and satisfactory exhalations of 6 seconds or a plateau in the volume-time curve were considered acceptable. Reproducibility criteria were used after three spirograms that were considered satisfactory were recorded.

Evaluation of Oropharyngeal Space Using CBCT (Fig. 3)

Prior to undergoing complete denture rehabilitation, the patient underwent a scan using a cephalostat and a CBCT equipment (Carestream CS 93003D, Rochester, USA) with a 13.5 × 17 cm field of view (FOV). In order to obtain a consistent orientation of sagittal images, the patient's position was standardized so that their head was inside the circular gantry housing of the X-ray tube, and the Frankfort plane a line that runs horizontally from the superior border

of the external auditory meatus to the inferior border of the orbital rim was kept parallel to the horizontal plane on the lateral view. The scanner had a typical 14-degree cone-beam angle, 0.18 mm voxel size, 0.9 mm Al-equivalent filtration, and a maximum output of 90 kV and 12 mAs. For analysis, the CS9300 software was utilized.

Selection and Measurement of Image

In this investigation, CBCT was employed. For one patient, two tomographs were recorded. The initial skull tomography was obtained prior to the rehabilitation of the complete denture. After receiving prosthetic rehabilitation, the second tomograph was taken. On demand 3D and CS 3D imaging software were used to take the measurements.

Fabrication of Complete Denture Prosthesis

The maxillary and mandibular complete dentures were fabricated using standardized techniques. Diagnostic casts and imprints of the maxillary and mandibular arches were made following a clinical examination. Using a face-bow transfer, record bases and occlusion rims were made on the casts and then moved to a semi-adjustable articulator. A record created while the patient was positioned in the centric relation at the specified vertical occlusion dimension. Selected anatomic teeth were placed in a bilaterally balanced occlusion. The prosthesis was prepared and completed in the customary way, following trial insertion and verification of the arrangement of teeth. Following prosthesis placement, a cephalostat was used to take a CBCT of the patient's skull while they were upright. The CBCT machine used was a Carestream CS 93003D from Roshester, USA, with a 13.5 × 17 cm FOV. Following denture insertion, spirometry and a skull tomograph were recorded and examined.

Statistical Analysis

With the use of SPSS (Statistical Package for Social Sciences), version 17, all patient data were statistically analyzed. With the Wilcoxon signed rank test, the mean value of the variable was compared before and after complete denture rehabilitation. Statistics were considered significant if the *p*-value was less than 0.05.

Results

Table 1 shows the distance between the anterior and posterior wall of the oropharynx (retropharyngeal space) among 15 patients. The largest and lowest measured distances prior to complete denture restoration were 12.6 and 6.4 mm, respectively. Following complete denture rehabilitation, the largest distance measured was 12.9 mm, and the lowest distance recorded was 6.8 mm.

Table 2 depicts the volume of the upper airway (oropharynx) before and after complete denture rehabilitation among 15 patients. The upper airway's highest volume was 8575.5 mm^3, and its lowest volume was 4413.3 mm^3 prior to complete denture restoration. The highest capacity of the upper airway measured after complete denture rehabilitation was 12263 mm^3, and the lowest amount was 5489.11 mm^3.

Tables 3 and 4 and Figures 4 and 5 show the oropharyngeal space and volume of the upper airway. The mean oropharyngeal space measurement before and after complete denture rehabilitation was 9.18 and 10.20 mm, respectively. It was discovered that there was a statistically significant difference ($p = 0.001$). The oropharynx's mean volume before complete denture rehabilitation was 5533.50 mm^3, and it was 6562.39 mm^3 after denture rehabilitation was finished. A statistically significant difference was discovered ($p = 0.028$).

Table 1: Evaluation of distance between anterior to posterior wall of oropharynx (retropharyngeal space) among 15 patients

Sl. No.	*Before complete denture rehabilitation (mm)*	*After complete denture rehabilitation (mm)*
1	10.4	11.4
2	6.4	6.9
3	6.6	6.8
4	9.9	10.4
5	6.5	7.9
6	6.5	7.9
7	7.8	8.5
8	11.5	12.5
9	10.8	12.6
10	10.9	12.9
11	12.6	12.9
12	11.8	12.8
13	6.7	7.5
14	8.9	10.6
15	10.4	11.5

Table 2: Evaluation of volume of upper airway (oropharynx) before and after complete denture rehabilitation among 15 patients

Sl. No.	*Before complete denture rehabilitation (mm^3)*	*After complete denture rehabilitation (mm^3)*
1	8575.5	12263
2	6178.47	7664.63
3	5160.2	6240.6
4	7490.83	8631.2
5	5190.2	5489.11
6	6089.82	7667.4
7	8476.5	11253
8	5430.42	6490.5
9	6283.7	7582.11
10	4413.3	5534.12
11	6178.11	7664.34
12	5160.2	6384.2
13	7490.83	8631.2
14	8476.5	11253
15	6283.7	7582.11

Table 3: Evaluation of the oropharyngeal space and volume of upper airway

Parameter	*Timeline*	*Mean*	*SD*	*SEM*
Oropharyngeal space	Before	9.18	2.23	0.57
	After	10.20	2.37	0.61
Volume of airway	Before	5533.50	1677.2	433.3
	After	6562.39	2450.07	632.6

Discussion

A vital component of prosthodontic treatment is the rehabilitation of edentulous patients with complete dentures. Dentures not only enhance phonetics and esthetics, but they also help patients regain their desired ability to masticate. Additionally, it improves disorders like OSA/hypoapnea and restores altered vertical dimensions, which gives the orofacial structure appropriate support.[7]

Table 4: Mean value comparison of before and after denture rehabilitation

			95% Confidence interval of the difference			
Parameters	*Mean difference*	*SD*	*Lower*	*Upper*	*'z' statistic*	*p-value*
Oropharyngeal space (After–before)	1.02	0.548	0.712	1.021	3.372	0.001
Volume of airway (After–before)	1028.89	924.27	478.12	1472.12	2.62	0.028

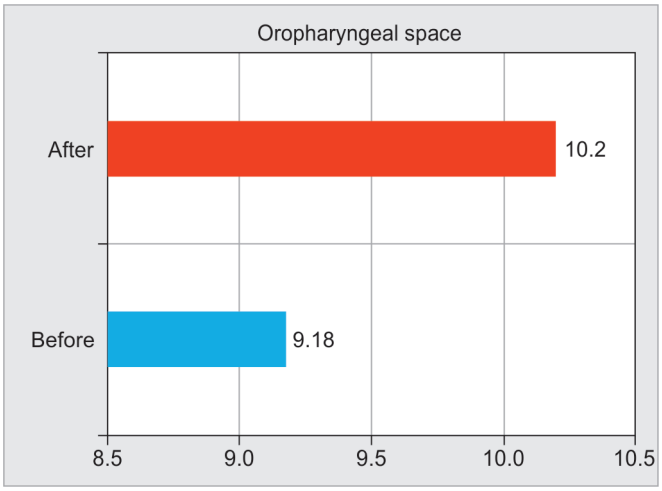

Fig. 4: Oropharyngeal space before and after denture

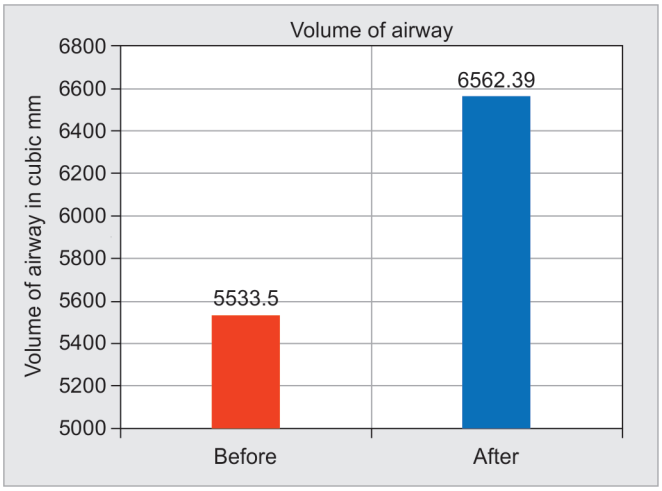

Fig. 5: Upper airway volume before and after denture

Cone-beam computed tomography, which is inexpensive, practical, sharp, and low radiation dosage, has greatly advanced dentistry. Bidimensional images frequently included flaws such as distortion, magnification, and superimposition of features, which restricted research on the upper airway. Because of its reduced radiation dose, lower cost, easier accessibility, and quicker image acquisition time than magnetic resonance imaging, CBCT was presented as an alternative.[8]

Although CBCT's soft tissue imaging is not as good as magnetic resonance imaging, it is nevertheless a reliable and simple method for identifying the upper airway. The distinction between soft tissues and empty spaces is easily seen on the CBCT, which is crucial for assessing the upper airway. On the other hand, CBCT cannot distinguish between different types of soft tissues, such as muscles, connective tissue, and fat. Instead, magnetic resonance imaging can.[9]

In this study, the retropharyngeal space that is, the distance between the anterio-posterior oropharyngeal wall distance at the level of the c2 vertebrae was assessed using CS 3D software on a sagittal view both before and after a complete denture was placed.[10]

The current study's findings indicated that the mean retropharyngeal space was 9.18 mm before complete denture rehabilitation and 10.20 mm after. Comparing individuals with complete dentures made at an acceptable vertical dimension to those who were edentulous, significant alterations were seen. The findings showed a correlation with research conducted earlier by Singhal P et al.[10] and Gupta P et al.[11] The findings can be explained by the possibility that modifications to the structure and function of the upper airways are part of the process underlying the association between the loss of teeth and sleep disorders. The subjects are more susceptible to apnea, hypopnea, or the upper airway resistance syndrome due to an increase in upper airway resistance brought on by a reduction in the retropharyngeal space linked to compromised function of the genioglossus and other upper airway dilating muscles.

This is also in line with previous studies by Bucca et al.,[12] who found that the retropharyngeal gap shrank from 15 to 6 mm as a result of denture removal. A different recent study by Singhal et al. found that patients who are edentulous also have reduced retropharyngeal space.[10]

Additionally, using on-demand 3D software from a sagittal perspective, upper airway volumetric analysis was performed in this study both before and after complete denture rehabilitation. The current study's findings demonstrated that the upper airway's mean volume before denture rehabilitation was 5533.50 mm^3, and after denture rehabilitation was finished, it was 6562.39 mm^3. These findings are consistent with a study by Kusunoki T et al.[13] that found that the loss of the vertical dimension of occlusion causes changes in the position of the mandible and hyoid bone, which in turn may affect the size and functionality of the upper airway. The volume of the airway is improved by complete denture rehabilitation, which replaces the lost vertical dimension of occlusion.

According to Smith AM and Battagel JM,[14] moving the mandible forward without increasing the vertical dimension of occlusion and with or without a tongue holding device could result in an increase in posterior airway space.

In edentulous subjects with obstructive sleep apnea, Mayer and Knudson[15] and Malhotra A et al.[16] created a prosthesis to establish a vertical and protrusive jaw position. They discovered that the edentulous patient's posterior airway space expanded dramatically with the prosthesis.

Additional study is required with edentulous patients who have OSA in order to investigate the possibility of using modified complete dentures or allowing permitted adjustments to increase the vertical dimension of occlusion of a complete denture for use as an oral appliance in patients. This will allow researchers to assess the impact of using such modified dentures on orofacial structures and determine whether they will be comfortable for these patients.

Conclusion

In conclusion, before and after complete denture rehabilitation, a statistically significant difference was seen in the oropharyngeal space and airway volume. From the perspective of edentulous patients with obstructive sleep apnea, in which the oropharyngeal and posterior airway spaces are abnormally small, these notable variations are relevant. It is possible to minimize pharyngeal collapsibility and hence reduce apnea-hypopnea episodes in these individuals by providing complete dentures that are made with an acceptable and possibly even improved vertical dimension of occlusion within the limits of tissues acceptance.

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