



## Determination of vertical dimension of occlusion by using the phonetic vowel “O” and “E”

### Određivanje vertikalne dimenzije okluzije pomoću samoglasnika O i E

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#### Abstract

**Background/Aim.** The vertical dimension of occlusion is a very important parameter for proper reconstruction of the relationship between the jaws. The literature describes many methods for its finding, from the simple, easily applicable clinically, to quite complicated, with the use of one or more devices for determination. The aim of this study was to examine the possibility of determining the vertical dimension of occlusion using the vocals “O” and “E” with the control of values obtained by applying cognitive functions. **Methods.** This investigation was performed with the two groups of patients. The first group consisted of 50 females and 50 males, aged 18 to 30 years. In this group the distance between the reference points (on top of the nose and chin) was measured in the position of the mandible in the vertical dimension of occlusion, the vertical dimension at rest and the pronunciation of the words “OLO” and “ELE”. Checking the correctness of the particular value for the word “OLO” was also performed by the phonetic method with the application of cognitive exercises when the patients counted from 89 to 80. The obtained difference in the average values in determining the vertical dimension of occlu-

sion and the “OLO” and “ELE” in the first group was used as the reference for determining the vertical dimension of occlusion in the second group of patients. The second group comprised of 31 edentulous persons (14 females and 17 males), aged from 54 to 85 years who had been made a complete denture. **Results.** The average value obtained for the vertical dimension of rest for the entire sample was 2.16 mm, for the word “OLO” for the entire sample was 5.51 mm and for the word “ELE” for the entire sample was 7.47 mm. There was no statistically significant difference between the genders for the value of the vertical dimension at rest, “ELE” and “OLO”. There was a statistically significant difference between the values for the vertical dimension at rest, “OLO” and “ELE” for both genders. There was a statistically significant correlation between the value for the vertical dimension at rest, “OLO” and “ELE”, for both groups of subjects. **Conclusion.** Determining the vertical dimension of occlusion requires 5.5 mm subtraction from the position of the mandible in pronunciation of the word “OLO” or 7.5 mm in pronunciation of the word “ELE”.

**Key words:**  
vertical dimension; dental occlusion; adult; cognition.

#### Apstrakt

**Uvod/Cilj.** Vertikalna dimenzija okluzije veoma je važan parametar za pravilnu rekonstrukciju odnosa između vilica. U literaturi su opisane mnoge metode za njeno određivanje, od jednostavnih, klinički lako primenljivih, do prilično komplikovanih, uz primenu jednog ili više uređaja za registraciju. Cilj ovog istraživanja bio je ispitivanje mogućnosti određivanja vertikalne dimenzije okluzije primenom glasa O i E uz kontrolu dobijenih vrednosti primenom kognitivnih funkcija. **Metode.** Ispitivanja su vršena kod dve grupe ispitanika. Prva grupa se sastojala od 50 osoba ženskog i 50 osoba muškog pola, starosti od 18 do 30 godina. Kod ove grupe vršeno je merenje rastojanja između referentnih tačaka (na vrhu nosa i brade) pri položaju mandibule u vertikalnoj dimenziji okluzije, vertikalnoj dimenziji mirovanja (VDM) i izgovoru reči OLO i ELE. Provera korektnosti određene vrednosti za reč OLO vršena je takođe fonetskom metodom uz primenu vežbi kognitivnog tipa pri brojanju od 89 do 80. Dobijena razlika u prosečnim vrednostima pri određivanju vertikalne dimenzije okluzije i OLO i ELE, u prvoj grupi, korišćena je kao referenca za određivanje vertikalne dimenzije okluzije kod druge grupe ispitanika. Drugom grupom obuhvaćena je 31 bezuba osoba (14 žena i 17 muškaraca), starosti od 54 do 85 godina, a kojima su izrađivane totalne proteze. **Rezultati.** Prosečna vrednost dobijena za vertikalnu dimenziju mirovanja za ceo uzorak je 2,16 mm, za reč OLO iznosila 5,51 mm i za reč ELE 7,47 mm. Nije bilo statistički značajne razlike između polova za vrednosti VDM, OLO i ELE. Ustanov-

bule u vertikalnoj dimenziji okluzije, vertikalnoj dimenziji mirovanja (VDM) i izgovoru reči OLO i ELE. Provera korektnosti određene vrednosti za reč OLO vršena je takođe fonetskom metodom uz primenu vežbi kognitivnog tipa pri brojanju od 89 do 80. Dobijena razlika u prosečnim vrednostima pri određivanju vertikalne dimenzije okluzije i OLO i ELE, u prvoj grupi, korišćena je kao referenca za određivanje vertikalne dimenzije okluzije kod druge grupe ispitanika. Drugom grupom obuhvaćena je 31 bezuba osoba (14 žena i 17 muškaraca), starosti od 54 do 85 godina, a kojima su izrađivane totalne proteze. **Rezultati.** Prosečna vrednost dobijena za vertikalnu dimenziju mirovanja za ceo uzorak je 2,16 mm, za reč OLO iznosila 5,51 mm i za reč ELE 7,47 mm. Nije bilo statistički značajne razlike između polova za vrednosti VDM, OLO i ELE. Ustanov-

ljena je statistički značajna razlika između vrednosti za vertikalnu dimenziju mirovanja, OLO i ELE za oba pola. Takođe, ustanovljena je statistički značajna korelacija između vrednosti za vertikalnu dimenziju mirovanja, OLO i ELE za obe grupe ispitanika. **Zaključak.** U praktičnom radu za određivanje vertikalne dimenzije okluzije treba

oduzeti 5,5 mm od položaja mandibule pri izgovaranju reči OLO ili 7,5 mm pri izgovoru reči ELE.

**Ključne reči:**  
vertikalna dimenzija; zubi, okluzija; odrasle osobe; mentalni procesi.

## Introduction

Several factors are necessary for correct determination of the vertical dimension of occlusion (VDO).

VDO is the height of the lower part of the face measured between the two reference points when the dental arches are in occlusion at maximum intercuspation<sup>1</sup>.

Vertical dimension at rest (VDR) is the height of the lower part of the face measured between the two reference points when the mandible is in physiological rest position – in occlusion<sup>1</sup>.

Occlusal rest space (ORS) is the distance between the occlusal surfaces of antagonistic teeth when the jaw is in the position of physiological rest. This is the difference between VDO and VDR<sup>1</sup>.

Speech area (SA) is the distance between the occlusal surfaces of antagonistic teeth during pronunciation of certain voices.

In edentulous people there is no mutual contact of the teeth and no elements that indicate the relationship of the upper and lower jaw. Jaw relationship when making dentures, in this case, should be reconstructed with artificial dental arches in the proper vertical and horizontal relationships. According to Gutiérrez de Venezia<sup>2</sup> this is one of the most complex procedures in prosthodontics.

One of the most important parameters, without diminishing the importance of others, in making full denture is determination of the correct VDO<sup>3,4</sup>. With regard to this, Brian and Dale<sup>5</sup> stated: "Determination of VDO is a critical procedure for total and partial dentures". According to Sharry<sup>6</sup> determining VDO is not a precise process, and many experts will come to this dimension using different methods.

Different methods have been proposed for determining VDO<sup>7,8</sup> and many of them were used by various authors<sup>8,9</sup> in edentulous people as well as in people with teeth.

Methods for determining VDO mostly date back to the early 20th century<sup>10</sup>. Techniques for determining VDO are numerous and are based on the determination of VDR<sup>11,12</sup> speaking method<sup>13-15</sup> preextraction registrations<sup>16</sup> photographs<sup>17</sup> measurements of face and intraoral measurements<sup>18</sup> cephalometric radiographs<sup>19</sup> and so on.

The vertical dimension is relatively constant throughout life<sup>20,21</sup>. According to Atwood<sup>22</sup> interocclusal distance can vary and it may be affected by many factors such as age, fatigue, mental state, some medications, etc.

At the beginning of the 20th century, a physiological rest was considered constant throughout life<sup>3</sup>. Later researchers, Tallgren<sup>23,24</sup>, Basker et al.<sup>25</sup>, Berry<sup>26</sup>, Cocco and Lloyd<sup>27</sup>, Ash and Ramfjord<sup>28</sup> did not accept this concept in the strictest sense. Researchers who do not accept the

constancy of VDR consider that the patient's neuromuscular system can adapt to changes of dentoalveolar complex.

Although researchers raise the question of the constancy of the position of VDR, it is still used as a starting point for determining the VDO<sup>29</sup>.

According to Willis<sup>18</sup>, the distance between the pupil of the eye and corner of the lip is equal to the distance of subnasal point and lower edge of the chin. According to Chou et al.<sup>30</sup> asymmetry of the face makes the value of this method questionable.

Ward and Osterholtz<sup>31</sup> notes that swallowing can be used only as a guide in determining the VDO and Swerdlow<sup>8</sup> believes that the phonetic method as a method for the determination of interocclusal distance is more reliable than techniques of swallowing.

Mehring<sup>32</sup> concluded that tooth loss does not affect the speech position of the mandible. According to the Benediktsson's<sup>33</sup> findings during the pronunciation of the consonant "S", SA varies from 0–14 mm (average value is 2.6 mm), and Howel's<sup>34</sup> results are 0–8 mm (average value is 3.1 mm).

According to Petrović<sup>35</sup> SA is a reliable functional indicator for reconstruction occlusal relations and suggests that this data is registered at the time of having of the teeth in the mouth and recorded in the patient's chart and later, after the loss of teeth, used for reconstruction of occlusal relations.

For every sound there is a corresponding position of the mandible in relation to the maxilla, i.e. the distance between the reference points in the vertical direction. The most appropriate consonants for testing, according to Suvin<sup>36</sup>, are "M", "F" and "S", and the vowels "O" and "I". During pronunciation of the vowel "O", or words that end in "O", for example *olovo* (lead in English), the lower bite rim should be 6–8 mm away from the upper, in the frontal part.

In 1959 Morrison<sup>37</sup> proposed the use of English words "sixty-six" (66) and "Mississippi" to determine the VDO in edentulous people.

According to Ismail and George<sup>38</sup>, VDR itself tunes over time according to VDO. With normal changes in alveolar processes VDO will be adjusted to the length of the muscle<sup>39</sup>. The adaptive process appears to be maintained throughout life so that if necessary, the dimension of alveolar process changes<sup>40</sup>.

Dawson<sup>40</sup> showed that VDO was not generally affected by strong abrasion of teeth because VDO compensates by elongation of alveolar process.

Sharry<sup>6</sup> determined VDO by phonetic method using Arabic words and comparing the results with the values for VDO obtained in swallowing. The obtained values of both methods were congruent.

Pound<sup>10</sup> proposed the method of counting for determining the VDR. A patient counts from 50 to 55, and then rests with the lips in touching position.

Čelebić et al.<sup>41</sup> found that head position has a significant impact on the size of free interocclusal space if VDO is determined by physiognomy, while with phonetic method, (“s” and “mi”) the size of free interocclusal space remains constant at different positions of the head.

Comparison of the size of interocclusal space between positions of VDR and VDO determined by clinical procedure and using sirognatograph was done by Poštić and Krstić<sup>42</sup>. Higher numerical value of this area has found using clinical method in 71.4%.

The method for determining the VDO on the basis of the differences in the distance between VDR and VDO is quite objective, but because of non-constancy of VDR it is not reliable. Clinically, it is difficult to determine the VDO by this method because the measurements are taken on moving tissues of the skin<sup>7</sup>. VDR is not a stable parameter and it does not define a precise height, so its use is not reliable for determining the VDO<sup>23,43</sup>.

There is an evidence that suggests that sensory feedback information from the oral cavity plays a major role in maintaining cognitive function in the hippocampus. Masticatory stimulation helps cognitive function. The execution of cognitive tasks requires coordinated activation of different cortical and subcortical regions associated with the hippocampus<sup>44</sup>. The prefrontal cortex is one of these cortical areas, and it plays a particularly important role in the formation of arbitrary connections between sensory signals and establishing voluntary actions to perform a specific task.

In the available literature, the authors did not find data on the use of cognitive functions as an auxiliary method for more precise determination of VDO.

The aim of this study was to investigate the possibility of determining of VDO during pronunciation of words that contain the voices “O” and “E” and control of the values obtained by this method by applying cognitive function, starting from the assumption that the use of vowels to determine VDO is more comfortable than the application of consonants for that purpose.

## Methods

The samples of this study were the two groups of patients. The first group was an experimental group of dentistry students at the University of Niš. The second are consisted of edentulous patients of the Clinic of Dentistry, Clinical Center Niš.

The first group included 50 female and 50 male students aged 18–30 years. All the subjects had the full dental arch (except those with no wisdom teeth), Class I occlusion, with no abnormalities, surgery or trauma, no previous orthodontic treatment and temporomandibular disorders. The first group of respondents included students with the mentioned characteristics of stomatognathic system starting from the premise that they can get relevant information on practical application. All the participants were informed about the

nature of the study and gave their consent for participation in the study.

The subjects were sitting upright, without head restraints, and occlusal surfaces of upper teeth were parallel to the floor in accordance with the recommendations by Silverman<sup>14</sup>.

The reference points were marked with a thin marker at the top of the nose and chin. For each phase, the position of the reference points at the top of the nose and jaw were marked in a chart and later distances measured using a digital Nonius S·H made in China. The obtained values were rounded up to 0.5 mm.

In the first phase the value of the distance of the reference points for VDO was registered (teeth at maximum intercuspation).

In the second stage VDR was registered (using the position of the mandible at rest, the pronunciation of the consonant M combined with swallowing and the appearance of the patient).

In the third phase the subjects uttered the word “OLO” repeatedly, quickly and without pause, while the distance of reference points was noted.

In the fourth phase the subjects counted backwards from 89 to 80. The previously obtained distance between the reference points for the word “OLO” was compared with the value obtained by counting. Registration of the reference points was carried out at the start of pronouncing the number 8, i.e. the vowel “O” (*osam* in Serbian).

In the fifth phase the subjects were asked to pronounce the word “ELE” repeatedly, quickly and without pause, and the distance of the reference points was determined using the same principle as for the word “OLO”.

The procedure was repeated three times and then the mean value was calculated.

In the first group of respondents the starting position of the mandible was VDO, because all the subjects had teeth that determined this position of the mandible. This position was given a numeric value of 0.

The second group, representing the control group, consisted of 14 female and 17 male edentulous persons aged 50–82 years who needed full dentures.

In the second group with no natural teeth to determine the relationship between the jaws, the initial position of the mandible for further research was the position of the mandible during the pronunciation of the word “OLO” and it got a numeric value of 0.

The obtained results in the first group (the average distance between the reference points on the chin and the tip of the nose during the pronunciation of the word “OLO”) were compared with the position of reference point on the chin during pronunciation of the numbers from 89 to 80. From the obtained values 5.5 mm were subtracted, which corresponds to the position of the mandible for VDO. VDO determination was also done during pronunciation of the word “ELE” by subtracting 7.5 mm from the obtained value (the approximate average value between the reference points during the pronunciation of the word “ELE” and VDO).

VDO position control, obtained by using the words "OLO" and "ELE" in the second group of respondents, was performed by determining the position of VDR, and from that value 2 mm were subtracted. As the position of the mandible for VDR, in relation to the position for the word "OLO" (numeric value 0) is in the opposite direction from the position of the mandible for the word "ELE", numerical values for VDR have a negative sign and for the word "ELE" positive.

Determining the position of the mandible for the words "OLO", "ELE" and VDR was performed under the same criteria as in the first group.

A specific VDO was also checked when the dentures were tried out with the word "OLO" and during pronuncia-

the parametric Student's *t*-test, Friedman's nonparametric test and Pearson's correlation test were used.

The study was conducted in accordance with the ethical standards of the Committee for Experiments on Humans and the obtained approval from the competent ethics committee for this study (the decision of the Faculty of Medicine in Nis no. 01-890-11).

## Results

Statistical analysis led to the following results presented in Tables 1 and 2.

The average value of VDR between female and male subjects did not differ significantly (2.10 mm and 2.23 mm,

**Table 1**  
**Characteristics of the first group of respondents (with the full dental arch, Class I occlusion without previous oral and orthodontic treatment or temporomandibular disorders)**

First group	Minimum	Maximum	$\bar{x}$	SD
<b>Women (n = 50)</b>				
Age (years)	18.00	30.00	21.3000	2.91548
VDO, mm	0.00	0.00	0.0000	0.00000
VDR, mm	1.00	4.00	2.1000	0.82065
OLO, mm	2.50	10.00	5.6100	1.67603
ELE, mm	5.00	11.00	7.5300	1.36804
Distance „OLO“ ↔ VDR, mm	1.50	6.50	3.5000	1.30540
Distance „ELE“ ↔ VDR, mm	3.50	8.00	5.4300	1.07860
Distance „OLO“ ↔ „ELE“, mm	0.50	3.50	1.9200	0.82906
<b>Man (n = 50)</b>				
Age (years)	18.00	30.00	23.4800	2.34077
VDO, mm	0.00	0.00	0.0000	0.00000
VDR, mm	1.00	4.00	2.2300	0.70138
OLO, mm	2.50	10.00	5.4100	1.59300
ELE, mm	5.00	10.00	7.4200	1.23040
Distance „OLO“ ↔ VDR, mm	1.00	6.00	3.1800	1.25259
Distance „ELE“ ↔ VDR, mm	3.00	7.00	5.1900	0.91968
Distance „OLO“ ↔ „ELE“, mm	0.00	4.00	2.0100	0.75248
<b>Total sample (n = 100)</b>				
Age (years)	18.00	30.00	22.3900	2.84940
VDO, mm	0.00	0.00	0.0000	0.00000
VDR, mm	1.00	4.00	2.1650	0.76229
OLO, mm	2.50	10.00	5.5100	1.62987
ELE, mm	5.00	11.00	7.4750	1.29563
Distance „OLO“ ↔ VDR, mm	1.00	6.50	3.3400	1.28291
Distance „ELE“ ↔ VDR, mm	3.00	8.00	5.3100	1.00448
Distance „OLO“ ↔ „ELE“, mm	0.00	4.00	1.9650	0.78899
Valid N (listwise)	50			

VDO – vertical dimension of occlusion; VDR – vertical dimension at rest.  
Note: Details about parameter measured see in the section Methods.

tion of numbers from 89 to 80. The patients with disturbed cognitive functions were counting forwards. A specific VDO was also checked during the pronunciation of the word "ELE".

The second group also underwent statistical analysis of parameters obtained by measuring the values of the distance between the position of the reference point for VDR, "OLO" and "ELE".

The obtained results were statistically analyzed using the statistical software package – Statistical Package for Social Science (SPSS) software, version 17. Depending on the characteristics tested, methods of descriptive statistics and

respectively;  $t = 0.852, p > 0.05$ ). There were also no statistically significant differences in the average value for "OLO" (5.61 mm for women, 5.41 mm for male;  $t = -0.612, p > 0.05$ ) and the average value for "ELE" – (7.53 mm for women, 7.42 mm for male;  $t = -0.423, p > 0.05$ ). Friedman's test was used to check whether the average values of variables for the VDR, "OLO" and "ELE" measured in male and female subsample differ significantly. On the basis of the values obtained statistically significant difference ( $\chi^2 199.504, p < 0.01$ ) was determined.

We studied the correlation between the VDR, "OLO" and "ELE" for female and male subjects, and statistically

Table 2

Characteristics of the second group of patients (edentulous persons who needed full dentures)				
Second group	Minimum	Maximum	Mean	Std. Deviation
Women (n = 14)				
Age (years)	51.00	76.00	61.5714	6.39368
VDR, mm	-4.50	-2.50	-3.5714	0.64621
OLO, mm	0.00	0.00	0.0000	0.00000
ELE, mm	1.00	2.50	1.9286	0.51355
Distance OLO ↔ VDR, mm	2.50	4.50	3.5714	0.64621
Distance ELE ↔ VDR, mm	5.00	6.00	5.4643	0.45844
Men (n = 17)				
Age (years)	50.00	82.00	68.2353	8.69288
VDR, mm	-4.50	-2.00	-3.3824	0.80096
OLO, mm	0.00	0.00	0.0000	0.00000
ELE, mm	1.00	3.00	2.1765	0.61087
Distance OLO ↔ VDR, mm	2.00	4.50	3.3824	0.80096
Distance ELE ↔ VDR, mm	3.50	6.50	5.4706	0.69531
Total sample (n = 31)				
Age (years)	50.00	82.00	65.2258	8.32950
VDR, mm	-4.50	-2.00	-3.4677	0.72956
OLO, mm	0.00	0.00	0.0000	0.00000
ELE, mm	1.00	3.00	2.0645	0.57361
Distance OLO ↔ VDR, mm	2.00	4.50	3.4677	0.72956
Distance ELE ↔ VDR, mm	3.50	6.50	5.4677	0.59070
Valid N (listwise)	14			

VDO – vertical dimension of occlusion; VDR – vertical dimension et rest.

Note: Details about parameter measured see in the section Methods.

significant correlation was obtained ( $r = 0.637, 0.633,$  and  $0.879$ , respectively;  $p < 0.01$ ).

The average distance between the reference points for “OLO” and VDR in the females was 3.5 mm and 3.18 mm for the males. There was no statistically significant difference between them ( $t = -1.251; p > 0.05$ ). The average distance between the reference points for “ELE” and VDR in the females was 5.43 mm and 5.19 mm for the males. In both of these variables, there was no statistically significant difference ( $t = -1.197, \text{Sig} > 0.05$ ). The average distance between the reference points for “OLO” and “ELE” in the female subjects was 1.92 mm and 2.01 mm for males and between them there is also no statistically significant difference ( $t = 0.568, p > 0.05$ ).

In the fourth phase of testing control of the obtained value for the word “OLO” was done. In all cases, when counting from 89–80, the reference point on the lower jaw, at the beginning of the word that starts with the voice “O” (*osam* in Serbian), coincided with the reference point on the carton for the voice “O”, and later, when other voices uttering (s, a, m, d...) oscillated around the point marked on the carton. Measuring the amplitude of oscillation of the reference point was not conducted due to the complexity of the procedure.

In the second group the average value obtained for VDR (OLO-VDR) for female subjects was -3.57 mm, -3.38 mm for the males and for the entire sample it was -3.46 mm. The average value for “ELE” (“OLO” + “ELE”) for the females was 1.92 mm, for males 2.17 mm and for the entire sample 2.06 mm. There was no statistically significant difference between the values for VDR for the females and the males ( $t = 0.712, p > 0.05$ ) and “ELE” ( $t = 1.207, p > 0.05$ ). There was a correlation between the values for VDR and

“ELE” in the entire sample of the second group ( $r = 0.771, p < 0.01$ ).

This group was also tested for determining the distance between the average values of the reference points for “OLO” and VDR between female and male participants. In females the distance was 3.57 mm, and 3.38 mm for the males. Between the tested groups there was no statistically significant difference ( $t = -0.712, p > 0.05$ ). The same procedure was also performed for the value of the distance between the reference points for “ELE” and VDR. For the females the average distance was 5.46 mm, and 5.47 mm for the males. In this case there was no statistically significant difference between the variables ( $t = 0.029, p > 0.05$ ).

The values of the distance between “OLO” and “ELE” in both groups (whole sample) were compared and no statistically significant difference found ( $t = 0.767 p > 0.05$ ).

The same was done for VDR-OLO values between both groups, and no statistically significant difference was found ( $t = 0.697; p > 0.05$ ).

## Discussion

For a comprehensive prosthetic reconstruction determination of VDO is often referred to as the central issue, the core problem<sup>45</sup>. Change in VDO affects facial appearance, creates difficulties in pronunciation and discomfort in muscles<sup>46</sup>. Correctly determined VDO provides adequate patient appearance, enables efficient chewing and prevents jaw joint dysfunction.

Among many methods available for determining VDO some authors argue that the most comfortable are applied in practice. Vidya and Gopinathan<sup>47</sup> proposes the choice of method for VDO according to their accuracy, repeatability of

measurements, the adaptability of techniques, type and complexity of equipment and duration of registration. Sadowsky<sup>48</sup> proposes combining several methods to obtain adequate interocclusal distance.

The method for VDO determining by swallowing and the phonetic method of Gittelson<sup>49</sup> are universal for all people. The main advantage of these techniques is easy functional determination of height, and the adequacy of the results can be evaluated. According to Dowson<sup>50</sup> the phonetic method is ideal for determining the vertical dimension of occlusion in edentulous patients, or in wrongly determined vertical relationship. In practice he uses the Silverman's SA method during the pronunciation of the consonant "S" (patient counts from 60–66 in English).

Pouysségur et al.<sup>51</sup> propose the use of the letter "S", surrounded by a neutral vowel ("E", "EU") as an ideal phonetic instrument for determining the vertical dimension.

For the reconstruction of the intermaxillary relation in edentulous patients there are no absolutely safe parameters.

The choice of the specific amount of vertical dimension is primarily based on clinician's clinical experience and practice. Despite the large number of different methods for determining VDO there is still no precise method. Individually, the methods are not very valuable, but a combination of several methods may lead to the diagnosis<sup>2</sup>.

The methods for determining the VDO using special measuring devices provide more accurate results, but due to the complicated procedure and the need for having these devices are not favored in comparison to the conventional methods.

VDO determination on the basis of VDR according to Tallgren<sup>23,24</sup>, Berry<sup>26</sup>, Coccaro and Lloyd<sup>27</sup>, Atwood<sup>22</sup>, Ash and Ramfjord<sup>28</sup>, Willis<sup>18</sup>, is not a fair method considering the volatility of VDR. However, determining VDO on the basis of VDR is widespread in practice because of its simple and fast methodology to obtain the results which was pointed to by Johnson and Stratton<sup>29</sup>.

All the classic phonetic methods for VDO determining use pronunciation of certain vocals (s, m i.) simultaneously registering the interocclusal space. This space is small (average value is 1–2 mm – Silverman<sup>14,15</sup>, 2.6 mm – Benediktsson<sup>33</sup>, 3.1 mm – Howell<sup>34</sup>) and the lips are close together so it is not possible to observe the interocclusal space. All the authors who have used the phonetic method for determining the VDO aimed at getting the value for the SA and then that value was used to obtain values f or VDO. Most authors dealt with the influence of the letter S on the size of interocclusal space. During pronunciation of the voice "M" words as Mississippi, a reference point on the mandible oscillates vertically so the verification of the position of the point is uncertain. In principle, a reference value should be obtained which is a starting point for obtaining the VDO.

Compared to other sounds, during pronunciation of the vowels "O" and "E", we get much greater value of interocclusal space, so it was also the reason that the authors opt for this method bearing in mind that the amount of mouth opening in this case is within the limits of pure rotation of the mandible<sup>20</sup>. Application of this method allows visual moni-

toring of the situation in the mouth unlike with other phonetic methods.

For determining VDO the words "OLO" and "ELE" were selected, with the presence of voices "O", "E" and "L". During pronunciation of the the voice "O" in the so-called vowel trapezium (Figure 1) (where ordinate shows the position of the tongue in height and the abscissa position of voice creation), the vertical position of the tongue is at the junction of middle and upper thirds of the vocal trapeze and horizontally rear. During the pronunciation of voice "E" position of the tongue along the vertical is the same as the voice "O" and horizontally it occupies the front position.

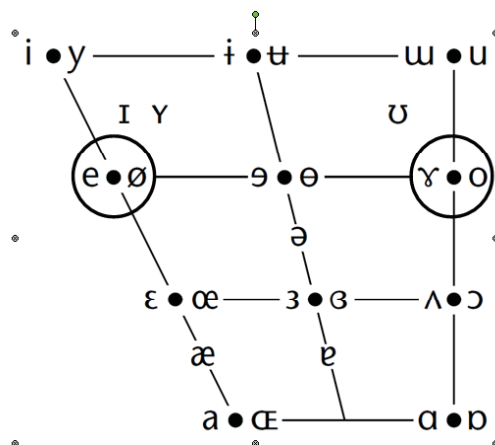


Fig. 1 – Vowel trapezium.

During pronunciation of the consonant "L", position of tongue is the dorzo-velar by the place of creation, and by the manner of creation it is alveolar lateral. Consonant "L" is inserted between the two vowels "O" and "E" to form a melodic word of voices that are close by the place of creation, i.e. it is not necessary to move the lower jaw horizontally nor vertically, it requires only a slight movement of the tongue<sup>52</sup>. During pronunciation of the vowel "O", the position of lips is formed, i.e. the mouth opening is slightly smaller than for the vowel "E", but sufficient for visual monitoring of the position of bite rims of the upper and lower jaw and the distance between them. During pronunciation of the vowel "E" the position of the lips is unshaped, the lips are maximally stretched horizontally and vertically, allowing maximum insight into the location and distance of the occlusal rim and the teeth.

Average values of the distance between the reference points, obtained in this study, at the position of VDR, in the first group, were 2.1 mm for the female respondents and 2.23 mm for the male, which agrees with the findings by Okeson<sup>53</sup>, Benediktsson<sup>33</sup>, Silverman<sup>14,15</sup>, but differs from the findings of other authors<sup>11,12,29</sup> for about 30%.

The test of values for VDR, "ELE" and "OLO", in the first group, provided a statistically significant correlation between the variables for both groups ( $r = 0.637, 0.633$  and  $0.879$ , respectively;  $p < 0.01$ ), which is logical, and points to the value of the research and complies with Ismail et al.<sup>54</sup> research (VDR has a tendency to follow VDO).

The average distance between the reference points at VDO and the position of the mandible during pronunciation of the voice “O” in the female subjects was 5.61 mm, and 5.41 mm in the male and the average value for the whole sample was 5.51 mm. Between the variables for “OLO” for the female and the male subjects there is no statistically significant difference ( $t = -0.612, p > 0.05$ ) which simplifies the use of this method. Considering that the SA according to Benediktsson<sup>33</sup> is 0–14 mm, and according to Howell<sup>34</sup> 0–8 mm, the average value between VDO and the position of the mandible during pronunciation of the voice “O” of 5.51 mm which was determined by this examination, is consistent with the findings of these authors.

When using the methods of registering VDO by the sound “O” the distance between the reference points is on average approximately 5.51 mm, using the sound “E” 7.47 mm, which is the maximum value for the pronunciation of certain voices. In this case, the lips are distant from each other so that it is possible to visually observe the situation in the mouth or the distance between the occlusal rims or artificial teeth. In this case, VDO is obtained by subtracting 5.5 mm from the value obtained during the pronunciation of the words “OLO” or 7.5 mm for the word “ELE”. Approximate measurement of the distance between walls or teeth is made using a plastic strip with the width of 5.5 and 7.5 mm, and inserted between the rims in the front during pronunciation of the word “OLO” or “ELE”.

The lack of statistically significant difference between the parameters for the “OLO” – “ELE” and VDR – “OLO”, between the first and the second group indicates the constancy of these positions during life.

The fact that the value of the obtained interocclusal space during pronouncing of the sounds “O” or “E” is within the hinged movement of the mandible during the initial opening of the mouth indicates that this method is in accordance with the gnathological principles.

Based on statistical processing of parameters in clinical practice, it is possible to check the correctness of the author's method by comparing it with data obtained by some other method, as Millet et al.<sup>55</sup> say there is no perfect technique that will ensure success.

Thus, check of a certain position of mandible for VDO using this method can be done by comparing the position of the reference point on the mandible during pronunciation of the words “OLO” or “ELE”, so to determine the position of the mandible for VDR using other method, and measure the distance of the mandible for the position for “OLO” – VDR and for “ELE” – VDR. It should be about 3.34 mm, and about 5.31 mm, respectively.

Taking into account the results and opinion proposed by Harper<sup>56</sup> for determination of VDO by VDR, the method for determining VDO using the sounds “O” and “E” gains importance. Dowson's<sup>50</sup> opinion is in accordance with the previous and he believes that the phonetic method is ideal for determining VDO.

In the next phase, when dentures are tried out, after the experience acquired with this method, it is possible to very easily verify the correct VDO. In continuous, rapid repetition

of the words “OLO” and “ELE” the mandible is in a static position, meaning without moving, and the registration of the distance between the reference points is simple.

During counting from 89–80 the reference point on the mandible oscillates around the point on the paper determined by pronouncing the sound “O”. Counting from 89 to 80 (in Serbian) requires constant repetition of voice “O” (10 times) whereby the value of the previously registered interocclusal spaces is controlled. Counting forward (80–89) is usually done automatically and is resistant to the effects of aging. Counting backwards is a cognitive operation that requires patient's concentration which deteriorates with age. Counting backwards (89 to 80) moves thoughts away from dental procedures, has a relaxing effect on the masticatory muscles and contributes to obtaining a more accurate value of VDO.

In the second group of subjects, in the patients with disturbed cognitive functions, which is often the case in older people who generally require full dentures, it turned out that they were not able to count backwards, which was not pleasant for them. In this case the forward counting method is applied (80 to 89), which was much easier and allowed the authors to obtain data for the VDO, i.e. its control. Counting forward for patients with disturbed cognitive functions, however, was enough for the patients to stop thinking about the current intervention which enabled control of the registered position of the mandible.

This study did not focus on examining cognitive function, but the count was intended to decenter a patient from the current intervention, in order to achieve more precise determination of the position of the mandible during pronunciation of the sounds “O” or “E”.

To apply this method to other people with different linguistic background, it is necessary to apply other numbers with the sound “O” at their beginning. For example, in Greek *ogdonda enea* (ογδόντα εννέα) – 89, in Italian *ottanta nove* – 89, in Czech *osmdesát-devět* – 89. Similarly, it is possible to use this method with the sound “E” for the English-speaking area (eighty-nine, 89), and Greek *eneninda enea* (eneninda enea) – 89.

Depending on the native language, appropriate words are used, containing the desired sounds. So Burnett and Clifford<sup>57</sup> used the words with sh, s, j, z, ch, zh in the assessment of SA.

Fuad<sup>4</sup> used the phonetic method with the Arabic words for determining VDO.

The distance between VDR and VDO is about 3 mm according to Niswonger<sup>11</sup>, Pyott and Schaeffer<sup>19</sup>, Pleasure<sup>12</sup>, but may be in the range 1.5–6 mm<sup>18</sup> or from 2–4 mm<sup>53</sup>. The results obtained by the author are 2.16 mm (just under the average of the findings of these authors), but in accordance with the rank.

The exact determination of VDO on the basis of intra- or extraoral measurements is impossible due to the technique of measurement (diameter of the two reference points, types of measuring devices, sample cards, a ruler, or a more accurate measuring device, the mobility of marked points on the skin or a sticking plaster, removing or deleting reference points with a handkerchief or the patient's hand when wiping the chin and the nose after rinsing the mouth with water, etc.).

Rivera-Morales and Mohl<sup>58</sup> believes that for the vertical dimension there is certain optimal space and that it is not just a point. Rebibo et al.<sup>45</sup> think that perhaps there is a great ability to adapt to changes in VDO, but only under the rotation about hinged axis. Lim and van Waas<sup>59</sup> says: "Determination of VDO seems a combination of art, science and experience".

However, Millet et al.<sup>55</sup> consider that VDR determination by VDO is one of the most commonly used clinical methods, and according to Burnett and Clifford<sup>57</sup> the phonetic method is one of many available techniques for determining the VDO.

Based on examination, Willie<sup>60</sup> finds that the most commonly applied method for determining the VDO is aesthetic appearance and the phonetic method, and the most common combination of methods is phonetic, aesthetic appearance and swallowing.

### Conclusion

Despite a large number of methods for determining the vertical dimension of occlusion based on different systems, techniques and clinical experience, an absolutely safe method for vertical dimension of occlusion is currently lacking.

The phonetic method for determining the vertical dimension of occlusion, using pronunciation of the vowels "O" and "E" is simple, economical and easy to perform. It does not require special operating conditions, equipment, nor training of the doctors.

An approximate value of interocclusal space during vowel pronunciation "O" of 5.5 mm and 7.5 mm of vowel "E" pronunciation can be used to determine the vertical dimension of occlusion in both genders.

Using cognitive functions during counting from 89 to 80 while checking correctness of vertical dimension of occlusion is a simple and good method for checking certain vertical dimension of occlusion in practice. In cases of patients who cannot count backwards, the method of forward counting is applied (80–89).

Previous experience of authors indicates that the proposed method for determining and controlling the vertical dimension of occlusion is clinically acceptable.

Studies have confirmed the hypothesis that the determination of vertical dimension of occlusion using the vowels "O" and "E", and control of the obtained position with the use of a cognitive type of exercises is quite reliable, practical and easy to use in clinical practice.

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