

Research Article

Comparative Evaluation of the Inter-Occlusal-Distance and Closest Speaking Space in Different Angle's Occlusion Classes

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Abstract

Objectives: Measuring the Vertical Dimension (VD) and Inter-Occlusal-Distance (IOD) is necessary for fabrication of fixed or removable prostheses. Generally, IOD is considered as 2 to 4 mm in the first-premolars-region of all patients which is questionable. Because IOD may be different in Angle class I, II, and III. The objective of current research was to examine IOD in different-occlusion-classes in Iranian population.

Materials and methods: This cross-sectional-research was carried out on 124 students of different faculties of Tehran University (N=124). 74 of them were Class I, 25 were Class II, and 25 were Class III. 62 male and 62 female students were included in the study. The selected students seated on a dental unit in vertical position without headrest and asked to look forward. Vertical Dimension of Occlusion (VDO) and Vertical Dimension of Rest Position (VDR) were measured using three different methods (swallowing, phonetics, and tactile sense). The difference between VDO and VDR was recorded as IOD of that technique. In order to determine the VD, Nasion and Menton distance was measured using a digital caliper. For determining the Closest-Speaking-Space (CSS), the students were asked to pronounce a hissing-sound-letter. Then the incisal edges of the maxillary central teeth were marked on the labial surfaces of the mandibular-central-teeth during pronouncing these letters. Another mark was drawn in Maximum-Inter-Cuspal-Position (MIC). The difference between these two marks were calculated as CSS.

Results: The means of IODs in the students with Angle's occlusion of class I, II, and III were 2.61, 2.52 and 2.40 mm, respectively. The means of CSS in the students with Angle's occlusion of class I, II, and III were 2.42, 3.28 and 1.02 mm, respectively. There were not any significant differences between different occlusion classes in IODs. But, there were statistical differences between them in CSSs. There was not any significant relationship between age and gender of the students and IOD and CSS.

Conclusions: According to the current study, IOD values in a specific occlusion with each of three methods were significantly different. CSS values in people with different occlusion classes were significantly different. There was no significant relationship between the age and gender of the studied people. IOD and CSS values in the age range of the investigated people had no statistical differences.

Keywords: Vertical Dimension of Occlusion Vertical Dimension of Rest; Closest Speaking Space; Inter Occlusal Distance

Introduction

Determining the Vertical Dimension of Occlusion (VDO) is one of the most important factors in full-mouth-reconstruction with fixed prostheses and Complete Dentures (CD) in patients with different Angle's-occlusion-classes I, II, and III. Determining the

exact VDO is also important in treatment of some Temporomandibular Disorders (TMD). Altering the Vertical Dimension (VD) can effect on the patient's phonetic.

Nowadays, IOD is conventionally considered to be 2-4mm for fabrication of CD in Angle's different occlusion classes (i.e. I, II, and III), according to Niswonger ME [1]. Of course, Niswonger had evaluated 200 dentate patients and explained that 83% of these patients had IOD=3mm. He observed that none of the studied patients had IOD more than 6mm or less than 3mm [1]. However,

using the same IOD for all occlusion classes and all nations seem to be irrational [2]. In addition, many interfering factors may cause changes in IOD in different people and even in one person during the life span. Some of these factors include reduced-muscles-tonicity due to age increase, changes in skin texture because of losing weight and loss of sub-cutaneous-fats, severe-tooth-wear, changes in VDR, and abnormal contraction of skin and facial muscles.

Generally, Maxillomandibular Relationship (MMR) are evaluated as horizontal and vertical relationships. VDO and Vertical Dimension at rest position (VDR) are used to determine the vertical relationship of maxilla and mandible. In the clinic, the Physiological-Rest-Position (PRP) is frequently considered as a reference point for determining the VDO. In fact, PRP is a normal position of the mandible which is considered as VDR. In order to determine PRP, the patient should be in either sitting or standing-relaxed-position. The mandibular position (e.g. in PRP) is always maintained under interaction effect of three mechanisms including muscle tonus, myostatic reflex, and gravity. In completely-edentulous-patients and full-mouth-reconstructions, exact determination of VDO, VDR, and Inter-Occlusal-Distance (IOD) is mandatory for regaining the esthetics, mastication, and phonetics.

Obviously, one of the main reasons of failure in prosthetic treatment is incorrect registration of VD. If VDO is recorded less than normal, it may cause facial-form-discrepancy and will decrease the masticatory forces. Other consequences of reduced VDO include over-closed-mouth (i.e. the chin is too close to the nose), chin protrusion, dropping of the mouth corners, less visibility of the lips redness, and reduced tonicity of the muscles. TMDs and hearing problems are other complications of reduced VDO [3-7].

Increased VDO may also lead to serious damages to the whole masticatory system. Muscular tension, bruxism, clenching of the teeth during speech, phonetic and esthetical problems are among other consequences of increased VDO. Complications of increased VDO are usually more detrimental compared to those of reduced VDO. So that increased VDO may lead to failure more frequently [3-7].

Various current studies tried to find correlation between VDO and other facial distances and even fingers lengths in different populations and different sex groups [8-18]. Some of these studies claimed that there were correlations between VDO and inter-pupillary distance and Nasion-Sella distance in men [8,12]. Some other articles expressed that there was no correlation between VDO and their studied-facial-measurements [17,18]. However; most of the researched articles expressed that there was correlation between VDO and their facial measurements, fingers lengths, and etc. [9-11,13-16].

Closest-Speaking-Space (CSS) shows the VD of patient's face when mandible and the related muscles are in the physiological function of speech (i.e. during pronouncing the hissing-sound-letters such as s, sh, z, ch, and so on). Different researchers had

recorded CSS between 0 to 10mm [4,19-21].

IOD can also be used for evaluating the patient's VD. IOD should be recorded during patient's PRP. IOD mainly depends on the physiologic-repeated-length of the elevator muscles of mandible. VDR can be measured during different methods such as swallowing (S), muscles fatigue, anatomical landmarks, phonetics (Ph), tactile sense (T), and appearance. Teeth can maintain their eruption potential throughout human's life. One of the controlling factors of teeth eruption is the balance between muscles forces and the teeth-eruption-forces. The balance between these two forces causes the maxillomandibular distance remains almost constant and does not change because of teeth wear resulted from bruxism, erosion, abrasion, etc. Several factors are involved in determining the VDO during the childhood, including relative length of opening and closing muscles, eruption force of the teeth, and alveolar process growth [22].

Two of the main controlling factors of PRP include: (a) the muscles which can close, open, protrude, and retrude the mandible, and (b) the patient's head position. As a result of complete loss of natural teeth, the neonatal pattern of swallowing is repeated. CD replacement allows the patient to regain the adult pattern of swallowing [3-7].

According to Dawson, although VDO is measured when the teeth are completely occluded, but teeth are not regarded as a determining indicator for VD. However, VDO is more related to the general height of maxilla which is fixed in each patient at a specific age and to the position of mandible which is maintained with the muscles [22]. Some researchers have tried to determine VDO and VDR using transcutaneous-electrical-neural-stimulation (TENS). However, Williamson indicated that the PRP measured with TENS had a significant difference with clinical RP [21].

Niswonger believed that rest position and VDR are stable and unchanged [1]. However; Atwood and Tallgren in their studies claimed that PRP and VDR are not stable [20,23]. Additionally, Atwood stated that RP may change up to 4mm during one appointment and may even change more than 4mm in the next sessions [21].

Although PRP is not a definite and accurate guide, but it can specify the VDR correctly especially if it is used along with other methods. IOD of CD wearers should be 2-4 mm in the premolars area [3].

Winkler believed that PRP is a borderline position, and explained that there should be 2.5-3mm IOD in the premolars area, which depends on several anatomical, physiological, and psychological factors [6]. Yemm Berry explained that PRP is a passive balance, controlled with gravity and the elastic quality of mandibular tissues and muscles [24].

Dawson claimed that the Closest-Speaking-Space (CSS) presented by Silverman gives the best reliable and stable method for recording VD in patients who do not have any natural-occlusal-stopping-

points. The obtained VD is repeatable and accurate even after several months [22,25].

CSS method used to measure VD using phonetic method should not be mistaken with the IOD (so-called free-way-space) of the physiological method. CSS and FWS are two different measurement methods. Burnetiet al carried out a review study to determine the VDO using the CSS. They concluded that pronunciation of vowel sounds causes the jaws to be placed in a special position in which CSS can be used for determining the patient's VDO [26].

Rivera Morale et al.in their study in 1991 at New York University concluded that CSS has significant relationship with VDO. They concluded that CSS is better than VDR to record VDO [27]. There are different mechanical and physiological methods to determine VDR. Mechanical methods include records of pre-extraction of the teeth, the parallelism and relationships of ridges. Physiological methods also include PRP and speech. Patient's comfort and esthetics can also be used to confirm the measured VDR, by experienced clinicians [3].

Several methods have been introduced to determine the IOD. All the previous studies searched by the authors have evaluated IOD only in occlusion Class I. The objective of this research was to investigate IOD in a sample of Iranian population consist of Angle's occlusion classes I, II, and III. According to the null hypothesis of the current study, there would be no statistically differences between VDO, VDR, IOD, CSS in different age groups and different Angel's occlusion Classes.

Materials and Methods

A cross sectional study was carried out. The sample size of the current study was 124 people (N=124). 74 students of them had occlusion class I (n=74), 25 of them had occlusion class II (n=25), and 25 of them had occlusion class III (n=25). The selected students included 62 females and 62 males and their ages were ranged between 18 and 40 years. The sample size was estimated by the statistician using statistical-software-program.

The researchers evaluated the studied population, from different faculties of Tehran University of Medical Sciences. After interviewing and initial examination, students who met the inclusion criteria were selected. The characteristics of these students and the results of clinical examinations were inserted in a questionnaire designed for this purpose. The inclusion criteria were included:

- 1-Presence of all the natural maxillary and mandibular posterior and anterior teeth (i.e. completely-dentate-students).
- 2- Absence of bruxism, clenching, and severe-teeth-wear.
- 3-Lack of any orthodontic-treatment- history.
- 4-Lack of any asymmetry and/or mandibular deficiency.

5-Lack of any functional disorder and/or pain in the neuromuscular system.

6- Lack of abnormal contraction of skin and/or facial muscles,

7- Lack of any temopromandibular disorder (TMD).

The relation of the first molars in the selected students were examined. According to Angle's classification in the 1890s, in Class I occlusion, mesiobuccul cusp of the maxillary first molar occludes in the buccal groove of the mandibular first molar. In Class II, and III malocclusion, mandibular first molar distally, and mesially positioned relative to the maxillary first molar, respectively. In the current study, anteriorposterior curving line of occlusion was not considered.

The students were asked to sit upright on the chair while their heads had no rest and they looked forward. The distance between Nasion and Menton (under the chin) was recorded clinically using a digital caliper with an accuracy of 0.01mm. The fixed parts of the caliper were placed in Nasion and Menton, in a way that no pressure was imposed on the skin and chin muscles and it did not induce any stimulation for the studied student. First VDO and then VDR were measured. As the students should not be provoked, nervous, or tired during the measurements and should have acceptable level of mental relaxation and readiness, all measurements were performed in the early hours of day (between 8:30 am to 10:30 am).

According to Heartwell [5], before recording VD the following points should be taken into consideration:

1-Gravity can affect mandibular position. So that the preferred position of the patient is to sit in an upright and comfortable position. The patient's head should be upright and he should look forward.

2-PRP is a relaxed position of the mandible. So that the clinician should not record VDR, when the patient is excited, nervous, tired or provoked. In addition, even if the clinician is stressful, nervous, tired, or provoked, the recorded VDR may be questionable.

3- Determining the MMR is too difficult in patients with TMDs and/or musculoskeletal disorders. These disorders should be treated before registering the patient's MMRs and VD.

4-PRP is a spatial position, which cannot be maintained for a long period of time. Thus, the dentist should measure PRP immediately.

5. As there is not one universal, accepted, and valid method to determine the PRP in all patients, it is preferable to use several methods and compare the results for each patient.

6-When mandible is in PRP, the IOD should exist between the teeth. Lack of IOD in artificial teeth will lead to discomfort, pain, and generalized hyperemia. Finally, bone loss will consequently

occur. During PRP, lips should have partial contact with each other from the profile view.

In the current research, the VD of face was calculated using the following methods (S, Ph, and T), and IOD was obtained for each method. Then, the CSS was measured in Angle's different-occlusal-classes. In tactile method, the patient was asked to open his mouth as wide as possible and maintain this maximum opening until the jaws, the related muscles, and temporomandibular joint get tired. Then, the patient was asked to guide the mandible to the most comfortable position that has not any muscular contraction and/or stretching during closing or opening the mouth. In this position the teeth should have no contact with each other. The vertical height of the face (the distance from Nasion to Menton), is measured and recorded by the caliper and was considered as the VD in tactile method.

In the swallowing method, the students were asked to swallow their saliva. At the end of each swallowing, the mandible was guided to CR which is considered as PRP. In CR, the teeth are separated from each other and the neuro-muscular-system of the jaws is at the most comfortable position. The VD in CR during swallowing was measured as VDR in swallowing method.

In phonetic method, the students were asked to pronounce the words ending to letter M such as the word "Mommm". By pronouncing the bilabial letter M, the patient's lips contact, while the teeth are apart from each other and the jaws and the relevant neuro-muscular system are in the rest position. In this technique, like the others, the distance between Nazion and Menton was measured as VDR in phonetic method.

In order to achieve CSS between the anterior teeth during speech, the patient occlude the teeth in centric occlusion (CO). In CO, the intersection of the incisal edges of the maxillary-anterior-teeth on the labial surface of the mandibular-anterior-teeth were marked. This line was considered as CO line. Then, the patient was asked to pronounce one of the hissing sounds, such as words "30-33", and "60-66". While slightly opening the mouth and leaving the CO position. Then in this position, the new place of the interception of maxillary-centrals-incisal-edges on the mandibular-centrals-labial-surfaces was marked. The second line indicated the closest-speaking-line. The distance between the first and second lines was measured by caliper and was recorded as CSS of the patient.

Finally, VDO, VDR, and CSS were measured using tactile, swallowing, and phonetic methods. Then by subtracting VDO from VDR, the IOD in each method was recorded in mm.

One-way ANOVA was used to compare the mean of IOD and CSS in different occlusion classes, age groups, and gender groups. Kruskal-Wallis nonparametric test was used to compare the mean of different methods for measuring IOD in each occlusion class. To compare the mean of CSS and IOD in different methods, paired t-test was used.

Results

All data resulted from the questionnaires were statistically analysed using stata-8 and SPSS-11 software. The relative frequency and distribution of IODs in all studied methods and in different occlusal classes were analysed and their differences in different occlusion classes, age, and gender were examined.

Table (1) indicates that the mean of IODs in all three occlusion classes has no significant difference when measured with one method. But in a student (with a specific occlusion class), IODs measured with different methods had significant differences with each other. The maximum IOD was related to the phonetic method. One-way ANOVA was used to analyse the data.

Measurement method Occlusion Classes	Phonetic Mean (SD)	Swallowing Mean (SD#)	Tactile Mean (SD)
I	2.95(0.89)	2.43(0.94)	I
II	2.82(1.06)	2.36(0.97)	II
III	2.78(0.82)	2.14(0.80)	III
P-value	NSD	NSD*	P-value
* SD means standard deviation. *NSD means not statistically different.			

Table 1: The means of IOD values in three different methods and in different occlusion classes are compared.

According to table 2, in phonetic method, the resulted IODs for each of occlusion classes did not have any significant differences in all different age groups. The data were analysed using one-way ANOVA test.

Different age groups Occlusion Classes	25-31 Mean (SD)	18-24 Mean (SD)	32-42 Mean (SD)
I	2.73(0.79)	3.06(0.94)	2.75(0.77)
II	3.5(1.73)	2.64(0.91)	2.79(0.91)
III	2.83(0.75)	2.82(0.67)	2.6(1.34)
P-value	NSD	NSD	NSD

Table 2: The means of IODs using phonetic method in different age groups and different occlusion classes are presented.

Table 3 shows that the means of IODs in swallowing method for each of three occlusion classes were not significantly different among three different age groups. The data were analysed using one-way ANOVA test.

Different age groups Occlusion Classes	32-42 Mean (SD)	25-31 Mean (SD)	18-24 Mean (SD)	P value
I	2.52(0.94)	2.45(1.04)	2.13(0.89)	NSD
II	2.018(0.89)	2.75(1.26)	2.5(1.04)	NSD
III	2.14(0.63)	2.08(0.80)	2.2(1.30)	NSD

Table 3: The means of IOD values using swallowing method in different age groups and in different occlusion classes are presented.

As Table 4 shows, the means of IODs resulted from tactile method for each of three occlusion classes were not significantly different among three different age groups. The data were analysed using one-way ANOVA test.

Different age groups Occlusion Classes	32-42 Mean (SD)	25-31 Mean (SD)	18-24 Mean (SD)	P value
I	2.53(0.75)	2.36(0.67)	2.25(0.86)	NSD
II	2.25(0.51)	3(0.82)	2.29(0.76)	NSD
III	2.18(0.82)	2.5(1.05)	2.3(0.67)	NSD

Table 4: The means of IOD values using tactile method in different age groups and in different occlusion classes are presented.

As table 5 shows, the means of IODs obtained from phonetic

method for each of three occlusion classes were not significantly different in two gender groups of males and females.

Different age groups Occlusion Classes	Male Mean (SD)	Female Mean (SD)	P value
I	2.97(0.10)	2.92(0.77)	NSD
II	2.67(0.98)	2.96(1.14)	NSD
III	2.68(0.91)	2.91(0.70)	NSD

Table 5: The means of IOD values using phonetic method in different age groups and in different occlusion classes are presented.

As table 6 shows, the means of IODs obtained from tactile method for each of three occlusion classes were not significantly different in two gender groups of males and females. The data analysis was performed using one-way ANOVA.

Different age groups Occlusion Classes	Male Mean (SD)	Female Mean (SD)	P value
I	2.47(0.83)	2.42(0.69)	NSD
II	2.29(0.69)	2.46(0.67)	NSD
III	2.32(0.77)	2.23(0.93)	NSD

Table 6: The means of IOD values obtained from tactile method in males and females, and different age groups and in different occlusion classes are presented.

As table 7 shows, the means of IODs obtained from swallowing method for each of three occlusion classes were not significantly different in the gender groups of males and females.

Different age groups Occlusion Classes	Male	Female	P value
I	2.34(1.05)	2.51(0.82)	NSD
II	2.38(0.93)	2.35(1.05)	NSD
III	2.07(0.81)	2.22(0.82)	NSD

Table 7: The means of IODs obtained from swallowing method in males and females, and in different occlusion classes are presented.

According to table 8, the mean values of CSSs in different occlusion classes had significant differences. The maximum value of CSS was seen in class II (3.28mm), and the minimum value was observed in class III (1.02mm). The data were analysed using one-way ANOVA test.

Occlusion Classes	CSS Mean (SD)
I	2.42 (0.88)
II	3.28 (1.37)
III	1.02 (0.78)
P value	<0.0001

Table 8: The mean values of CSS in different occlusion classes are presented.

According to table 9, the mean values of CSS in each of occlusion classes for three age groups did not show any significant differences. The data were analysed using one-way ANOVA test.

Different age groups Occlusion Classes	32-42 Mean (SD)	25-31 Mean (SD)	18-24 Mean (SD)	P value
I	2.31(0.95)	2.64(0.92)	2.40(0.85)	NSD
II	3.57(1.72)	3.5(1.29)	3.07(1.27)	NSD
III	1.1(1.14)	1.25(0.76)	0.89(0.68)	NSD

Table 9: The mean values of CSS in different age groups and different occlusion classes are presented.

According to table 10, the mean values of CSSs for each of the occlusion classes in two gender groups of the males and fe-

males had no significant differences. The data were analysed using one-way ANOVA test.

Different age groups Occlusion Classes	Male	Female	P value
I	2.34(0.97)	2.5(0.77)	NSD
II	3.25(1.48)	3.31(1.32)	NSD
III	1.04(0.84)	1(0.47)	NSD

Table 10: The mean values of CSS for males and females in different occlusion classes are presented.

The presented data in table 11 suggested that the mean values of CSSs and IODs resulted from tactile method in occlusion class I did not have any significant differences with each other.

Occlusion Classes	Tactile	CSS	P value
I	2.45(0.09)	2.42(0.10)	NSD
II	2.38(0.13)	3.28(0.27)	0.01
III	2.28(0.17)	1.02(0.16)	< 0.0001

Table 11: The mean values of CSS and IODs obtained from tactile method in different occlusion classes are presented.

However, the mean values of CSSs and IODs resulted from tactile method in occlusion classes II and III had significant differences with each other. These data were analysed using Paired T test.

According to table 12, the mean values of CSS and IODs resulted from swallowing method in the students with occlusion class I did not have any significant differences. However, in the students with occlusion classes II and III, the mentioned values had significant differences. These data were analysed using Paired T test.

Occlusion Classes	Swallowing	CSS	P value
I	2.43(0.11)	2.42(0.10)	NS

II	2.36(0.19)	3.28(0.27)	0.0126
III	2.14(0.16)	1.02(0.16)	0.0001

Table 12: The mean values of CSSs and IODs obtained from swallowing method in different occlusion classes are presented.

According to table 13, the mean values of CSSs and IODs resulted from phonetic method in all occlusion classes had significant differences. The data were analysed using Paired T test.

Occlusion Classes	Phonetic	CSS	P value
I	2.95(0.10)	2.42(0.10)	0.0003
II	2.83(0.21)	3.28(0.27)	0.2347
III	2.78(0.16)	1.02(0.16)	<0.0001

Table 13: The mean values of CSSs and IODs obtained from phonetic method in different occlusion classes are presented.

According to table 14, the mean values of IODs in occlusion class I and III had significant differences, when they were evaluated using different measurement methods (i.e. swallowing, tactile, and phonetic). But in occlusion class II, there were not any significant differences in IODs measured with all three methods. The data were analysed using Nonparametric test (Kruskal-Wallis).

Occlusion Classes	Tactile	Swallowing	Phonetic	P-value
I	2.45(0.76)	2.43(0.94)	2.95(0.89)	0.0007
II	2.38(0.67)	2.36(0.97)	2.82(1.06)	NSD
III	2.28(0.83)	2.14(0.80)	2.78(0.82)	0.02

Table 14: The mean values of IODs obtained from different methods of measuring IODs in different occlusion classes are presented.

Discussion

In this prospective-cross-sectional study, IOD and CSS were evaluated in students with different Angle's occlusion classes using three different methods (i.e. S, Ph, and T).

The major difference of the current study with the previous studies was that in almost all the previous studies, occlusion class I patients had been evaluated. However; in the current study, patients with different occlusion classes (i.e. class I, II, and III) were studied. Different studies tried to find any correlation between VDO and many other factors in order to predict VDO more easily, accurately, and precisely [8-21]. Lada R et al conducted a cross sectional study on 400 dentate subjects. They expressed that inter-

pupillary-distance can be used to reliably predict VDO for male patients [8].

Alhajj MN et al in an anthropometric study, stated that the distance from distal canthus of the eye to the dividing line of the lips seemed to be a reliable distance to predict VDO of Yemeni-dental-students [9]. Basnet BB et al in an anthropometric study, implied that thumb length can be used to establish VDO in edentulous patients [10]. Ladda R et al in a similar study explained that the variations between VDO and figure length were within the range of 2-4mm. So that this non-invasive and simple method can be routinely used to predict VDO in everyday practice [14].

Debnath N et al conducted a study on 120 dentate South-Indian-population. They found a reliable correlation between inter condylar distance and the buccopalatal position of maxillary-first-molar [11]. Helal MA et al, in a cross-sectional study, recommended that the base of chin-sub nasal-distance measured through Willis's measurement can be used as a helpful guide to predict VDO in dentate and completely-edentulous-subjects [13].

Kuč J et al. in a preliminary study showed that there was a directly-proportional-correlation between the height of the alveolar part in the lateral regions of the mandible and VDO of the lower face in 25 Edentulous-Caucasian-patients [15].

Igić M et al. tried to determine VDO by using the phonetic vowels 'O' and 'E'. They concluded that during pronunciation of the words "OLO" the following formula should be used: $VDO - 5.5mm = VDR [OLO]$. While during pronunciation of the word "ELE", 7.5mm should be subtracted from VDO (i.e. $VDO - 7.5mm = VDR [ELE]$) [2]. Their study indirectly implied that generally considering 2-4mm as IOD for all patients is not reliable.

There are also some studies in the literature which could not find any statistically correlation between VDO and the studied variables [17,18]. Nagpal A et al. stated that the Glabella-Subnasion-distance, Pupil-Stomion-distance, Pupil-Rim-Oris-distance (PROD), and the distance between the two angles of the mouth had no statistically significant role in predicting VDO. They had selected 180 subjects in the age groups of 50-60 years [17].

Muhamad Shaftree NEA et al. evaluated whether there was any correlation between the PROD and VDR among Sundanese population. They concluded that the PROD should be suggested as an objective method to determine the VDO. In this cross-sectional study, they concluded that there was no significant difference between VDO and PROD in Sundanese population. According to the previous review article VDO was similar related to PROD among the Studied-Indian-population [18].

There are various-invaluable-classic-articles about VDR, VDO, and IOD [1,3,6,20,23,25,28-30]. Silverman MM determined the VDO using the CSS method [25].

Swerdlow et al. obtained that the CSS during pronunciation of letter "S" is to be 1-2 mm in average. He concluded that the phonetics method is more reliable than swallowing method for determining the VDO [30]. Niswonger (1934) investigated the mandibular PRP and its relationship with FWS. He considered FWS as a reference to measure the vertical relationship [1]. Boucher reported that the amount of IOD in PRP is about 2 to 4 mm in the premolars area [3].

Winkler Sh. reported that IOD at the rest position is 2.5-3-mm in the premolars area. He explained that the range of IOD variations depends on many anatomical, physiological, and psychological factors [6]. Atwood claimed that the Physiological-Rest-Position (PRP) is not stable and it is not a reliable reference to determine VDO. He also reported 4mm difference during one session and about 8mm difference between several sessions in measuring the PRP in the same patient [20]. Tallgren investigated the VDO and rest position variations and their impacts on the IOD. He concluded that VDR can change according to VDO changes in the dentate and edentulous patients. He also claimed that as the mandible is not a stable and fixed member, it cannot be regarded as a reliable reference to determine the VDO [23].

Shirinian et al., in a comparative study compared and examined the IOD among 40 females and males from two races of black Americans and Caucasians (20 people of each race), who aged between 30 to 65 years. They calculated the Menton-Nasion-distance from cephalometric radiographs using different methods of swallowing and phonetics (pronouncing the word "Mississippi"). They expressed that the mean of IOD in the studied black Americans was 1.66mm and in the studied Caucasians was 3.05mm. They stated that despite the significant difference between the amount of IODs in black Americans and Caucasians, the conventionally-accepted-amount of 3mm for all patients seem to be unreasonable [31].

In the current study, IOD and CSS amounts were investigated in three different occlusion classes. The studied population included 124 male and female students of Tehran University of Medical Sciences, aged between 18 to 40 years. All data obtained from interviews and clinical examinations were analysed using Stata-8 and SPSS-11 software.

Analysing the data leads to the following findings:

In students with occlusion Class I, the mean of IOD resulted from the mean of three methods of measurements was 2.61mm. And the mean of IOD separately resulted from each measurement method was as follows:

Tactile method (T) = 2.42mm, swallowing method (S) 2.42mm, and phonetic method (Ph)=2.95 mm.

In students with occlusion Class II, the mean of IOD resulted from the mean of three methods of measurements was 2.52mm.

And the mean of IOD separately resulted from each measurement method was as follows:

(T) = 2.38mm, (S) 2.36mm, and (Ph) = 2.82 mm.

In students with occlusion Class III, the mean of IOD resulted from the mean of three methods of measurements was 2.40mm. And the mean of IOD separately resulted from each measurement method was as follows:

(T) = 2.28mm, (S) 2.14mm, and (Ph) = 2.78mm.

The mean of IOD resulted from the means of three occlusion classes using T, S, and Ph methods were 2.37, 2.31, and 2.85mm, respectively.

The means of IODs resulted from the means of three methods in males with occlusion class I, II, and III were 2.59, 2.45, and 2.36mm, respectively. The means of IODs resulted from the means of three methods in females with occlusion class I, II, and III were 2.62, 2.59, and 2.34mm, respectively.

The means of CSSs in students with occlusion class I, II, and III were 2.42, 3.28, and 1.02mm, respectively. The means of CSSs in males with occlusion class I, II, and III were 2.34, 3.25, and 1.04mm, respectively. The means of CSSs in females with occlusion class I, II, and III were 2.50, 3.31, and 1.00mm, respectively.

The amounts of IOD in people with different occlusion patterns of class I, II, and III had no significant differences. But the results of IOD measurements using three different methods were slightly different in one student with specific occlusion class.

In the current research, IOD in Ph method in all students, showed greater values than IODs in T and S methods. It seems that in both T and S methods, stimulating factors may guide mandible toward maxilla (i.e. may cause the mandible to close and so that reduced values of IODs were recorded). This factor in the T method may be the tiredness of the muscles during the maximum opening of the mouth. And in the S method, the adult act of swallowing itself guide the mandible to CR (i.e. the most returned position of the mandible). In addition, the upward movement of the mouth-floor-muscles (i.e. mylohyoid muscles) during the swallowing causes the mandible to further move towards the maxilla and causes the partial contact of the teeth at the beginning of swallowing. However, in the Ph method, when the letter M is pronounced, the teeth are separated and only the lips have a partial contact. The mandible retrudes during swallowing and it protrudes during pronunciation "S". After these movements, IOD and CSS values in the age range of the investigated people had no statistical differences. It is recommended to study anterior posterior-mandibular-movements in the future studies using jaw-motion-tracking-device.

In the current study, CSS values showed significant differences in people with different occlusion classes. Class II students

showed the greatest CSS and class III students showed the lowest CSS. This finding may be due to increased vertical overlap in Class II people. The mean of IODs in different investigated-age-groups showed no significant differences, in none of the occlusion classes I, II, and III. Limited age range of investigated people in this research (aged from 18 to 40 years) may be an explanation for this result.

The mean of CSS in different age groups had no significant differences in all occlusion classes. The mean of IOD and CSS in male and female age groups had no significant differences in all occlusion classes. There was a direct correlation between IOD and CSS values in students with occlusion class I, which confirmed the results of the study conducted by Rivera-Morale et al [27]. There were significant differences between IOD and CSS in students with occlusion Class II and Class III. There was not any significant relationship between the age and gender of the students. In female students, the mean of IOD was slightly higher than that of male students. Of course, this difference was not statistically significant.

Significant relationship was found between VDO and CSS (i.e. as VDO increased, CSS would also increase). The mean value of IOD in people with occlusion classes I, II, and III followed a slightly decreasing trend (i.e. IOD was reduced from class I to class III), but this reduction was not statistically significant. Considering the diversity of the measurement methods in order to determine the vertical relationships of the jaws, it is recommended not to use a single method. Various methods should be used to determine the vertical relationships and the mean of these results should be recorded as the patient's VD. It is better to use both IOD and CSS determine VD in completely-edentulous-patients and RPD wearers who already have their anterior teeth (i.e. distal-extension-patients with no posterior-teeth-stops). Because IOD indicates the vertical height at the rest time of the muscles (physiological-tonus-position of the muscles), but CSS indicates the vertical height at physiological and functional period of the muscles during speech. In the current study, similar to some previous studies, dentate students were selected [11,13,17]. So that overgeneralization of the results of this study to the completely/partially-edentulous-patients should be performed with caution. The main reason of using dentate students was to evaluate different occlusion Classes (I, II, and III) more easily through examining the relationship of their first molars. In edentulous patients and partially-edentulous-patients who does not have first molars, cephalometric radiography is mandatory for classification of the maxillary and mandibular ridges as skeletal Class I, II, and III. Of course, using X-ray in people only for evaluating their IOD and CSS is not ethically acceptable. It is recommended to perform another similar study in edentulous patients with different occlusion Classes who have already needed cephalometric radiographies for any other reasons. The skeletal classification of Angle is the anterior-posterior relation of the man-

dible with respect to the maxilla which needs cephalometric analysis. While in the current study, dental classification of Angle was evaluated considering the relation of the first molars in the selected students. In the current literature, there are some case reports in which cephalometric radiographies had been used for determining VDO [32,33]. Alhajj MN et al in a retrospective study, collected 93 digital-cephalometric-radiographies from the archive of orthodontics department of Sana'a University, Yemen. They concluded that Nasion-sella-distance can be used as an additional method to estimate VDO only in men of the studied population [12].

Another limitation of the current study was that the sample sizes of Class II and Class III were limited. Generally, the results will be more reliable, if larger sample sizes can be examined. However; Class II and III people are not very frequent.

Conclusions

Considering the limitations of this study, the following conclusions were drawn:

- 1- The mean of IOD resulted from the means of three measurement methods, in students with occlusion class I, II, and III were 2.61, 2.53, and 2.40mm, respectively.
- 2- The mean of IOD values in different occlusion classes (i.e. Class I, II, and III) were not significantly different.
- 3- IOD values in a specific occlusion with each of three methods were significantly different.
- 4- Ph method indicated the greatest IOD in almost all students.
- 5- The mean of CSS resulted from the means of three measurement methods, in students with occlusion class I, II, and III were 2.42, 3.28, and 1.02mm, respectively.
- 6- CSS values in people with different occlusion classes were significantly different.
- 7- The Studied Class II cases had the greatest value and the Class III cases had the lowest value of CSS.
- 8- There was a direct relationship between the values of IOD and CSS in students with occlusion Class I. IOD and CSS values were not significantly different in the students with occlusion Class II and Class III.
- 9- There was no significant relationship between the age and gender of the studied people. IOD and CSS values in the age range of the investigated people had no statistical differences.
- 10- There was a significant relationship between VOL and CSS values.

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