

CLINICAL RESEARCH

# The effect of age and prosthodontic status on the clinical and electromyographic assessment of the interocclusal rest space



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The assessment and determination of the vertical dimension of occlusion (VDO) is essential for managing patients requiring oral reconstructive procedures. The Glossary of Prosthodontic Terms<sup>1</sup> defines VDO as “the distance between 2 selected anatomic or marked points (usually one on the tip of the nose and the other on the chin) when in maximal intercuspal position.” In edentulous patients with several missing posterior teeth or those who have lost the VDO because of severe and extensive denture wear, the therapeutic VDO is often determined based on different mandibular positions—at rest,<sup>2</sup> when swallowing,<sup>3</sup> pronouncing sibilant words,<sup>4,5</sup> or based on esthetic harmony.<sup>6</sup> In addition, a clinical rest space within the range of 2 to 4 mm must be subtracted from the measurements obtained to achieve a functional and comfortable VDO.<sup>7,8</sup> Although many specialists do not accept the concept of a constant rest position in the strict sense,<sup>9</sup> the physiological mandibular rest position has traditionally been used to calculate the VDO.<sup>2</sup>

## ABSTRACT

**Statement of problem.** Clinicians are aware that the vertical dimension of occlusion and the interocclusal rest space (IRS) are 2 major factors that require consideration in the management of patients needing oral reconstructive procedures. However, how the dimensions vary with age and prosthetic status is unclear.

**Purpose.** The purpose of this clinical study was to analyze the IRS in dentate, partially edentulous, and completely edentulous participants using both conventional and electromyographic (EMG)-based methods. The effect of age and prosthodontic status on the clinical and EMG assessment of the IRS was also explored.

**Material and methods.** The IRS was determined for a group of dentate (n=31) and partially edentate (n=31) participants, as well as a group of completely edentulous (n=31) participants who had worn dentures for at least 10 years before participating in the study. Clinical and EMG-based assessments (monitoring both elevator and depressor activity) were carried out using 5 different methods: rest, relaxing mask, phonetics, deglutition, and myobalance. Bivariate and multivariate analyses (forward stepwise linear regression models) were performed to compare the effect of age and prosthodontic status on the IRS ( $\alpha=.05$ ).

**Results.** The average IRS values obtained from clinical and EMG-based assessments were significantly greater among dentate participants ( $2.8 \pm 0.4$  mm and  $3.6 \pm 0.6$  mm, respectively) than partially edentulous ( $1.9 \pm 0.5$  mm and  $2.6 \pm 0.5$  mm) and completely edentulous participants ( $1.4 \pm 0.5$  mm and  $2.2 \pm 0.6$  mm). The IRS values obtained using the 5 methods of clinical assessment were statistically smaller than those obtained by EMG. Correlation and regression analyses showed that age and extended edentulism significantly decreased the IRS. For the IRS determined clinically, a decrease was found of 0.01 to 0.02 mm/year, based on the age of the participant. However, this decrease became greater (0.05 to 0.6 mm) where the participant had changed from being dentate to partially edentulous and partially edentulous to completely edentulous.

**Conclusions.** The IRS becomes significantly smaller in relation to age and denture extension. The rest position in the clinical examination was located cranial to the position used to make the EMG-based measurement. Small but significant differences were found between the IRS values obtained in the clinical and EMG-based methods of assessment in all the prosthetic groups. (J Prosthet Dent 2019;121:791-6)

The clinical rest position is the position assumed by the mandible after using different methods to determine a correct clinical interocclusal rest space and the VDO,

Supported by Advances in Oral Health Group (<http://avancesaludoral.usal.es>) of the University of Salamanca (Spain) which is headed by the first author.

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## Clinical Implications

Clinicians should consider that the interocclusal rest space reduces with age when planning complete occlusal rehabilitations. Interocclusal rest space reduction is probably because of the higher activity of both elevator and depressor muscles in elderly people and denture wearers.

which occurs when the patient is seated with his/her head in an upright position with the Frankfort horizontal plane parallel to the floor.<sup>10</sup> By contrast, the electromyographic (EMG) rest position is the vertical dimension where minimal EMG activity is detected (lowest muscular tonus).<sup>8</sup> Because the mandibular rest position is maintained through an equilibrium or the minimal muscle tonus between the depressor and elevator muscles when standing in an upright position, it could be assumed that the clinical and EMG rest positions are the same. However, based on clinical data,<sup>8,10</sup> the clinical rest position involves more muscle activity than the EMG rest position because masticatory muscles are slightly contracted when maintaining the mandible in this so-called rest position.

Muscles, under the control of the neuromuscular system, move the mandible from the rest position through the space that ends when the teeth come into maximal intercuspal position.<sup>6</sup> An adequate interocclusal rest space (IRS) is required for optimal jaw function (such as mastication or speech) because muscles need to return to resting length after the functional load to maintain metabolic homeostasis.<sup>11,12</sup> IRS equals rest position minus VDO.<sup>11</sup> Hence, in edentulous patients who have lost posterior tooth support, the occlusal contacts for stopping the mandible during the closing movement are not present; therefore, the exact reference required to determine either the VDO or the IRS is missing. Moreover, restoring the correct VDO is even more complicated because the rest position as well as the initial VDO could change,<sup>13,14</sup> consequently affecting the IRS in both dentate and edentulous patients.<sup>15</sup>

Decades ago, Atwood<sup>16</sup> postulated that the rest position is a dynamic rather than a static concept that varies from person to person and among individuals. In addition, a downshift (an increase in the vertical dimension) of the mandibular rest position occurs upon the insertion of dentures in most patients.<sup>17</sup> In contrast, other authors consider that since muscular tonicity decreases with age, the mandible tends to rest at a reduced level than in a younger person.<sup>18</sup> Also, the IRS increases with age<sup>11</sup> and in edentulous patients as compared with dentate patients.<sup>18</sup> Consequently, clinicians are in need of studies that address the effect of age and prosthetic status on the muscular tonus and on the IRS.

Although several techniques are available for determining the VDO, no advantage has been confirmed for using one technique over another with respect to cost, time, and equipment requirements.<sup>19</sup> In addition, few studies have focused on comparing EMG activity in partially and completely edentulous patients and dentate patients using phonetics, swallowing, and relaxation methods.<sup>10,20-22</sup> Because electromyography was introduced into dental research in 1947,<sup>23</sup> the relationship between the clinical rest position induced by conventional clinical methods and muscle electrical activity has been compared to identify the most reproducible way to localize the rest position.<sup>24,25</sup>

The purpose of the present study was to analyze the IRS in dentate, partially edentulous, and completely edentulous participants using both conventional and EMG-based methods. The effect of age and prosthetic status on the measurements of IRS was also explored. The research hypothesis tested was that the clinical rest position should be located cranially to the EMG rest position and that age and prosthetic status influence the measurements of the IRS.

## MATERIAL AND METHODS

All procedures performed in this study were in accordance with the ethical standards of the institutional research committee of the University of Granada and with the 1964 Helsinki Declaration and its later amendments. Informed consent was obtained from all participants. The VDO and the IRS were determined in a group of dentate, partially edentulous, and completely edentulous (denture wearing) participants using conventional methods (rest, relaxing mask, phonetics, deglutition, and myobalance), while an electromyographic device monitored the activity of both the elevator and depressor muscles. Based on the data dispersion of the VDO and IRS obtained using both clinical and EMG-based methods, it was estimated that with 31 participants per group, differences of approximately 1 mm could be detected among the groups with a power of 80% and an  $\alpha$  error of .05. Therefore, each of the 3 groups consisted of 31 participants, whose age ranged from 20 to 92 years and who had attended the Dental School of the University of Granada. All partially and completely edentulous participants had worn their dentures for at least 10 years before participating in the study.

Exclusion criteria, which were applied according to Dworkin and LeResche<sup>26</sup>, included signs or symptoms of craniomandibular disorders: tenderness to palpation of the temporomandibular joint or masticatory or neck muscles; maximum mandibular opening less than 40 mm or laterotrusive movements of less than 7 mm.

Age, sex, the number of standing teeth, and the prosthetic status (dentate or partial or complete denture

**Table 1.** Sociodemographic and clinical description of prosthetic groups (n=93)

Variables	Dentate (n=31; 33.3%)		Partially Dentate (n=31; 33.3%)		Completely Edentulous (n=31; 33.3%)	
	Mean	SD	Mean	SD	Mean	SD
Sociodemographic						
Age (y)**	26.5	8.2	53.6	6.6	71.3	9.2
Sex	N	%	N	%	N	%
Female	13	41.9	17	54.8	11	35.5
Male	18	58.1	14	45.2	20	64.5
Clinical						
Standing teeth**	27.7	0.8	14.7	4.9	0.0	0.0
Occlusal vertical dimension (mm)*	55.4	4.4	52.9	4.9	52.2	7.2
Elevator activity at occlusion ( $\mu$ V)**	62.7	34.1	34.8	13.8	40.3	24.1
Depressor activity at occlusion ( $\mu$ V)**	24.3	8.9	32.2	10.2	31.3	9.1

SD, standard deviation. Statistically significant differences after ANOVA tests at \* $P < .05$  level or \*\* $P < .01$  level.

wearers) were the predictor variables of the IRS and the muscular activity at several jaw positions. To record EMG activity, four 10-mm-diameter Ag/AgCl contact electrodes (Lessa ECG; AB Medica SA) were placed onto the anterior temporal and masseter muscles (elevator muscles) and on the suprahyoid muscles (depressor muscles) on both sides of the jaw after scrubbing the skin with diethyl ether and applying a conductive gel (Spectra; Parker Lb). The electrodes were connected to a QPET2 electromyograph (Brainquiry Lb) using a 200-Hz sampling rate and 24-bit resolution. The digitalized signal was sent to a computer through a Bluetooth connection (Windows 7; Microsoft Corp) with the Bioexplorer (v1.6; CyberEvolution) software. The obtained signal was bandpass filtered (2 to 100 Hz) using a notch filter (50 to 60 Hz) to minimize noise and to remove electrical network interferences. The average amplitude of the EMG signals of the elevator and depressor muscles was recorded at different jaw positions.

Participants were seated in an upright position with the Frankfort plane parallel to the floor. To clinically assess the vertical dimension of all the participants, 2 pencil marks were made on the subnasal point and the chin (mentolabial fold) with a point in the midline. The VDO was recorded while the patient maintained their teeth (natural and/or artificial) in light occlusal contact at the maximal intercuspal position with their dentition or dentures. This distance was subtracted from the measurements obtained for the other jaw positions assessed by 5 different methods to calculate the IRS. The conventional method (CM) consisted of instructing the patient to maintain the mandible in a relaxed posture, with the lips in soft contact (unforced). The relaxing mask method was similar to the CM but involved the patient breathing normally with the eyes covered for 1 minute so that they were unaware they were being evaluated. The phonetic method consisted of measuring the vertical dimension during the pronunciation of the word "Mississippi," and the vertical dimension was registered

during swallowing saliva with the deglutition method. Finally, the mandible position was measured using the myobalance method when the activity of both the elevator and depressor muscles was at the most balanced positions.

The IRS was measured based on conventional clinical procedures (clinically based), but IRS was also measured when the EMG recordings gave the lowest amplitude in microvolts ( $\mu$ V) during such tasks (EMG based). In addition, the mean of 3 sequential measurements made by both the clinical and EMG-based recordings was calculated for all the evaluations conducted. Finally, the overall average was computed for each IRS assessed by the 5 different methods (named as average\_total).

To compare all the quantitative data from the 3 prosthodontic groups, analysis of variance with post hoc Bonferroni corrections was used after evaluating for normal distribution of the data using the Shapiro-Wilk test. Paired  $t$  tests, using the average\_total values as a reference, were also performed to compare the IRS values obtained with the 5 methods. The linear association between the quantitative variables was explored using the Pearson correlation coefficients ( $r$ ), and the Spearman coefficient ( $r_s$ ) was used to detect differences between quantitative and ordinal variables. A forward stepwise linear regression model was performed for predicting the IRS after including all the potentially explanatory variables. Statistical software (IBM SPSS Statistics, v20; IBM Corp) was used for the statistical analyses ( $\alpha = .05$ ).

## RESULTS

Table 1 shows the sociodemographic and clinical description of the prosthodontic groups. Complete edentulous participants were significantly older (71.3  $\pm$  9.2 years) than partial edentates (53.6  $\pm$  6.6 years), and both groups were significantly older than those in the dentate group (25.6  $\pm$  8.2 years). However, the sex distribution was not significantly different among the

**Table 2.** Comparisons of interocclusal rest spaces (IRS) during 5 methods (CM, RM, PM, DM, and MM) assessed clinically through facial marks and based on lowest EMG recordings within prosthetic groups (n=93)

IRS (mm)	Dentate (n=31; 33.3%)		Partially Dentate (n=31; 33.3%)		Completely Edentulous (n=31; 33.3%)	
	Mean	SD	Mean	SD	Mean	SD
CM: conventional method						
Clinically based*	2.9 <sup>a</sup>	0.6	2.8 <sup>b</sup>	1.1	2.4 <sup>b</sup>	0.6
EMG based*	6.5 <sup>b</sup>	1.9	7.8 <sup>b</sup>	1.7	6.6 <sup>b</sup>	2.3
RM: relaxing mask method						
Clinically based**	3.2 <sup>b</sup>	0.8	2.8 <sup>b</sup>	1.1	2.0 <sup>b</sup>	0.8
EMG based*	5.0 <sup>b</sup>	2.1	4.0 <sup>b</sup>	2.0	3.5 <sup>b</sup>	1.8
PM: phonetic method "S"						
Clinically based**	3.0 <sup>b</sup>	0.7	2.5 <sup>b</sup>	1.0	2.1 <sup>b</sup>	0.7
EMG based**	3.7 <sup>a</sup>	1.3	2.6 <sup>a</sup>	1.1	2.3 <sup>a</sup>	1.0
DM: deglutition method						
Clinically based	0.0 <sup>b</sup>	0.0	-0.3 <sup>b</sup>	0.7	-0.7 <sup>b</sup>	1.3
EMG based*	0.0 <sup>b</sup>	0.0	-1.5 <sup>b</sup>	0.6	-2.1 <sup>b</sup>	1.4
MM: myobalance method**						
Average_total	4.7 <sup>b</sup>	1.1	1.2 <sup>b</sup>	0.4	1.4 <sup>b</sup>	0.7
Clinically based**	2.8 <sup>a</sup>	0.4	1.9 <sup>a</sup>	0.5	1.4 <sup>a</sup>	0.5
EMG based**	3.6 <sup>a</sup>	0.6	2.6 <sup>a</sup>	0.5	2.2 <sup>a</sup>	0.6

EMG, electromyographic; SD, standard deviation. Statistically significant intergroup differences after ANOVA tests at \* $P < .05$  level or \*\* $P < .01$  level. Distinct letters in columns mean significant differences after paired  $t$  test, which have average of clinically and EMG-based methods as reference.

groups. The VDO was significantly greater among dentates (55.4 ± 4.4 mm) than in partial (52.9 ± 4.9 mm) or complete (52.2 ± 7.2 mm) denture wearers. The EMG recordings of the elevator muscles at occlusion were significantly higher in dentate participants (62.7 ± 34.1 μV) than in both types of denture wearers. By contrast, the activity of the depressor muscles was higher among denture wearers than those in the dentate group.

Table 2 depicts the IRS at distinct mandible positions using both clinical and EMG-based methods. The ANOVA test showed that the average clinically based IRS was significantly higher ( $P = .002$ ) among dentates (2.8 ± 0.4 mm) than among the partially edentulous (1.9 ± 0.5 mm) and completely edentulous (1.4 ± 0.5 mm) participants. Similarly, the EMG-based IRS was on average significantly higher ( $P = .001$ ) among dentates (3.6 ± 0.6 mm) than among the partially edentulous (2.6 ± 0.5 mm) or completely edentulous (2.2 ± 0.6 mm) participants. The paired  $t$  test showed that all the IRS obtained by the 5 methods were statistically smaller with clinically based assessments than with the EMG-based recordings. The exceptions were the IRS observed with the EMG-based phonetic method for all prosthodontic groups and the IRS registered clinically by the CM in dentates.

Table 3 shows that the muscular activity of both the elevators and depressors of the mandible was significantly higher in complete or partial edentates than for dentates ( $P = .004$ ). Also, a general trend of increased muscular activity was observed, starting from dentates to

**Table 3.** Comparisons of muscular activity (elevators and depressors of mandible) with distinct methods (CM, RM, PM, DM, and MM) for determining occlusal vertical dimension within prosthetic groups (n=93)

EMG recordings (μV)	Dentate (n=31; 33.3%)		Partially Dentate (n=31; 33.3%)		Completely Edentulous (n=31; 33.3%)	
	Mean	SD	Mean	SD	Mean	SD
CM						
Elevators*	18.8 <sup>a</sup>	8.9	24.6 <sup>b</sup>	10.0	21.8 <sup>b</sup>	7.6
Depressors**	18.8 <sup>a</sup>	6.0	26.2 <sup>b</sup>	10.4	23.9 <sup>b</sup>	7.8
RM						
Elevators*	17.7 <sup>a</sup>	9.5	22.2 <sup>b</sup>	5.2	23.5 <sup>b</sup>	8.8
Depressors**	18.8 <sup>a</sup>	4.7	25.7 <sup>b</sup>	6.8	27.7 <sup>b</sup>	12.2
PM						
Elevators**	18.4 <sup>a</sup>	6.6	34.1 <sup>a</sup>	21.8	43.6 <sup>a</sup>	18.8
Depressors**	31.2 <sup>b</sup>	11.0	55.1 <sup>b</sup>	25.6	61.3 <sup>b</sup>	37.3
DM						
Elevators**	30.1 <sup>b</sup>	15.8	47.2 <sup>b</sup>	25.6	54.4 <sup>b</sup>	25.0
Depressors	73.6 <sup>b</sup>	35.1	63.4 <sup>b</sup>	29.8	67.9 <sup>b</sup>	40.4
MM						
Elevators**	17.6 <sup>a</sup>	7.0	33.2 <sup>a</sup>	15.0	39.0 <sup>a</sup>	25.1
Depressors**	16.3 <sup>a</sup>	5.6	33.2 <sup>a</sup>	11.4	31.6 <sup>a</sup>	9.6

CM, conventional method; DM, deglutition method; MM, myobalance method; PM, phonetic method; RM, relaxing mask method; SD, standard deviation. Statistically significant intergroup differences after ANOVA tests at \* $P < .05$  level or \*\* $P < .01$  level. Distinct letters in columns mean significant differences after paired  $t$  test, which have myobalance trial values as reference.

partial edentates and finally to the completely edentulous participants, for whom it was the highest. In contrast, during deglutition, the level of muscular activity was comparable among all the groups. As for the muscular activity recorded during the myobalance trial, the paired  $t$  test showed that both the elevators and depressors recorded a higher activity during deglutition than that recorded during the myobalance trial in all subgroups ( $P = .001$ ). In addition, the lowest muscular activity was registered during the CM and relaxing mask method in all prosthetic groups, being even lower than that observed for the myobalance method in partially and completely edentulous participants ( $P = .01$ ).

Table 4 shows the significant linear correlations between baseline conditions (age, prosthetic status, missing teeth, and VDO) for the IRS and the muscular activity recorded during all the clinical and EMG-based mandible positions. The IRS measured either clinically or electromyographically with most methods was significantly and inversely correlated with age, missing teeth, and the prosthetic status ( $P = .002$ ). Moreover, the muscular activity of both depressors and elevators was proportional to age, the prosthetic status, and the number of missing teeth. The VDO correlated with the IRS recorded using the different methods and inversely correlated with muscular activity.

The linear stepwise regression models (Table 5) showed that age and the prosthetic status were significant predictors ( $P < .001$ ) of the IRS after introducing all

**Table 4.** Linear correlation coefficients (Pearson and Spearman) between baseline conditions (age, prosthetic status, number of missing teeth, and VDO) with interocclusal rest space (IRS) and muscular activity recorded by distinct clinical and EMG-based methods

	Age (r)	Prosthetic Status (r <sub>s</sub> )	Missing Teeth (r)	VDO (r)
IRS, clinically based				
CM	-0.23*	-0.35*	-0.24*	0.08
RM	-0.48**	-0.50**	-0.47**	0.25*
PM	-0.38**	-0.45**	-0.34**	0.15
DP	-0.35**	-0.31**	-0.32**	-0.11
IRS, EMG based				
RM	-0.37**	-0.32**	-0.30**	0.19*
PM	-0.37**	-0.49**	-0.41	0.12
DM	-0.68**	-0.77**	-0.66**	0.09
MM	-0.79**	-0.71**	-0.74**	0.21*
Muscular activity (elevators)				
RM	0.29**	0.38**	0.26*	-0.15
PM	0.51**	0.63**	0.48**	-0.21*
DM	0.38**	0.42**	0.39**	-0.21*
MM	0.47**	0.56**	0.42**	-0.30
Muscular activity (depressors)				
CM	0.31**	0.24*	0.24*	-0.22*
RM	0.42**	0.41**	0.36**	-0.09
PM	0.43**	0.49**	0.40**	-0.22*
MM	0.28**	0.65**	0.25**	0.17
Average_total IRS				
Clinically based	-0.77**	-0.55**	-0.72**	0.21*
EMG based	-0.74**	-0.47**	-0.72**	0.28*

EMG, electromyographic; r, Pearson's correlation coefficients; r<sub>s</sub>, Spearman's correlation coefficients; VDO, vertical dimension of occlusion. Statistically significant linear correlation at \*P<.05 level or \*\*P<.01 level.

the potential predictors (age, sex, prosthetic status, missing teeth, and VDO). These results indicated that the IRS, determined clinically, would show a yearly decrease of 0.01 to 0.02 mm but that this decrease would be greater (0.05 to 0.6 mm) if the person changed from dentate to partially edentulous and from partially to completely edentulous. This model was highly predictive (corrected R<sup>2</sup>: 0.61). However, the IRS determined by EMG was only dependent on the prosthetic status and would decrease by 0.7 to 1.0 mm when dentate patients become partially edentulous and again when patients become completely edentulous. This model is also able to explain a large amount of variance (corrected R<sup>2</sup>: 0.56).

**DISCUSSION**

This study evaluated the IRS using several clinical and EMG-based methods among dentate and partially and completely edentulous patients. The data support the hypothesis that clinically based rest positions are located cranial to the EMG-based positions and that age and prosthetic status may have an effect on IRS measurements. The focus was on the IRS rather than the VDO because the former is independent of the specific facial

**Table 5.** Linear regression models (forward stepwise) for predicting average IRS determined clinically or by EMG after including all potential predictors (age, sex, prosthetic status, missing teeth, and VDO)

Parameters for Determining the Average Clinically Based IRS <sup>a</sup>	Standardized β	P	CI-95% β		
			β	Lower	Upper
Age	-.43	.008	-.02	-.01	-.03
Prosthetic status (dentate as reference)	-.38	.020	-.33	-.05	-.60
Parameters for determining the average EMG-based IRS <sup>b</sup>					
Prosthetic status (dentate as reference)	-.75	<.001	-.80	-.65	-.95

CI, confidence interval; EMG, electromyographic; IRS, interocclusal rest space; VDO, vertical dimension of occlusion. <sup>a</sup>F: 72.87; df: 2, P<.001. Corrected R<sup>2</sup>=0.61. <sup>b</sup>F=116.21; df: 1, P<.001. Corrected R<sup>2</sup>=0.56.

marks used for such purposes. A decrease in the IRS associated with age and prosthodontic status was observed. This observation could be related to a gradual shortening of the muscular movement range that occurs with aging. However, because the participants' exact opening movement range was not registered, future longitudinal studies are needed to evaluate this hypothesis. Also, it is plausible that the oral musculature of experienced denture wearers, which is used to limit the extension of their mandibular movements to stabilize their dentures, may have undergone a gradual shortening and increase of muscular tonicity. In fact, the muscular tone was observed to be significantly higher in denture wearers than dentate patients in all the mandible positions assessed.

In this regard, and as shown by the facial and skeletal measurements of the IRS,<sup>20</sup> more than 40% of denture wearers had no rest space at all because the conventional calculations of rest space (that is, the difference between the rest and the maximal intercuspal position) yielded a negative average IRS. This fact could support the idea that among completely edentulous individuals, the masticatory musculature is shortened at the rest position. When the head is stationary, the mandible is supported by passive viscoelastic forces in perioral soft tissues.<sup>12</sup>

Clinically, there is evidence that the fabrication of new dentures for an experienced denture wearer with worn existing dentures (low VDO) can present a severe problem, particularly if an attempt is made to restore the patient's original VDO. This occurs because the neuromuscular reaction to the restored dentures may preclude satisfactory function<sup>20</sup> and the elderly patient is most likely to resort to using the existing, ill-fitting but comfortable dentures with their reduced VDO. The muscular activity of both elevators and depressors is proportional to patient's age and the grade of edentulism (extension of the denture and the number of missing teeth), which supports the hypothesis of gradual spasticity with aging.

In contrast with several authors who reported that a phonetically induced rest position or when swallowing<sup>18</sup> corresponded to the position of minimal muscle activity,<sup>24,27</sup> we found that the conventional and masked rest positions were those where the muscular activity was the smallest in all the prosthodontic groups (Table 3). The relaxing mask could be useful for assessing VDO in patients.

According to the Posselt diagram,<sup>28</sup> the mandibular rest position was found to occur 2 to 4 mm from the maximal intercuspal position. In the present study, the 95% confidence interval for the clinically assessed IRS was 2.6 to 2.9 mm for dentates, 1.7 to 2.0 mm for partial dentates, and 1.3 to 1.6 mm for completely edentulous individuals. However, these 95% confidence intervals for the IRS were higher for the EMG-based recordings, that is, 3.4 to 3.8 mm for dentates, 2.4 to 2.8 mm for partial edentates, and 1.8 to 2.3 mm for completely edentulous individuals. These values are comparable with those reported by Gamick and Ramfjord,<sup>21</sup> who found that the mandibular rest position determined with EMG averaged 3.3 mm, and with the values observed by Hickman and Stauber<sup>25</sup> (3.4 mm) in nondysfunctional adults. Michelotti et al<sup>8</sup> suggest that within the first 3 to 4 mm of the opening movement, the elevators considerably decrease in electrical activity. However, they also reported that the mean IRS for the EMG-based recordings was 7.7 ±2.7 mm (range 0.4 to 12.7 mm) in dentate adults, which is higher than that observed for dentates in this study. Also, in the present study, the EMG-based positions were greater than the clinically based recordings, but the difference between both approaches was smaller than the 6.3 mm reported by Michelotti et al.<sup>8</sup> Furthermore, in contrast with Michelotti et al,<sup>8</sup> who reported that clinically based and EMG-based recordings were not significantly correlated ( $r=0.31$ ;  $P>.05$ ), a strong and significant correlation ( $r=0.76$ ;  $P<.001$ ) between both the variables in dentates was found in the present study.

## CONCLUSIONS

Within the limitation of this clinical study, the following conclusions were drawn:

1. The IRS is significantly shortened in relation to age and to the extension of the dentures.
2. The clinically based rest positions were located cranial to the EMG-based positions.
3. Small but significant differences regarding the clinically based and EMG-based methods of the IRS assessment were observed in all the prosthetic groups.

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<https://doi.org/10.1016/j.prosdent.2018.09.006>