THE JOURNAL OF PROSTHETIC DENTISTRY

CLINICAL RESEARCH

Impact of rehabilitation with removable complete or partial dentures on masticatory efficiency and quality of life: A cross-sectional mapping study

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ABSTRACT

Statement of problem. Tooth loss directly affects mastication, cognitive function, and oral health-related quality of life (OHRQoL). Complete dentures (CDs) and removable partial dentures (RPDs) represent a common oral rehabilitation approach. However, studies addressing the impact of removable dentures on replacing missing teeth are lacking.

Purpose. The purpose of this clinical study was to evaluate whether the OHRQoL, the jaw function limitation (JFL), and the masticatory efficiency of CD and RPD wearers are similar to those of patients with natural teeth and to evaluate whether wearing removable dentures can predict an effect on the OHRQoL, JFL, and masticatory efficiency of their wearers.

Material and methods. The Oral Health Impact Profile (OHIP-14) questionnaire and the JFL scale were used to measure OHRQoL and JFL. Masticatory efficiency was analyzed by using a subjective color-mixing index for the chewing gum bolus and shape index and an objective colorimetric analysis by using a software program ViewGum. Data were analyzed with Kruskal-Wallis and post hoc Dunn tests, followed by multiple linear regression (α=.05).

Results. The results from OHIP-14 evidenced that both denture groups presented a low impact on OHRQoL. JFL was higher for all denture wearers. For the subjective color-mixing analysis, the control and RPD groups presented better masticatory efficiency than CD wearers. Colorimetric analysis evidenced better masticatory efficiency for the control group, who differed from the CD and RPD groups. Wearing RPDs was a predictor of impaired JFL and OHRQoL, and the use of CDs was a predictor of impaired JFL and masticatory efficiency.

Conclusions. Despite being rehabilitated, CD and RPD wearers still had impaired OHRQoL, JFL, and masticatory efficiency. Also, the use of these prostheses can predict a negative effect on these 3 variables. (J Prosthet Dent 2022;128:1295-302)

Edentulism affects more than 158 million people worldwide[1] and may compromise speech, mastication, deglutition, and social abilities. These consequences, associated with the esthetic impairment edentulism imposes, may impact oral health-related quality of life (OHRQoL).[2-5] Untreated edentulous patients commonly prefer a soft diet, which might have low nutritive value, leading to reduced nutritional status.[6-9] Therefore, oral rehabilitation also aims to assist these patients to partially recover their mastication, cognitive function, and self-esteem and to improve their OHRQoL.[3,5,10-17]

Most of the drawbacks imposed by tooth loss, mainly as a result of caries and/or

Supported by Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code 001; Tutorial Education Program (PET), maintained by the Higher Education Secretariat (SESu/MEC).

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Clinical Implications

Oral rehabilitation with complete dentures or removable partial dentures seems to limit the function of the jaw, and they do not provide the masticatory efficiency of natural teeth. However, the impact of these prostheses on quality of life is low.

periodontal diseases, affect the population of low-income communities and countries. Dental implants can help postpone or reduce the impact of bone resorption subsequent to tooth loss. However, for these low-income populations, dental implants may not be an affordable resource and so removable partial or complete dentures (CDs) are still widely used.

Good oral health conditions have been demonstrated to play an important role in OHRQoL.[18-20] Also, the masticatory function of prosthetically rehabilitated patients has been investigated by using different methods.[11,13,21-24] Recent advancement in masticatory function measurement has included the digital assessment of 2 chewing gums with different colors.[21,25-31] This method is based on quantifying the mixture of hues of 2 different colors by using a digital software program to improve the reproducibility of the results, previously a major problem in masticatory efficiency studies.[32]

Despite some studies individually addressing OHRQoL, jaw function limitation (JFL), and masticatory efficiency of prosthesis wearers,[26,27,29] the lack of standardization for the masticatory efficiency evaluation limits a comparison among studies. Also, few studies have combined these 3 variables with the use of different types of removable dentures.[3,5,12] Therefore, the primary objective of this study was to evaluate whether the OHRQoL, the jaw function, and the masticatory efficiency of removable CD and removable partial denture (RPD) wearers were similar to those of patients with natural teeth. As a secondary objective, this study aimed to evaluate whether wearing these dentures affected the OHRQoL, jaw function, and masticatory efficiency of their wearers. The null hypotheses were that no difference would be found among CD wearers, RPD wearers, and dentate patients with regard to OHRQoL, JFL, and masticatory efficiency and that these types of dentures would not affect the OHRQoL, JFL, and masticatory efficiency of their wearers.

MATERIAL AND METHODS

The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines were followed to ensure an accurate and reproducible description of this analytical, observational cross-sectional study. The Helsinki Declaration requirements were followed, and the participants signed a written consent form regarding their participation in this trial. This study was approved by the local Ethics Committee on Human Research (CAAE 36332614.7.0000.5417).

The inclusion criteria were being over 18 years old at recruitment and wearing either CDs in both arches or an RPD in at least 1 arch. Those with a history of xerostomia; periodontal disease; motor, psychologic, or cognitive disorders; communication difficulties; malnutrition (BMI<18 kg/m^2); temporomandibular joint disorders; and users of orthodontic devices were excluded. For the control group, the participants had at least 20 well-distributed functional teeth (shortened dental arch, 10 teeth in each arch)[33-36] and perceived their mastication as being good.

The sample size was estimated from previous studies[21,25] and 116 participants were enrolled. After eligibility criteria analyses, 49 participants wearing either CDs or RPDs were enrolled. Twenty-seven participants with at least 20 occluding natural teeth who did not use any prosthetic device were included in the positive control group. The CD group (n=25) was composed of individuals who had been rehabilitated with both maxillary and mandibular CDs, and the RPD group (n=24) included participants who had been rehabilitated with maxillary and/or mandibular RPDs. If only 1 arch had been rehabilitated with a RPD, the opposing teeth could be natural or artificial.

All participants were patients at the Bauru School of Dentistry, and they were recruited during their periodic dental visit, so no prostheses were made for the study. After consenting to be included in this study, all participants received a professional cleaning of all teeth and received instructions regarding the tests to be applied. All evaluation took place during a single visit in the following sequence: Oral Health Impact Profile (OHIP-14) and Jaw Function Limitation Scale (JFLS-20) questionnaires and masticatory efficiency tests.

The participants completed the Oral Health Impact Profile questionnaire (Supplementary Table 1, available online) without the examiners' assistance. The final score was classified as 0=no impact; 0<OHIP-14≤9 as low impact; 9<OHIP-14≤18 as medium impact; and 18<OHIP-14≤28 as strong impact.[19,20] Functional limitation of the jaw was assessed by using the Jaw Function Limitation Scale (Supplementary Table 2, available online).[37] This 20-question questionnaire was also completed by each participant without the aid of the examiners. The masticatory efficiency was classified according to Schimmel et al.[21,25] After answering both questionnaires, the participant masticated a superposed combination of a blue and a red sugar-free chewing gum (Trident; Mondelez Ltda) for 20 masticatory cycles, bilaterally, under the guidance of the examiner.[14,21,25,26,29,30,38,39] Each gum was of regular

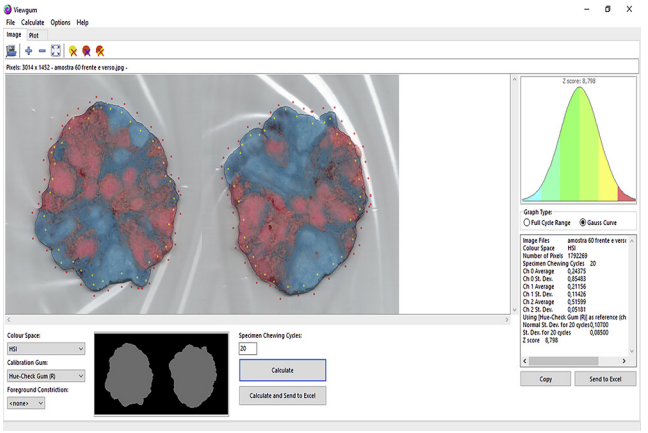

Figure 1. Image from masticatory efficiency analysis using software program (ViewGum).

format[21] (32×13.5×3.5 mm). After the cycles, the masticated gum bolus was placed in a plastic container which was coded by 1 operator (L.W.) to blind its identification from the examiners.

The gum was evaluated immediately after being removed from the mouth by 3 previously calibrated blinded examiners (C.Y.C.S., J.C.J., G.G.E.), who evaluated the color mixing (kappa>0.92) and the shape (kappa>0.83) of the gum according to the subjective color-mixing index for the chewing gum bolus (SCMI-B)[11] and its subjective shape index (SSI-B) (Supplementary Table 3, available online).[30,40] The most frequent score of the blinded examiners was selected based on these 2 indexes. In case of discrepancy among examiners, a consensus was achieved.

After the subjective analysis, the chewing gum boluses were flattened into a 1-mm-thick wafer. The objective color-mixing ratio for the chewing gum wafer was determined according to the studies by Schimmel et al.[21,25] Both sides of each wafer were scanned with a resolution of 500 dots per inch (HP DeskJet 2135 All-in-One). The digitalized pictures were placed side by side in a single 1000-pixel image and analyzed by using a software program (ViewGum; dHAL Software), which assessed masticatory efficiency by analyzing the dots of the mixture of the chewing gums' colors.[41] To do so, the 1000-pixel image was imported into the software program and segmented into foreground (containing the flattened gum bolus) and background by tracing the wafer with the mouse (Fig. 1). Then, the software program converted the foreground pixels to the hue, intensity, and saturation (HIS) color space. The hue factor was then isolated from the saturation and intensity factors to allow the measurement of color alteration. This process was described in detail in the study by Halazonetis et al.[41]

Data were assessed with a statistical software program (IBM SPSS Statistics, v23; IBM Corp). The bivariate analyses were conducted for the OHIP values for each dimension and the overall score, for the JFLS-20 questionnaire values, for the SCMI-B scores, for the SSI-B scores, and for the objective color-mixing ratio scores. Given the lack of normal distribution (Shapiro-Wilk test), Kruskal-Wallis and post hoc Dunn tests were used (α=.05). Thereafter, 3 multiple linear regression analyses (Backward method) were conducted: the first considering the OHIP overall score as the dependent variable (outcome); the second considering the JFLS-20 values as the dependent variable; and the third with the objective color-mixing ratio as the dependent variable. When the type of prosthesis (a categorical variable) was inserted in the model as an independent variable, dummy variables were set for each group (control, CD, or RPD).

RESULTS

Initially, 116 individuals were evaluated. Only 76 were included in the sample (Fig. 2), with the majority being women (n=46, 63.9%). The demographic characteristics of each group are given in Table 1.

All dimensions of the OHIP-14 questionnaire are shown in Table 2. No impact (scores=0) was found for the control group regarding functional limitation, social disability, and handicap. Low impact (0<scores≤9) was found for all other dimensions. For the CD group, all scores denote low impact within each dimension, except for social disability, which showed no impact. For the RPD group, all dimensions presented low impact, including the overall score (Table 2).

Data regarding JFLS-20 (Table 3), mastication, vertical jaw mobility, and emotional and verbal expressions indicated that the highest function limitation was detected for both the CD and RPD groups, differing from the control group (P<.001). The results from the masticatory efficiency analyses are displayed in Table 4. The chewing pattern detected in the control group was more frequently in the rounded or elongated shape, with better homogenization (SCMI-B: 3; SSI-B: 3) (Fig. 3A). The CD group often presented no evidence of crushing or mixing of chewing gum (SCMI-B: 1; SSI-B: 1) (Fig. 3B), while the RPD group presented intermediate mixing, with some folds and mixing (SCMI-B: 2; SSI-B: 1) (Fig. 3C). Representative images after flattening the boluses for the control group, CD wearers, and RPD wearers are shown in Figure 3D-F.

With respect to the multiple linear regression, residues were independent (Durbin-Watson<2.167). No multicollinearity (tolerance values>0.79; VIF values<1.265) and no outliers were detected in all cases. When the OHIP overall score was set as the dependent variable, age, SCMI-B scores, SSI-B scores, objective color-mixing ratio, JFLS-20 values, and type of prosthesis (dummy variables for CD, RPD, or none) were inserted in

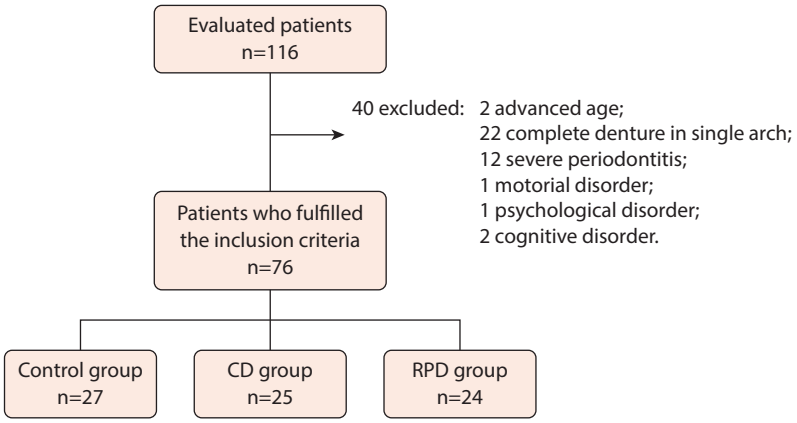

Figure 2. Flowchart of study design addressing number of individuals at each stage of study.

Table 1. Demographic characteristics of participants allocated to each group

Groups	Mean Age (Min-Max)	Mean Height (m) (Min-Max)	Mean Weight (kg) (Min-Max)	Sex M (%)/F (%)
Control	42.53 (18-76)	1.67 (1.5-1.96)	74.65 (50-103)	7 (25.9)/20 (74.1)
CD	64.2 (43-86)	1.61 (1.49-1.75)	70.2 (46-105)	10 (45.45)/12 (54.55)
RPD	58.2 (35-84)	1.64 (1.52-1.8)	71.76 (52-87)	9 (39.1)/14 (60.9)
Overall	54.12 (18-86)	1.64 (1.49-1.96)	71.62 (50-105)	26 (36.1)/46 (63.9)

CD, removable complete denture; RPD, removable partial denture.

Table 2. Median ±interquartile range of each dimension of Oral Health Impact Profile (OHIP-14)

Groups	Functional Limitation	Physical Pain	Psychological Discomfort	Physical Disability	Psychological Disability	Social Disability	Handicap	OHIP-14
Control	0.00 ±0.00 B	1.00 ±0.13 A	1.00 ±0.00 B	0.25 ±0.00 B	0.50 ±0.00 B	0.00 ±0.00 B	0.00 ±0.00 B	0.43 ±0.16 B
CD	1.00 ±0.00 A	2.00 ±1.00 A	1.00 ±0.50 AB	1.00 ±0.00 A	2.00 ±0.88 A	0.00 ±0.00 B	1.00 ±0.00 A	1.25 ±0.91 A
RPD	1.00 ±0.00 A	1.5 ±0.88 A	2.00 ±1.38 A	1.00 ±0.00 A	2.00 ±1.00 A	1.00 ±0.00 A	0.75 ±0.00 A	1.50 ±0.84 A

CD, removable complete denture; RPD, removable partial denture. Different uppercase letters denote significant differences between groups (Kruskal-Wallis and post hoc Dunn tests, $P<.05$).

Table 3. Median ±interquartile range corresponding to JFLS-20 assessment for each group

	Jaw Function Limitation Scale (JFLS-20)			
Groups	Mastication	Jaw Mobility	Emotional and Verbal Expression	Overall Score
Control	0.00 ±2.16 A	0.00 ±0.75 A	0.00 ±0.00 A	0.05 ±0.00 A
CD	3.66 ±4.36 B	4.25 ±4.75 B	1.80 ±4.00 B	2.95 ±1.80 B
RPD	2.75 ±2.58 B	1.37 ±5.00 B	1.05 ±3.95 B	1.80 ±0.83 B

CD, removable complete denture; JFLS-20, Jaw Function Limitation Scale; RPD, removable partial denture. Different uppercase letters denote significant differences between groups (Kruskal-Wallis and post hoc Dunn tests, $P<.001$).

Table 4. Median ±interquartile range of subjective visual analysis and objective analysis conducted using software program (ViewGum) on masticated gum boluses

	Subjective Analysis		Objective Analysis
Group	SCMI-B (Color Mixing)	SSI-B (Shape)	Colorimetric (ViewGum)
Control	3.00 ±2.00 A	2.00 ±2.00 A	0.19 ±0.07 B
CD	1.00 ±0.00 B	1.00 ±1.00 A	0.29 ±0.24 A
RPD	2.00 ±2.00 A	2.00 ±1.00 A	0.21 ±0.20 A

CD, removable complete denture; RPD, removable partial denture; SCMI-B, subjective color-mixing index for chewing gum bolus; SSI-B, subjective shape index. Different uppercase letters denote significant differences between groups (Kruskal-Wallis and post hoc Dunn tests, $P<.001$ for SCMI-B and objective analyses; $P>.05$ for SSI-B analysis).

the initial model as independent variables. This analysis also retrieved a statistically significant final model ($F_{[4,65]}=6.739$; $P<.001$; $R^2=0.250$) with SCMI-B, SSI-B, JFLS-20 values, and the use of RPD as the variables that could predict the outcome (Table 5).

When the analysis was conducted with the JFLS scores as the outcome, the predictor factors inserted in the initial model were age and type of prosthesis (dummy variables for CD, RPD, or none). The final model was statistically significant ($F_{[2,67]}=19.399$; $P<.001$;

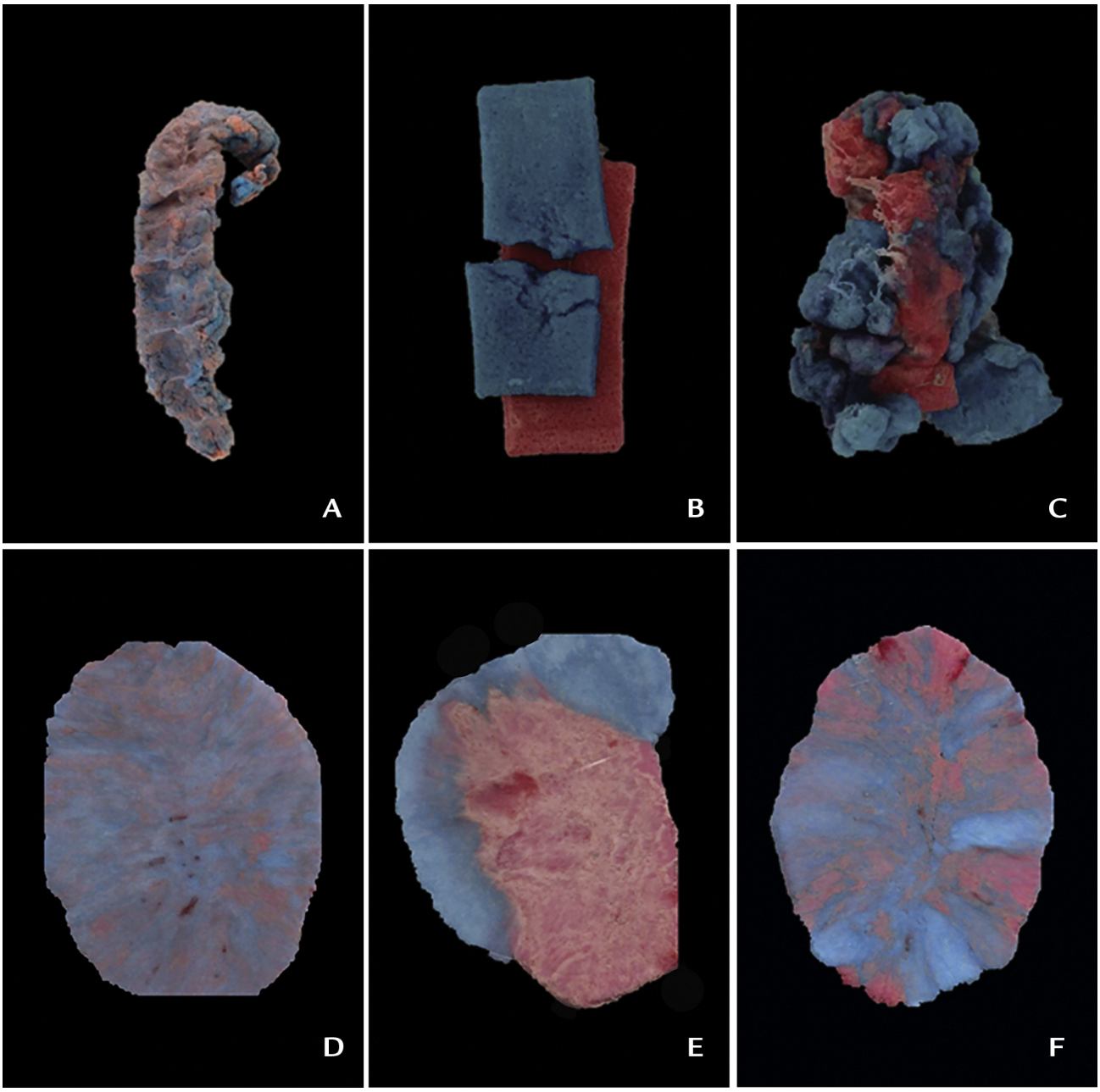

Figure 3. Representative images from each group of gum masticated before and after flattening. A, D, Control group. B, E, Complete denture group. C, F, Removable partial denture group.

R^2=0.348) and was composed by using CDs or RPDs as the predictor factors (Table 5).

Finally, with the objective color-mixing ratio considered as the dependent variable, the independent variables inserted in the initial model were age, OHIP overall score, JFLS values, and type of prosthesis (dummy variables for CD, RPD, or none). The results of this analysis reported a statistically significant final model (F [1,68] =9.893; P<.002; R^2=0.114) containing only the use of CDs as a predictor factor (Table 5).

DISCUSSION

The findings of this study provided evidence that OHRQoL, jaw function, and masticatory efficiency of CD or RPD wearers were impaired when compared with patients with natural teeth. Also, the results of the multiple linear regression provided evidence that the use of these removable dental prostheses could predict impairment of the OHRQoL, jaw function, and masticatory efficiency of their wearers. Therefore, all 4 null hypotheses were rejected.

Table 5. Final multiple linear regression models indicating independent variables related to dependent variable/outcome

Dependent Variable	Independent Variable	Standardized β	t	P
OHIP overall score	–	–	–	–
	JFLS-20 score	.288	2.494	.015
	SCMI-B score	-.355	-3.113	.003
	SSI-B score	.255	2.235	.029
	RPD use	.228	2.149	.035
	Constant	1.016	3.056	.003
JFLS-20 score	–	–	–	–
	RPD use	.451	4.125	<.001
	CD use	.660	6.038	<.001
	Constant	.458	1.538	.129
Objective color-mixing ratio	–	–	–	–
	CD use	.356	3.145	.002
	Constant	.217	6.516	<.001

CD, removable complete denture; JFLS-20, Jaw Function Limitation Scale; OHIP, Oral Health Impact Profile; RPD, removable partial denture; SCMI-B, subjective color-mixing index for chewing gum bolus; SSI-B, subjective shape index.

The oral rehabilitation of edentulous individuals leads to an improvement of OHRQoL.[3] The findings of this present study support that statement by providing evidence that the OHRQoL of prosthesis wearers is different from that of dentate individuals.[12] However, the impact of wearing prostheses on OHRQoL can be classified as low based on recently published studies.[19,20]

After the OHIP-14, the participants answered the JFLS-20 questionnaire, which assessed the functional capacity of the masticatory system by analyzing limitations in 3 constructs: mastication (questions 1 to 6), jaw mobility (questions 7 to 10), and emotional and verbal communication (questions 11 to 20).[37] Higher limitation was seen for CD and RPD wearers in all 3 constructs, yet the main limitation reported by the CD and RPD wearers were regarding mastication and jaw mobility. Therefore, CD or RPD wearers judge that masticating food is harder than for people with natural teeth, consistent with the results of masticatory efficiency found in the present study.

To enable a comparison with other studies,[21,27] this present study used the subjective classification proposed by Schimmel et al.[21] However, some participants in this present study, especially the CD wearers, presented difficulties in masticating the juxtaposed chewing gum, resulting in delicate cusp impressions or even no impressions at all (Fig. 3B). This difference could be attributed to the fact that Schimmel et al[21] used this classification for younger (27.5 years) and dentate individuals or individuals rehabilitated with implant-supported prostheses,[25] while the present study used this classification for CD and RPD wearers with double the average age (54 years). Also, the hardness of the gum should be taken into consideration for this analysis.[21] Given that the SSI-B classification did not predict these impressions made by CD and RPD wearers, this classification could be adapted in future studies.

Different methodologies have been used to analyze masticatory efficiency, but a lack of standardization and reliability of these methods hampers a comparison of results.[11,13,21-24] Therefore, to improve its reproducibility, Liedberg et al[30,31] developed a digital mean to analyze 2-colored chewing gum, considering it a straightforward and reasonably acceptable method. Since then, this method has been used to assess masticatory efficiency,[25-29] although Silva et al[27] have recommended the use of both visual and electronic colorimetric analyses, as used in the present study.

Previous studies concluded that masticatory ability was impaired when the individual had fewer than 20 well-distributed teeth.[35] Hence, given that individuals with 20 teeth (shortened dental arch) do not necessarily require oral rehabilitation,[33,34,36] those with at least 20 well-distributed functional teeth (10 teeth in each arch) were included in the control group. Also, the findings of masticatory efficiency for the control group in this study were consistent with those of Schimmel et al,[25] and differences detected for the CD group can be attributed to the fact that, in that study, CD wearers had been rehabilitated with 2 mandibular implants (removable complete overdentures), while in this present study no implants had been placed.

The multiple linear regression analysis revealed that the use of an RPD was able to predict an impairment in OHRQoL and jaw function. This may have occurred because participants who wore RPDs often reported dissatisfaction with the retention and esthetics of their prostheses, mainly related to the use of metal clasps.[16,17] This seems to justify the impact of the psychological discomfort, physical disability, psychological disability, social disability, and handicap dimensions of the OHIP-14 questionnaire on these participants. Nevertheless, these quality of life assessments are subjective, so other health determinants such as systemic condition, household monthly income, and educational level can also be associated with these findings.[20]

CD wearers also expressed dissatisfaction with the retention of their prostheses and reported difficulties in eating tough and fibrous food. These findings were consistent with those of Ribeiro et al,[12] who reported that rehabilitated individuals have reduced masticatory efficiency compared with natural teeth, mainly because of differences in the sensory-motor system and in the movements during mastication.[15]

Limitations of the present study included the small sample size and the sociodemographic parameters, which should be better considered in future studies to improve representativeness. This study did not evaluate the effect of wearing CDs and RPDs compared with when these participants were not wearing them, making

it impossible to evaluate how much they assisted the participants in improving their OHRQoL, jaw function, and masticatory efficiency. Also, the participants in this study were not rehabilitated by the same dentist or during the same period, and RPDs were not differentiated by their number of replacing teeth or by their Kennedy classifications. Based on this study, dentists should be aware of the limitations imposed by each type of removable denture to help them suggest alterations in order to achieve a more comfortable and fulfilling oral rehabilitation.[26]

CONCLUSIONS

Based on the findings of this clinical study, the following conclusions were drawn:

1. CD and RPD wearers have a lower masticatory efficiency and higher JFL than dentate individuals.
2. However, despite having a higher impairment of OHRQoL than dentate individuals, this impairment has a low impact.
3. Wearing CDs seem to predict an impairment in jaw function and masticatory efficiency, while RPDs seem to affect jaw function and OHRQoL.

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Acknowledgments
The authors thank the Tutorial Education Program (PET), maintained by the Higher Education Secretariat (SESu/MEC). The authors are also thankful for Elisabete Aparecida Caetano Ferreira for the help during data collection and for Prof Dr Heitor Marques Honório for statistical consultation.

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https://doi.org/10.1016/j.prosdent.2021.02.035