







# Evolution of Chewing Force in Geriatric Edentulous Patients

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## Abstract

**Objective** The aim of this study was to assess the evolution of chewing force in edentulous geriatric patients rehabilitated with complete dentures. Chewing function is compromised in individuals who lose all their teeth, as well as in those with complete dentures. The maintenance and recovery of the chewing function in these patients require replacement of the lost natural teeth.

**Materials and Methods** In this study, the chewing force was evaluated by electromyographic analysis of the temporalis and masseter muscle endings in 120 patients with old and new bimaxillary complete dentures.

**Results** Replacement of complete dentures was shown to improve stability, retention, occlusion, and support of the prosthesis. All jaw movements were evaluated using electromyography to assess the evolution of chewing force with and without occlusal adjustment, identify premature contact points, identify occlusal interference, respect the balanced occlusal scheme, and assess the increase in muscle strength. This study found that muscle strength in patients with prosthesis without occlusal adjustment was 527.1 N but was higher for prostheses with occlusal adjustment at 614.7 N, and this strength of 614.7 N was maintained after 1 month of control.

**Conclusion** The chewing force evolved in patients with complete dentures, and an increase was observed when occlusal adjustment was performed.

## Keywords

- ▶ bite force
- ▶ occlusal adjustment
- ▶ electromyography
- ▶ complete denture (MESH)

## Introduction

Edentulous patients with complete dentures present functional limitations in the stomatognathic system, reduced masticatory performance, tooth loss, alveolar bone resorption, oral mucosa dystrophy, and atrophy of the muscle fibers causing neurotransmitter reduction compared with patients with natural teeth.<sup>1,2</sup>

Chewing movements demonstrate decreased vertical development in geriatric patients wearing complete den-

tures compared with young patients. A factor causing mandibular crest resorption during function is ridge atrophy that could arise from compressive forces generated by dentures that exceed the physiological tolerance of the underlying bone.<sup>3,4</sup>

This indicates that the replacement of complete dentures accompanied by occlusal adjustment can effectively correct the function of the stomatognathic apparatus, as well as of respiration, phonation, chewing, and swallowing. Appropriate

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occlusal guidance exhibits an optimal contact relationship between the upper and lower teeth and generates a force that is transmitted appropriately to the supporting tissues.<sup>5,6</sup>

The optimal occlusal guidance in complete dentures is bilateral balanced occlusion. Unbalanced occlusal forces can lead to prosthetic instability, causing undesired movement of the prosthetic base and traumatizing the supporting structures.<sup>7,8</sup>

Electromyography (EMG) gives us the possibility of exploring the neuromuscular system to evaluate the normal muscle function. Additionally, it can analyze any pathological conditions arising from said normality.<sup>9</sup>

EMG observation has indicated that in patients wearing conventional complete dentures, there is significant reduction in the power of the anterior temporalis and masseter muscles, which alters the masticatory functional capacity, compared with patients with complete natural dentition.<sup>10,11</sup>

Thus, chewing efficiency is a parameter for quantifying the quality of mastication. It is defined as the number of chewing blows required to achieve a crushing level for a given aliment.<sup>12</sup>

Occlusal adjustment entails the evaluation of the relative bite forces by assessing relative occlusal forces, data recording, determining premature contacts, study and management of the occlusal balance in patients with natural teeth, and complete coronary or implant restorations in patients with complete dentures.

Therefore, this study aimed to assess the evolution of the masticatory force in rehabilitated geriatric patients with complete dentures.

## Materials and Methods

This was an experimental, descriptive, observational, and quantitative study. The sample universe ( $n = 120$ ) included completely edentulous patients with preexisting bimaxillary complete dentures, completely edentulous patients without dentures, and patients comfortable with their old dentures. The following four study groups were formed: control group (GC,  $n = 30$ ), edentulous patients with old complete dentures; Group 1 (G1,  $n = 30$ ), patients with immediate installation of complete dentures without occlusal adjustment; Group 2 (G2,  $n = 30$ ), patients with immediate installation of complete dentures with occlusal adjustment; and Group 3 (G3,  $n = 30$ ), patients with complete dentures with occlusal adjustment after 1 month of installation (► Fig. 1).

## Methods

This study was conducted at the Dental Care Center of the Universidad de las Américas (UDLA) and approved by the Bioethics Committee (CEISHSOLCAQ.OBS.19.124). The medical history was recorded for all patients. If patients expressed interest in being a part of the study, they were requested to read, accept, and sign the informed consent form.

The enrolled patients were asked to sit in front of the table where the EMG was placed at a 90-degree angle with the gaze straight ahead. New complete dentures were installed

without occlusal adjustment, and we waited for 10 minutes. A gel was used for the echo with the electrodes, as a means of conduction of the muscular electrical signals to the EMG. The electrodes were placed on the anterior temporalis and superficial masseter muscles. We placed a piece of chewing gum without sucrose bilaterally at the level of the first molars, and the patient was asked to bite four times with pauses of 4 seconds. A software with a green light indicator indicated if the bite was unilateral or bilateral for each contraction. The values sent by the electrodes to the EMG were evaluated by software via Bluetooth. The electrodes were removed, and the data were stored in the EMG program. Data were evaluated and expressed in histograms in the EMG software installed on the computer. For the new complete dentures, the occlusal adjustment was performed using Accufilm II 80  $\mu\text{m}$  articulating paper positioned bilaterally in the patient's mouth, to ensure that the patient performed opening, closing, lateral, protrusive, and retrusive movements, and the same procedure indicated previously was repeated.

## Results

The results obtained in relation to muscle strength and chewing action, with and without occlusal adjustment, were analyzed descriptively as a prevalence variable. The concordance between total fit and nonocclusal fit prosthetics was analyzed using EMG electrodes (► Table 1).

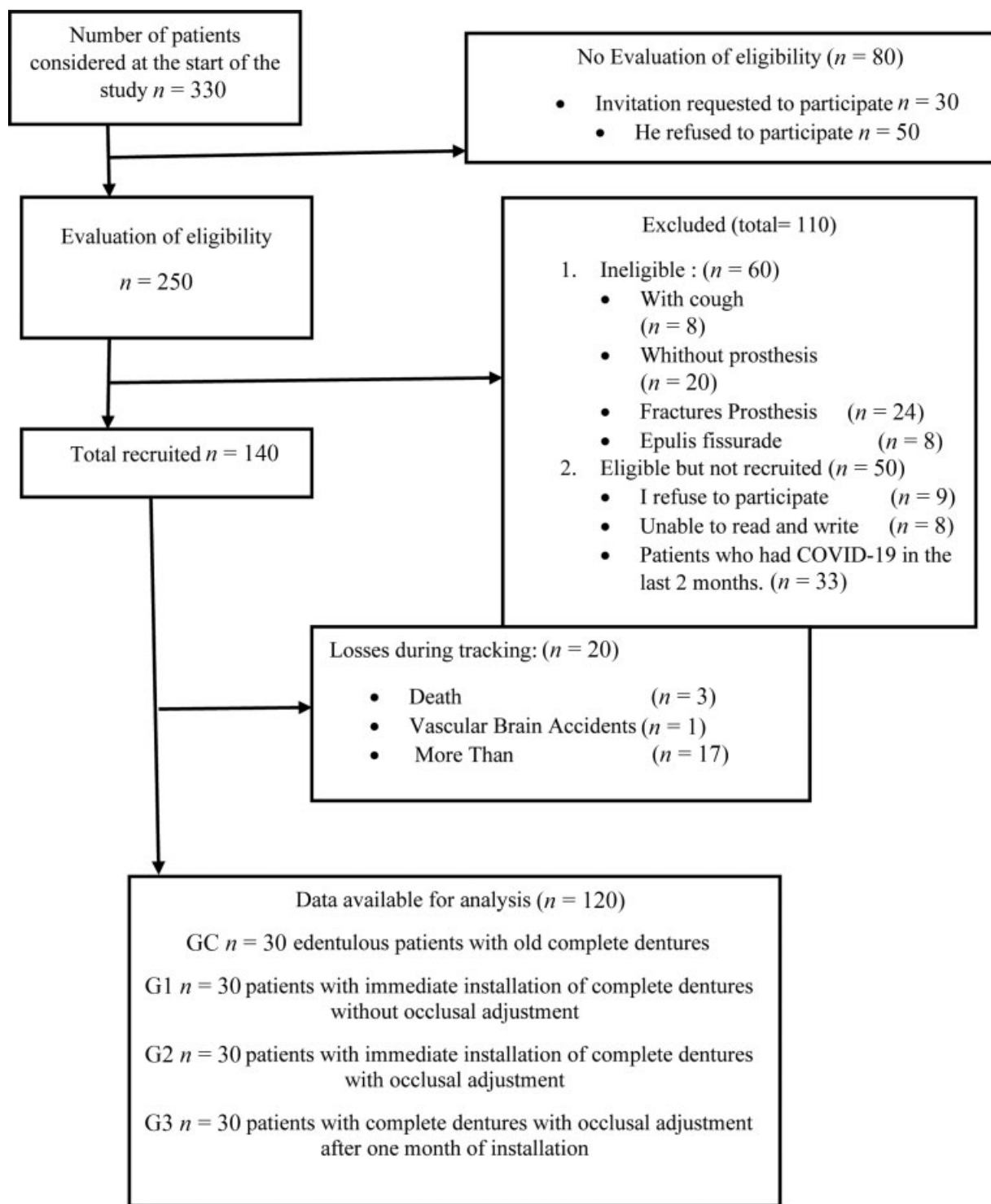
Patients with old prostheses obtained constant lower values during the four contractions with a mean of 372.4 N, but the values were higher for the prosthesis installed without occlusal adjustment. For the prosthesis installed with occlusal adjustment, greater muscle strength was achieved, with no variation of forces observed after 1 month of control (► Table 1).

The muscular assessment of the right masseter muscle showed that it exerted lesser force as compared with the left masseter, in case of old prostheses. When the prosthesis was installed without occlusal adjustment, both sides showed similar forces. In dentures with occlusal adjustment, a force of 614.2 N was observed on the right side, compared with 614.3 N on the left side. After 1 month of control, the muscle strength was maintained on both sides (► Table 2).

The right temporalis muscle with old prosthesis presented a lower force than the left temporalis, 394.6 N. In the prosthesis installed without occlusal adjustment, 560 N, there was an increase to 630.3 N on the left side compared with the right side. In dentures with occlusal adjustment, the forces were maintained 1 month after installation, 630.2 N (► Table 3).

## Discussion

When an older adult presents edentulism, masticatory performance, phonation, self-esteem, and aesthetics are affected; with the use of total prostheses to replace the lost teeth, it is intended to improve their lifestyle.<sup>13</sup> Automated and computerized methods used allow the visualization of neuromuscular adaptability in an objective way. Surface EMG during isometric



**Fig. 1** Flow diagram of the study.

contraction of the mandibular elevator muscles and recording of bite force have good reproducibility in clinical use.<sup>14</sup>

The EMG activity in the temporal muscles (bilateral chewing force)<sup>15</sup> with old total prostheses generated 372.7 N of strength; with new prostheses installed in the mouth, it increased to 527.8 N of strength; and with the respective occlusal adjustment, it increased to the month of control, 614.9 N of force.<sup>4</sup>

Alfaro et al showed that relative masticatory muscle activity is 2.57 times higher in patients carrying total prostheses than in toothed ones; the duration of the masticatory sequence was increased with the crushing force of food.<sup>16</sup> The study showed significant changes mainly in EMG silence, both in its duration and in the percentage of inhibition. When comparing the muscular forces in masseters (right and left) in new prostheses without occlusal adjustment, 533.8 N of force was obtained,

**Table 1** Comparison between the muscle contraction forces in the four groups

Old complete denture				New complete denture without occlusal adjustment			
Contraction <sup>a</sup>	N <sup>b</sup>	Media (N) <sup>c</sup>	Of (N) <sup>d</sup>	Contraction <sup>a</sup>	N <sup>b</sup>	Media (N) <sup>c</sup>	Of (N) <sup>d</sup>
Contraction 1	30	372.4	59.5	Contraction 1	30	533.8	89.3
Contraction 2	30	372.4	59.6	Contraction 2	30	533.8	89.1
Contraction 3	30	372.3	59.4	Contraction 3	30	527.1	88
Contraction 4	30	372.4	59.6	Contraction 4	30	527.7	88
New complete denture installed with occlusal adjustment				Complete dentures with occlusal adjustment after 1 month of installation			
Contraction <sup>a</sup>	N <sup>b</sup>	Media (N) <sup>c</sup>	Of (N) <sup>d</sup>	Contraction <sup>a</sup>	N <sup>b</sup>	Media (N) <sup>c</sup>	Of (N) <sup>d</sup>
Contraction 1	30	614.1	42.2	Contraction 1	30	614.2	42.2
Contraction 2	30	614.2	42.2	Contraction 2	30	614.3	42.2
Contraction 3	30	614.3	42.5	Contraction 3	30	614.3	42.4
Contraction 4	30	614.7	42.2	Contraction 4	30	614.7	42.2

<sup>a</sup>Contraction muscle.  
<sup>b</sup>N: Newton.  
<sup>c</sup>p < 0.05; Kruskal–Wallis H test.  
<sup>d</sup>p < 0.05; analysis of variance test.

**Table 2** Comparison between the right and left masseter muscles

Right masseter describes 95% confidence interval for the mean							
Patients <sup>a</sup>	N <sup>b</sup>	Media (N) <sup>c</sup>	Of (N) <sup>d</sup>	Lower limit <sup>e</sup>	Upper limit	Minimum <sup>f</sup>	Maximum
Old complete denture	30	372.3	59.5	350.1	394.6	299.1	478.8
Complete denture immediate installation without occlusal adjustment	30	533.8	89.4	500.5	567.2	350.6	681.7
Complete denture immediate installation with occlusal adjustment	30	614.2	42.3	598.4	630	538.3	703.5
Complete dentures 1 month after control	30	614.2	42.3	598.4	630	538.3	703.5
Total	120	533.6	116.2	512.6	554.7	299.1	703.5
Left masseter describes 95% confidence interval for the mean							
Patients <sup>a</sup>	N <sup>b</sup>	Media (N) <sup>c</sup>	Of (N) <sup>d</sup>	Lower limit <sup>e</sup>	Upper limit	Minimum <sup>f</sup>	Maximum
Old complete denture	30	372.6	59.6	350.3	394.8	299.1	478.4
Complete denture immediate installation without occlusal adjustment	30	533.8	89.1	500.5	567	349.8	681
Complete denture immediate installation with occlusal adjustment	30	614.3	42.3	598.5	630.1	538.9	701.2
Complete dentures 1 month after control	30	614.3	42.2	598.5	630	538.3	703.5
Total	120	533.7	116.1	512.7	554.7	299.1	701.2

<sup>a</sup>Subject of the study.  
<sup>b</sup>N: Newton.  
<sup>c</sup>Standard deviation.  
<sup>d</sup>Error rate.  
<sup>e</sup>p < 0.05; Kruskal–Wallis H test.  
<sup>f</sup>p < 0.05; analysis of variance test.

increasing with occlusal adjustment to 614.2N, a value that was maintained a month after installation. Herrero et al<sup>17</sup> demonstrated, during the maximum bilateral muscle contraction of the masseter, that the differences between old and new

prostheses are significant, greater strength in prostheses new results coincident with the study.<sup>17</sup>

In the present study, the analysis of the muscular activity of the right masseter muscle showed lower values with old

**Table 3** Comparison between the right and left temporalis muscles

Right temporalis describes 95% confidence interval for the mean							
Patients <sup>a</sup>	N <sup>b</sup>	Media (N) <sup>c</sup>	Of (N) <sup>d</sup>	Lower limit <sup>e</sup>	Upper limit	Minimum <sup>f</sup>	Maximum
Old complete denture	30	372.4	59.4	350.2	394.6	299	478.2
Complete denture immediate installation without occlusal adjustment	30	527.1	88	494.2	560	350.3	681.3
Complete denture immediate installation with occlusal adjustment	30	614.4	42.5	598.6	630.3	539	700.9
Complete dentures 1 month after control	30	614.4	42.3	598.6	630.2	539	700.9
Total	120	532.1	116.1	511.1	553.1	299	700.9
Left temporalis describes 95% confidence interval for the mean							
Patients <sup>a</sup>	N <sup>b</sup>	Media (N) <sup>c</sup>	Of (N) <sup>d</sup>	Lower limit <sup>e</sup>	Upper limit	Minimum <sup>f</sup>	Maximum
Old complete denture	30	372.7	59.4	350.5	394.8	299.3	478.9
Complete denture immediate installation without occlusal adjustment	30	527.8	87.9	495	560.6	350	682.1
Complete denture immediate installation with occlusal adjustment	30	614.3	42.3	598.5	630.1	538.9	701.2
Complete dentures 1 month after control	30	614.9	42.2	599.1	630.6	540	702.1
Total	120	532.5	116.1	511.6	553.5	299.3	702.1

<sup>a</sup>Subject of the study.

<sup>b</sup>N: Newton.

<sup>c</sup>Standard deviation.

<sup>d</sup>Error rate.

<sup>e</sup> $p < 0.05$ ; Kruskal–Wallis H test.

<sup>f</sup> $p < 0.05$ ; analysis of variance test.

complete dentures (372.3 N). The value was 533.8 N for complete dentures installed without occlusal adjustment, while dentures installed with occlusal adjustment showed an increased strength with a value of 614.2 N. One month after the complete denture installation, the value of 614.2 N was still maintained, thus showing that there is no difference in forces between complete denture with occlusal adjustment and control. The changes in the masticatory function of the complete denture were examined with respect to any adverse effects on the muscles.

The complete denture with occlusal adjustment showed a force of 614.3 N for the left masseter. One month after installation, it still presented a force of 614.3 N, indicating that there was no variation in the force. However, with complete dentures installed without occlusal adjustment and old complete dentures, the values were lower at 533.8 N and 372.6 N, respectively.<sup>18</sup>

Regarding the right temporalis muscle, the values were lower with old complete dentures with a muscle force of 372.4 N. For complete dentures installed without occlusal adjustment, a force of 527.1 N was demonstrated, whereas the complete dentures installed with occlusal adjustment showed a force of 614.4 N that was significantly higher. After 1 month of control after installation, the force was maintained at 614.4 N.

The left temporalis muscle of the old complete dentures showed a slight increase compared with the right temporal muscle with a force of 372.7 N. For complete dentures without occlusal adjustment, a lower force of 527.8 N as compared with complete dentures with occlusal adjustment showing a force of 614.9 N was observed. After 1 month of complete denture control, the force of 614.9 N was maintained.<sup>19</sup>

Peeran et al mention that during the maximum voluntary contraction of the masseter muscle, the force was 231.93 N on the right side and 230.60 N on the left side with old complete dentures and 163.13 N on the right side and 171.73 N on the left side with new complete dentures after 5 months of follow-up.<sup>20,21</sup> The difference between the old and new complete dentures with respect to the activity of the masseter muscle on the right and left sides was 68.8 N and 58.8 N, respectively. Hence, it was inferred from these values that the right-side masseter muscle was more efficient than the left. Statistical analysis revealed a highly significant increase in muscle efficiency ( $p = 0.000$ ,  $p = 0.002$ ) in participants with the new complete denture after 5 months of follow-up compared with that in participants with a previous complete denture during maximum voluntary contraction.<sup>22</sup>

Fernández et al pointed out in their study with EMG that the temporalis and masseter muscles showed a decrease with increasing vertical dimension and change in the

mandibular angle, giving it better coefficients of inclination. This was commonly observed in men, and greater mandibular angle was associated with lower EMG activity in overdenture implants.<sup>20</sup> Chewing strength was statistically assessed using the *t*-test, and the mean bite strength of patients wearing implant-retained overdentures was found to be more than double than that of patients wearing conventional complete dentures.<sup>23</sup>

There were significant differences determined in the study. During the first contraction with an installed complete denture with occlusal adjustment, an average force of 614.1 N was observed, which was maintained even after 1 month of control. The complete dentures installed without occlusal adjustment presented lower average force of 533.8 N, while the old complete dentures presented the lowest value of 372.4 N. There were no significant differences in the chewing efficiency, and similar results to this study were observed even after 1 year of follow-up. Considering the quality criteria of the complete denture, no improvement in the stability of the mandibular complete dentures was observed with the new dentures ( $p = 0.157$ ), and only small changes were observed between the preexisting and new complete dentures. Therefore, this limitation probably influenced the chewing efficiency.<sup>24,25</sup>

The present study determined that the mean force of the muscle during the four contractions in the old complete denture wearers was 372.4 N, which differed significantly from the results of the previous study.<sup>24,25</sup> The bite force in users with a conventional complete denture was 128.5 N. The force value of the conventional complete denture wearers also differed from those with implant overdentures by 63.1 N, which may be justified because the evaluation method recorded the bite force values unilaterally. Closer results were obtained at 182.9 N, as the evaluation was performed with the bite bilateral force transducer, similarly to the present study. The evaluation of this study assessing the muscle strength of patients with complete dentures without occlusal adjustment showed a value of 527.1 N, which increased by performing the occlusal adjustment to 614.7 N in patients with complete dentures with occlusal adjustment. Moreover, the force was maintained at 614.7 N after 1 month of control.

Poli et al determined that the masticatory bite force is higher in men than in women, both in older adult patients with complete natural dentition, rehabilitated patients with conventional complete dentures, overdentures, and total edentulous ones, regardless of the presence or absence of teeth. In patients with complete denture or overdentures, there are no differences between men and women; prostheses improve compared with edentulous patients, considering it higher with overdentures prostheses; the subjects' chewing force in complete natural dentition is even higher; there are no differences between the chewing forces based on various body mass index categories. Older people who use prosthetics require special attention from a nutritionist to avoid the risk of malnutrition.<sup>26</sup>

Ruttitivapanich et al determined the bite force in the maximum intercuspation position between patients observing subjectivity. When measuring, they indicated the patient to bite on the right or left side or on both, and asked the same to

indicate where he feels that bite more. That is why advanced systems such as the T-scan III were used; it coincides with the subjective management in the study at the moment of determining the chewing force in geriatric patients with their old and new prostheses. When placing the gum, we do not assess the real force—on the right, left, and both sides—we only receive what the patient expresses to us. The use of articulating paper does not determine chewing force; it only discovers the point of contact in the prostheses.<sup>27,28</sup>

In the group with conventional complete dentures, the difference between the initial total score and total score after 3 months was not significant ( $p = 0.117$ ), except in the pain subscale, which showed an improvement over time ( $p = 0.003$ ). All other subscale scores were not significantly different. A significant difference in chewing efficiency was found between before and after rehabilitation with implant overdentures ( $p < 0.001$ ). For the conventional complete denture group, no significant differences were observed after 3 months ( $p = 0.889$ ).<sup>29,30</sup>

The impact of oral health on the quality of life was significantly lesser in the implant overdenture group than in the conventional complete denture group ( $p = 0.001$ ). Chewing efficacy significantly correlated with the implant overdenture results in the conventional complete denture group ( $p > 0.05$ ). However, no correlation was found in the implant overdenture group ( $p < 0.05$ ).<sup>31-33</sup>

The aging factor could be related to the reduced values of bite force in conventional complete denture users.<sup>34,35</sup> Decrease in the mass and force observed in the aging process is due to the nutritional decrease and consequent reduction in protein synthesis.<sup>36,37</sup>

The possibility of increasing the bite force and, consequently, the chewing function for patients with conventional complete denture can be considered with implant rehabilitation.<sup>30</sup> The use of implant-retained overdentures increases the chewing force from 43 to 53% compared with a conventional denture.<sup>38</sup> Analysis of the EMG activity of the right and left temporalis muscles in previous studies showed that they were more active than the masseter muscles. The temporalis muscle is one of the main active muscles involved in maintaining the mandibular posture.<sup>39,40</sup>

## Conclusions

The chewing force evolved in patients with complete dentures, and an increase was observed when occlusal adjustment was performed. The study was done to measure the limitation of masticatory forces with only the EMG; nonetheless the relative occlusal force was not measured with other devices (T-scan) even though it is recommended for studies in the future to consider this variant to conclude with the effectiveness of the occlusal scheme used.

### Authors' Contribution

Byron Velásquez-Ron was involved in preparation of paper, review, and recollection of information in the Prosthesis Department postgraduate unit of Oral Rehabilitation UDLA.

María Galárraga-Criollo was involved in preparation of paper, review, and recollection of information in the Prosthesis Department postgraduate unit of Oral Rehabilitation UDLA.

María Romero-Guerrero was involved in preparation of paper, review, and recollection of information in the Prosthesis Department postgraduate unit of Oral Rehabilitation UDLA.

Maria Rodriguez-Tates was involved in correction of the paper in the Prosthesis Department postgraduate unit of Oral Rehabilitation UDLA.

Flavio Pineda-Lopez was involved in maintenance and calibration of EMG used in the study; review of date found.

#### Conflict of Interest

The authors have explicitly stated that there are no conflicts of interest in connection with this article. The authors also received no support or funding for this report.

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