Original Article

A spirometric and cephalometric comparative evaluation of mandibular advancement devices and occlusal jig

Shaily Ujjwal, Pragati Kaurani, U. Narendra Padiyar, Sudhir Meena, Devendra Pal Singh, Hemant Kr. Sharma

Department of Prosthodontics, MGDCH, Jaipur, Rajasthan, India

Abstract

Aim: Aim of the current study was to evaluate the effect of occlusal jig with increased vertical dimension and mandibular advancement device on the oropharangeal volume in completely edentulous patients using spirometry and cephalometry.

Materials and Methods: The current study included includes 30 completely edentulous patient according to inclusion criteria. They were each subjected to cephalometric and spirometric analysis wearing CCD, OJ & MAD. Results obtained were subjected to following statistical analysis, one-way ANOVA test, unpaired *t*-test, and Dunnett's test.

Result: Both OJ & MAD brings about significant change in oropharangeal volume hence both the devices are effective treatment of choice for OSA, while greater increase was observed in oropharangealvolume of OJ as compared to MAD. Spirometric analysis shows insignificant changes in the oropharangeal volume caused by MAD while OJ causes small but significant change in oropharangeal volume (PIFR].

Conclusion: Within the limitation of the study, it can be concluded that, on cephalometric & spirometric evaluation, OJ shows greater increase in oropharangeal volume when compared to MAD in completely edentulous patient.

Keywords: Conventional complete denture, mandibular advancement device, obstructive sleep apnea, occlusal jig

Address for correspondence: Dr. Pragati Kaurani, C-31, Pratap Marg, Tilak Nagar, Jaipur - 302 004, Rajasthan, India.
E-mail: smile.pragati1@gmail.com
Received: 10th March, 2018, **Accepted:** 21st November, 2018

INTRODUCTION

Obstructive sleep apnea (OSA) is a potentially life-threatening disorder, that is, characterized by repeated collapse of the upper airway during sleep with the cessation of breathing.[1]

Apnea is a Greek word for "without breath." OSA was first described by Charles Dickens as cc in 1837. The estimated prevalence of sleep-disordered breathing (SDB) in urban Indian men was 19.5% apnea–hypopnea index >5 and 7.5% SDB with hypersomnolence.[2] This has major public health implications in developing countries like India.

The symptoms of OSA are (1) loud snoring (all cases of OSA elicit snoring, but all snoring cases need not to have OSA), (2) hypersomnolence (hallmark of OSA),

Access this article online	
Quick Response Code:	Website: www.j-ips.org
	DOI: 10.4103/jips.jips_94_18

How to cite this article: Ujjwal S, Kaurani P, Padiyar UN, Meena S, Singh DP, Sharma HK. A spirometric and cephalometric comparative evaluation of mandibular advancement devices and occlusal jig. J Indian Prosthodont Soc 2019;19:66-73.

(3) feeling of asphyxiation, (4) restless and unrefreshing sleep, (5) change in personality, and (6) nocturia.[3]

Edentulism has been hypothesized to produce OSA by causing anatomical changes such as a decrease in the vertical dimension of occlusion (VDO), change in position of the mandible, and change in position of the hyoid bone. It causes impaired musculature of the oropharynx such as tone in soft palate and pharynx and macroglossia.[4]

Continuous positive airway pressure, surgery, and oral appliance therapy are the major treatment options for OSA patients. Out of these treatments, an oral appliance is regarded as the conservative and noninvasive treatment modality,[5] resulting in higher patient compliance. Oral appliances are mainly mandibular advancement device (MAD), with or without increased VDO. Oral appliance alters the tongue position and also helps in regaining oral pharyngeal volume that is lost after a long span of complete edentulous.[4] The oropharyngeal space can be regained using an occlusal jig (OJ) with increased VDO and MAD. Both these devices have been suggested to be an effective treatment for patients with OSA.[6] However, the comparative evaluation of the effect of these two devices on the oropharyngeal volume is not known, thus the need of a study was felt.

The study conducted included thirty completely edentulous patients. Cephalometric and spirometric analyses of the oropharyngeal volume were done for each patient wearing OJ with increased VDO, MAD, and wearing conventional complete denture (CCD). The null hypothesis was that there is no statistically significant difference in the oropharyngeal volume in a completely edentulous patient wearing OJ with increased vertical dimension and MAD.

MATERIALS AND METHODS

This study was carried out in accordance with the 1964 Declaration of Helsinki criteria. This study was approved by the Institutional Ethical Committee (Ethical Clearance Certificate No. MDCH/MDS/2015) and all patients were informed about the nature of the study and the level of cooperation needed from them, and written consent was obtained from each patient.

Selection of subjects

The completely edentulous patients of the age between 40 and 70 years of either sex with a well-formed alveolar ridges and a Mallampati score of Class II, Class III, and Class IV[7] were selected for this study.

The assessment of Mallampati score was performed with the patient sitting up straight, mouth open, and tongue maximally protruded, without speaking or saying the word "ahh."

While patients with temporomandibular disorder and any systemic involvement, especially respiratory disease such as chronic obstructive pulmonary disease, asthma, and emphysema, were excluded from the study.

Out of the one hundred patients screened, thirty completely edentulous patients, satisfying the inclusion criteria were selected for the study.

Fabrication of devices

Fabrication of conventional complete denture

For each patient, standard CCD was fabricated as per the standard treatment protocols.

Fabrication of occlusal jig with increased vertical dimension

An OJ was fabricated for each of the thirty patients as follows:

The CCD was remounted on a semi-adjustable articulator. The vertical was raised by 3 mm on the semi-adjustable articulator by adjusting incisal guide pin, after petroleum jelly application, DPI self-cure acrylic resin was interposed between the upper and lower complete denture and stabilized with 18"orthodontic wire. Once set, the appliance was removed from the semi-adjustable articulator finished with tungsten carbide bur and polished using bench lathe buff [Figure 1]. The appliance was tried in patients mouth and checked for any interference.

Fabrication of mandibular advancement device

MAD was fabricated for each of the thirty patients.

On the insertion appointment, the patient was asked to wear CCD and protrude the mandible relative to the maximum intercuspation [Figure 2]. The point of

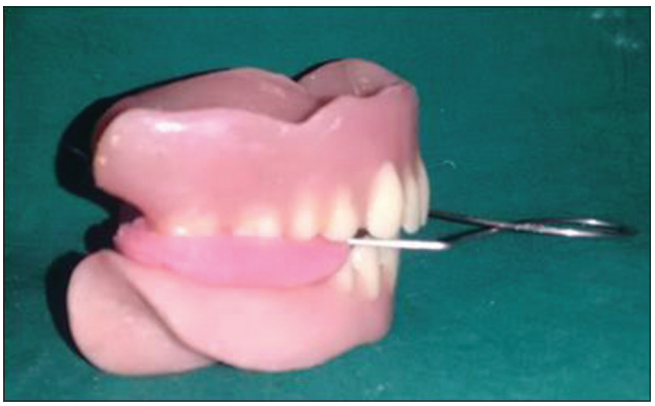

Figure 1: Occlusal jig appliance

maximum protrusion was recorded, and subsequently, 50% of the maximum protrusion was marked on the wooden stick [Figure 3]. The wooden stick with the protrusive mark was transferred to semi-adjustable articulator [Figure 4]. The MAD was fabricated using DPI self-cure resin that was interposed between upper and lower complete denture and stabilized with 18" orthodontic wire. Once set, the appliance was removed, finished with tungsten carbide bur, and polished using bench lathe buff [Figure 5]. The appliance was tried in patients mouth and checked for any interference.

Cephalometric and spirometric recordings

The lateral cephalographs were taken with the patient in an upright position, with the Frankfort horizontal plane (the Frankfurt plane is a line that passes from the bottom of the eye socket through the top of the ear opening)[8] oriented parallel to the floor. To standardize the position of the hyoid bone, the patient was requested to inhale slowly and then exhale[9] before film exposure. Three lateral cephalographs were obtained for each of the thirty patients wearing:

1. CCD
2. CCD with OJ
3. CCD with MAD.

An acetate tracing paper of the proper size was affixed to the cephalograph with scotch tape. The cephalograph was then positioned on the X-ray illuminating table (X-ray viewer) so that the profile faces the right when it was viewed [Figures 6-8]. Landmarks and reference lines were then drawn on acetate tracing sheets to calculate linear measurements.

Following cephalometric reference points were identified [Figure 9]:

1. apw – Point on anterior wall of the oropharynx
2. ppw – Point on posterior wall of the oropharynx
3. Cervical vertebrae (cv2ia) – The most anteroinferior point on the corpus of the second cervical vertebrae
4. cv4ia – The most anteroinferior point on the corpus of the fourth cervical vertebrae
5. hy – The most superior and anterior point on the body hyoid bone

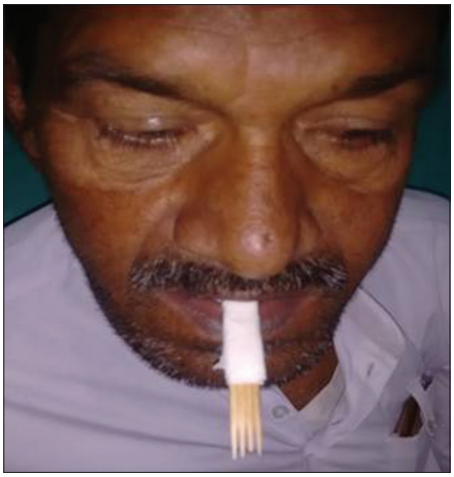

Figure 2: Recording 50% of maximum protrusion

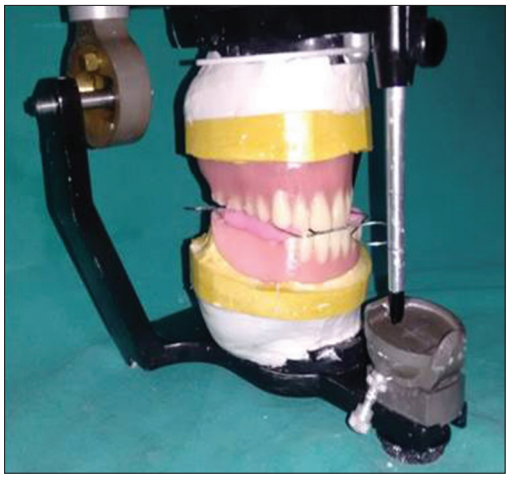

Figure 4: Mandibular advancement device appliance with 50% of maximum protrusion

Figure 3: Recording 50% of maximum protrusion

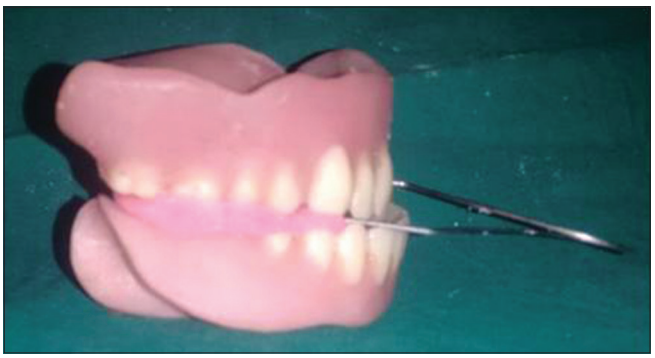

Figure 5: Mandibular advancement device appliance

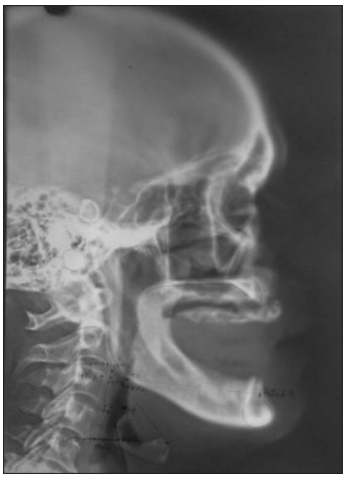

Figure 6: Cephalometric analysis of patient wearing conventional complete denture

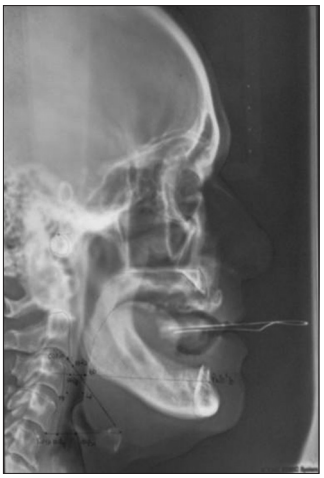

Figure 7: Cephalometric analysis of patient wearing occlusal jig

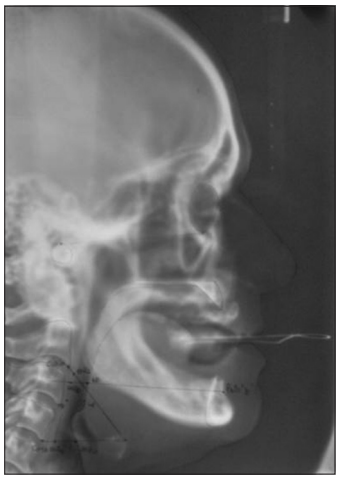

Figure 8: Cephalometric analysis of patient wearing mandibular advancement device

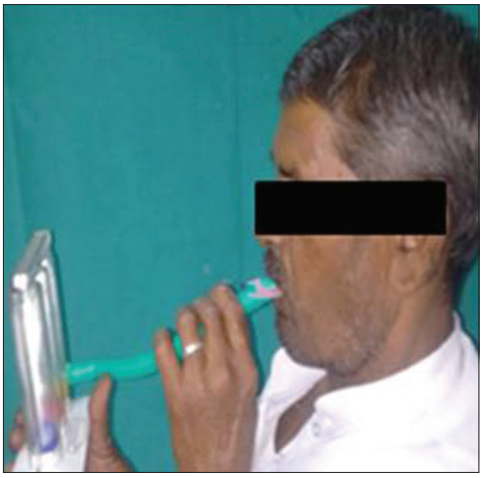

Figure 9: Patient giving spirometric recording for each appliance

6. Posterior pharyngeal wall 2 (ppw) – The ppw along the line intersecting cv2ia and hy
7. Anterior pharyngeal wall 2 (apw) – The apw along the line intersecting cv2ia and hy
8. ppw4 – The ppw along the line intersecting cv4ia and hy
9. apw4 – The apw along the line intersecting cv4ia and hy
10. Base of the tongue (tb) – The intersection point of a line from point B through go and the base of the tongue
11. Point B (supramentale) – The point at the deepest midline concavity on the mandibular symphysis between infradentale and Pogonion
12. ppwb – The intersection point of a line from B through go and the base of the ppw.

The cephalometric analysis was used to describe the following:

1. Retropharyngeal space (RPS) (apw-ppw) – The smallest distance between the apw and ppw in mm
2. Posterior airway space (PAS) (ppwb-tb) – Linear distance between a point on the base of tongue (tb) and another point on the ppwb in mm
3. apw2-ppw2 – Pharyngeal depth at the level of the second cervical vertebrae in mm
4. apw4-ppw4 – Pharyngeal depth at the level of the fourth cervical vertebrae in mm.

The above analysis was done on three cephalographs taken of (CCD, OJ, and MAD) each of the thirty patients. All the tracings were done by the same investigator.

The following tests were taken into consideration for spirometric analysis:

1. Forced vital capacity (FVC) – It equals the amount of air that can be forcefully exhaled after complete inspiration in cc
2. Forced expiratory volume (FEV1%) = $FEV_1/FVC \times 100$ – This ratio is an invaluable indicator of respiratory

disease and allows separation of ventilator abnormalities into "restrictive" or "obstructive" patterns
3. FEV_1 – It equals the volume of air exhaled during the first second of expiration
4. Peak inspiratory flow rate (PIFR) – It is PIFR during inspiration and represents extrathoracic airways in milliliter per second.

Each of the above tests was performed on each of the thirty patients wearing – CCD, OJ, and MAD [Figure 10].

All the readings were recorded by the same investigator.

RESULTS

A total of thirty completely edentulous patients of either sex from 40 to 70 years were subjected to cephalometric and spirometric analyses while wearing CCD, OJ, and MAD and values were recorded Table 1. The results obtained were subjected to statistical analysis using one-way ANOVA test, unpaired *t*-test, and Dunnett's test.

1. One-way ANOVA was applied to compare the means of the groups which had shown statistically significant difference between all the interventional groups (CCD, OJ, and MAD) on cephalometric analysis ($P < 0.001$), whereas statistically insignificant difference was found between the groups in all the spirometric analyses ($P > 0.001$) (FVC, FEV1%, and PIFR) [Table 2]
2. Dunnett's test was applied as *post hoc* test which had compared both the interventional groups OJ and MAD with the CCD. The result showed statistically significant difference between CCD and OJ ($P < 0.001$) as well as CCD and MAD ($P < 0.001$) in all the cephalometric analyses, whereas the insignificant difference was found between CCD and OJ and CCD and MAD in all spirometric analyses ($P > 0.001$), [Table 2]
3. Unpaired *t*-test was applied to compare the interventional groups OJ and MAD which showed statistically significant difference between OJ and MAD in all the cephalometric analyses ($P < 0.001$) [Table 2], whereas the insignificant difference was found in all spirometric analyses ($P > 0.001$), [Table 3].

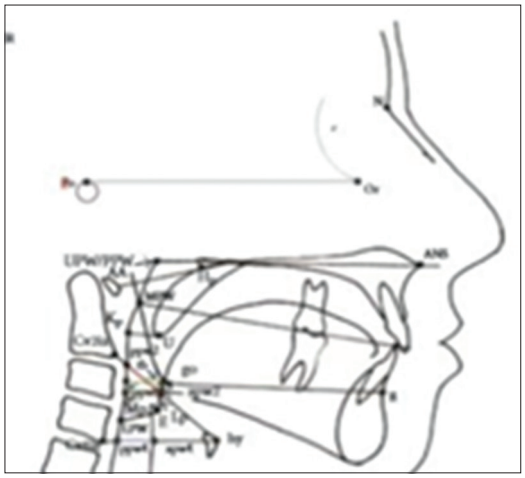

Figure 10: Cephalometric reference points

DISCUSSION

According to Gupta *et al*., edentulism leads to decrease in size and tone of the pharyngeal musculature.[6] It also

Table 1: Lateral cephalometric values

	Range (maximum–minimum)	Mean value	Percentage increase in comparison to control group
Retropharyngeal space (mp-lp) in mm			
CCD	10-4	5.7	0
OJ	11-6	7.9	38
MAD	12-5	7.17	25
Posterior airway space in mm			
CCD	9-4	5.3	0
OJ	11-7.4	8.78	65.6
MAD	11-6.7	7.97	49
apw2-ppw2 in mm			
CCD	9-4	8	0
OJ	11-6	9	12.5
MAD	10-5.8	8.9	11.2
apw4-ppw4 in mm			
CCD	8.4-6	6.7	0
OJ	10-6.3	8.3	23.3
MAD	9-6.3	7.59	13.2

CCD: Conventional complete denture, OJ: Occlusal jig, MAD: Mandibular advancement device, apw: Anterior pharyngeal wall, ppw: Posterior pharyngeal wall

Table 2: Statistical analysis of cephalograph and spirometric values

	One-way ANOVA (*P*)	Dunnett "D" test A=*P* value between CCD and OJ B=*P* value between CCD and MAD	Unpaired *t*-test (*P*)
Retropharyngeal space (mp-lp) in mm	<0.001	A=0.000 B=0.000	0.043
Posterior airway space (tb-ppw2) in mm	<0.001	A=0.000 B=0.000	0.000
apw2-ppw2 in mm	<0.001	A=0.000 B=0.003	0.018
apw4-ppw4 in mm	<0.001	A=0.000 B=0.003	0.003
FVC	>0.001	A=0.000 B=0.000	0.043
FEV1 percentage	>0.001	A=1.000 B=0.881	1* (NS)
PIFR in cc/s	>0.001	A=1.000 B=1.000	0.296 (NS)

CCD: Conventional complete denture, OJ: Occlusal jig, MAD: Mandibular advancement device, FVC: Forced vital capacity, FEV_1: Forced expiratory volume 1 s, PIFR: Peak inspiratory flow rate, NS: Not significant, tb: Base of the tongue

Table 3: Spirometric values

	Range (maximum-minimum)	Mean value	Percentage increase in comparison to control group
FVC			
CCD	200–60	92.6	0
OJ	200–60	92.6	0
MAD	200–60	92.6	0
FEV1 percentage in predicted			
CCD	45.4–15	28.54	0
OJ	45.4–15	28.54	0
MAD	45.4–15	28.54	0
PIFR L/S			
CCD	130–90	107.7	0
OJ	200–90	133.3	23.49
MAD	180–90	130.7	21.3

CCD: Conventional complete denture, OJ: Occlusal jig, MAD: Mandibular advancement device, FVC: Forced vital capacity, FEV_1: Forced expiratory volume 1 s, PIFR: Peak inspiratory flow rate

causes a reduction of the lower face height and rotation of the mandible and changes in the position of the hyoid bone, and this becomes a crucial risk factor for OSA. Dentures are intended to restore this natural anatomy and are being recognized to cause changes in the mandible, tongue, soft tissue, and the pharyngeal airway space to prevent or reduce OSA in edentulous patients.[10] Therefore, in this study, each of the thirty patients was treated with CCD as per the standard treatment protocols to regain lost anatomical features and were treated as the control group. Increased VDO has also shown to be an effective treatment modality for OSA patients by researchers. Abdallah *et al*. in his findings of the study showed that an increased vertical dimension produces a significant increase in the cross-section area of the velopharynx.[11] The findings of Abdallah *et el*. supported with the findings of Naggner and Sanner who used the upper airway closing pressure method to show improvement in the upper airway patency by increasing the vertical dimension.[12] Similarly, Gupta *et al*. found in his study that increasing the VDO by about 2–3 mm using custom-made acrylic OJ results in an increase in the RPS, thereby relieving OSA.[6] Therefore, in the present study, an adjustable custom-made acrylic OJ was fabricated for increased VDO by 3 mm. It was prepared using the same method as suggested by Gupta *et al*. and was treated as the second group.

MAD treatment at 50% of the maximum protrusion position, particularly in mild and moderate cases, provides satisfactory results.[13] In 1990, adjustable MADs became the predominant form of dental therapy for OSA. MAD opens the upper airway by moving the mandible forward, which reduces the upper airway collapsibility[14] (e.g., by improving the upper airway muscle tone). This device helps in sustaining upper airway patency. Keyf *et al*. device was fabricated with the advancement of 75% of the maximum protrusion of the patient's maximum advancement of the mandible to achieve maximum comfortable protrusion.[15] Piskin *et al*. reported modified MAD which displaces bulky muscles laterally to provide more space for the tongue in edentulous patients.[16] Therefore, in this study, an adjustable custom-made MAD was fabricated for each of the thirty patients using the same method and was treated as the third group. Even though both OJ and MAD have been suggested to be an effective treatment for patients with OSA,[6] a comparative evaluation of the effect of these two devices on oropharyngeal volume is not known. Therefore, in this study, we compared and evaluated both the treatment modalities for a completely edentulous patient and its effect on an oropharyngeal volume using cephalometry and spirometry.

According to a study by Salles *et al*., it was reviewed that the cephalometric analysis is a valuable tool for the diagnosing OSA and should be considered among the routine examinations.[17] Cephalometry is a diagnostic procedure to collect information on skeleton abnormalities and soft tissues of patients with OSA.[15] Padmanabhan *et al*. evaluated PAS in edentulous patients with the insertion of the denture using cephalometry.[18] Therefore, in the present study, cephalometry has been used to compare and evaluate the changes in the oropharyngeal volume in completely edentulous patient with CCD, OJ, and MAD.

According to the ATS guidelines that are given for interpretation of spirometry, FVC, FEV1%/FVC, and FEV1% are the only measurements that should be used for ventilatory defects.[19] Various researchers have used spirometry as a method for measuring lung volumes in OSA patients. Bucca *et al*. found the effect of dentures in PIFR FEV FVC in OSA patients using spirometric analysis.[19] Similarly, Vukoja *et al*. using spirometry assessed OSA patients and concluded that airway resistance measured is higher in OSA patients.[20] Therefore, in the current study, spirometry was used.

The present study result showed that statistically significant difference was found in the RPS in patients wearing OJ and MAD in comparison to CCD. These values were found to be lesser in the same subjects on wearing MAD when compared to OJ (25% increase in RPS and $P < 0.001$). It was also found in the study that significant changes were observed in PAS, pharyngeal depth at c2 vertebrae, and pharyngeal depth at c4 vertebrae both in OJ and MAD when compared to CCD, but OJ brings about a greater increase in the above spaces when compared to MAD.

Thus from the above analysis, it is clear that increasing the vertical dimension by 3 mm helps in greater increase in oropharyngeal space when compared to MAD. Our findings are similar to the findings of previous researchers.[6]

Pitsis *et al*. proposed that the downward stretch of the upper airway by increasing the vertical dimension is as effective as anterior expansion (MAD) in maintaining its patency.[21] Altering the VDO with oral appliances may increase tongue activity, mainly genioglossus muscles activity, thereby improving SDB. Chen *et al*. found that genioglossus muscles myoelectric decreases slowly and results in airway obstruction in edentulous patients.[22] By increasing myoelectric activity of the genioglossus muscle, contraction increases, which pushes the tongue forward and thus enlarges the retroglossal airway space.[22] Moreover, Gupta *et al*. in his finding had concluded that increasing the vertical dimension by 3 mm will help to suppress the symptoms of OSA. Similarly, Abdallah *et al*. had also supported with his study that increasing the vertical dimension will increase the cross section of velopharynx, thereby increasing the oropharyngeal volume.

The current study shows that MAD does bring about significant changes in the anatomical structures when compared to CCD even though the observed changes are less than those caused by OJ. The increase in the anatomic spaces may be due to reasons stated by Jayesh and Bhat who reviewed that MAD induces changes in the position of the hyoid bone toward a more forward position.[23] It creates a new position of balance of the suprahyoid musculature, which in turn, favors an increase in volume and permeability of the upper airway. The upper airway is widened, particularly in its lateral dimension. The pharyngeal fat pads relocate laterally from the airway and the tongue base muscles move anteriorly. This leads to a reduction in pharyngeal collapsibility. Keyf *et al*. stated that MAD causes mechanical advancement of the mandible, and thereby increases the anteroposterior dimensions of the oropharynx.

Although both the interventions (OJ, MAD) bring about significant change in oropharyngeal volume, percentage increase in oropharyngeal volume was greater in OJ when compared to MAD (23.49% compared to 21.3%).

Thus, it can be concluded, with cephalometric analysis, that OJ brings about a greater increase in oropharyngeal volume in comparison to MAD in completely edentulous patients.

Limitations of the study

The sample size chosen was thirty patients; however, a greater sample size would lead to more accurate results. Second, with the recent advances in three-dimensional (3D) imaging, more accurate analysis of the faciomaxillary region is possible. However, because of the increase in cost involved with 3D imaging, cephalometric analysis was chosen. The sample size chosen was normal edentulous patients. Further studies are suggested to further testify the above result on patients with OSA.

CONCLUSIONS

The current study was undertaken to compare and evaluate the oropharyngeal volume in completely edentulous patients wearing CCD, OJ, and MAD using cephalometric and spirometric analyses.

Within the limitations of this study, it can be concluded that:

1. Both OJ and MAD bring about significant change in oropharyngeal volume when evaluated using cephalometry
2. Greater increase in oropharyngeal volume was found in OJ as compared to MAD when evaluated using cephalometry
3. Spirometric analysis shows insignificant changes in the oropharyngeal volume by both MAD and OJ.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given his consent for his images and other clinical information to be reported in the journal. The patient understands that name and initials will not be published and due efforts will be made to conceal identity, but anonymity cannot be guaranteed.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Bharadwaj R, Ravikumar A, Krishnaswamy NR. Evaluation of craniofacial morphology in patients with obstructive sleep apnea using lateral cephalometry and dynamic MRI. Indian J Dent Res 2011;22:739-48.
2. Randerath WJ, Verbraecken J, Andreas S, Bettega G, Boudewyns A, Hamans E, *et al*. Non-CPAP therapies in obstructive sleep apnoea. Eur Respir J 2011;37:1000-28.
3. Prabhat KC, Goyal L, Bey A, Maheshwari S. Recent advances in the management of obstructive sleep apnea: The dental perspective. J Nat Sci Biol Med 2012;3:113-7.
4. Murali Mohan S, Gowda EM, Banari AS. Obstructive sleep apnea (OSA): A prosthodontic perspective. Med J Armed Forces India 2015;71:S395-9.
5. Pimentel MJ, Bacchi A, de Castro GC, Rizzatti-Barbosa CM. Oral

appliance for the treatment of severe obstructive sleep apnea in edentulous patient. J Indian Prosthodont Soc 2014;14:255-9.
6. Gupta P, Thombare R, Pakhan AJ, Singhal S. Cephalometric evaluation of the effect of complete dentures on retropharyngeal space and its effect on spirometric values in altered vertical dimension. ISRN Dent 2011;2011:516969.
7. Manabe Y, Iwamoto S, Miyawaki H, Seo K, Sugiyama K. Mallampati classification without tongue protrusion can predict difficult tracheal intubation more accurately than the traditional mallampati classification. Oral Sci Int 2014;11:52-5.
8. Hegde V. Significance of the Frankfort mandibular plane angle in prosthetic management of partially or completely edentulous patient of class 11 malocclusion. J Indian Prosthodont Soc 2005;5:175-9.
9. Dubey A, Upadhyay S, Mathur S, Kant S, Singh BP, Makwana R, *et al*. Comparative evaluation of craniofacial anthropometric measurements in Indian adult patients with and without obstructive sleep apnea: A pilot study. J Indian Prosthodont Soc 2015;15:331-6.
10. Heidsieck DS, de Ruiter MH, de Lange J. Management of obstructive sleep apnea in edentulous patients: An overview of the literature. Sleep Breath 2016;20:395-404.
11. Abdallah RM, Rashad HA, Kashef NA, El-Sheikh MN, The effect of changes in the intermaxillary distance in mandibular advancement splints as a treatment of obstructive sleep apnea. Tanta Dent J 2016;13:193-8.
12. Ng AT, Gotsopoulos H, Qian J, Cistulli PA. Effect of oral appliance therapy on upper airway collapsibility in obstructive sleep apnea. Am J Respir Crit Care Med 2003;168:238-41.
13. Rashmikant US, Chand P, Singh SV, Singh RD, Arya D, Kant S, *et al*. Cephalometric evaluation of mandibular advancement at different horizontal jaw positions in obstructive sleep apnoea patients: A pilot study. Aust Dent J 2013;58:293-300.
14. Sivaramakrishnan G, Sridharan K. A systematic review on the effectiveness of titratable over nontitratable mandibular advancement appliances for sleep apnea. J Indian Prosthodont Soc 2017;17:319-24.
15. Keyf F, Ciftci B, Fırat Güven S. Management of obstructive sleep apnea in an edentulous lower jaw patient with a mandibular advancement device. Case Rep Dent 2014;2014:436904.
16. Bulent P, Fatih S, Haldun S, Hakan A, Kaan G, Murat K, *et al*. Efficacy of a modified mandibular advancement device for a totally edentulous patient with severe obstructive sleep apnea. Sleep & Breathing = Schlaf & Atmung 2009;14:81-5.
17. Salles C, Flores Campos SP, de Andrade NA, Daltro C. Obstructive sleep apnea and hypopnea syndrome: Cephalometric analysis. Rev Bras Otorrinolaringol 2005;71:369-72.
18. Padmanabhan TV, Banu RF, Mahalakshmi A, Aziz A, Bohra S, Kumar VA, *et al*. Dimensional change in soft tissues with complete dental prosthesis and its effect on airway space and natural head position. Indian J Dent Res 2015;26:144-7.
19. Bucca CB, Carossa S, Colagrande P, Brussino L, Chiavassa G, Pera P, *et al*. Effect of edentulism on spirometric tests. Am J Respir Crit Care Med 2001;163:1018-20.
20. Vukoja M, Milicic D, Bokan A, Andrijevic IK. Lung function in patients with obstructive sleep apnoea. ERJ Open Res 2017;46:318-20.
21. Pitsis AJ, Darendeliler MA, Gotsopoulos H, Petocz P, Cistulli PA. Effect of vertical dimension on efficacy of oral appliance therapy in obstructive sleep apnea. Am J Respir Crit Care Med 2002;166:860-4.
22. Chen LY, Ye JY, Cui JH. The study of genioglossus muscle activity on patients with obstructive sleep apnea hypopnea syndrome. Chin Arch Otolaryngol Head Neck Surg 2005;12:453-7.
23. Jayesh SR, Bhat WM. Mandibular advancement device for obstructive sleep apnea: An overview. J Pharm Bioallied Sci 2015;7:S223-5.