

Surface roughness implant-retained mandibular bar and ball joint overdentures and adherence of microorganisms

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ABSTRACT

Objective: The aim of this study is to assess the surface roughness of the implant-retained mandibular bar overdenture (BOD) and the implant-retained mandibular ball joint overdenture (BJOD) in jaw and its relation with the adhesion of molds and yeasts and mesophyll aerobe, in time 30 and 180 days in mouth. **Materials and Methods:** Five-systems titanium bar CARES[®] and synOcta[®] Straumann[®] Dental Implant System, Holding AG Inc., Basel, Switzerland (BOD), and five-systems joint ball Klockner[®] Implant System; Soadco Inc., Escaldes-Engordany; Andorra (BJOD), were used in two parallel groups of five participants, in an essay to simple blind person. To 30 and 180 days, the overdentures were withdrawn and evaluated the Ra: μm . SJ-301[®] Mitutoyo Corporation Inc., Kanagawa, Japan, and the adhesion of microorganisms (colony-forming unit/ml). **Results:** The results were as follows: the R_a : μm (30th and 180th): BOD, 0.965–1.351; BJOD, 1.325–2.384. Adhesion: Molds and yeasts, BOD, 2.6×10^2 and 4.6×10^3 ; BJOD, 3.0×10^2 and 5.3×10^4 . Adhesion: Mesophyll aerobe, BOD, 3.8×10^6 and 5.8×10^6 ; BJOD, 4.3×10^6 and 7.1×10^7 . **Conclusions:** At 30 days ($P = 0.489$), there were no differences in BOD and BJOD for adhesion of molds and yeasts and mesophyll aerobe between both overdentures. At 180 days ($P = 0.723$), there were differences in the adhesion of mold and yeast and mesophyll aerobe, being greater in BJOD.

Key words: Bacterial adhesion, clinical studies/trials, implantology, overdenture, surface properties

INTRODUCTION

In the treatment of the mandibular edentulous, the implant-retained overdenture has been shown to have advantages in support, retention, stability, and esthetics,^[1,2] improving masticatory efficiency, decreasing anterior bone loss and injury in soft tissues, and increasing comfort, satisfaction, and improvement of the patient's health quality.^[3] According to the type of anchorage recommended, we have the implant-retained mandibular bar overdenture (BOD) and implant-retained ball joint overdenture (BJOD). Bar

anchors are retention systems that provide adequate support for rehabilitation.^[4,5] By the other side, the ball joints are axial anchors with retention system through threaded connections for mandibular prosthetic reconstruction. It is considered that regardless of the retention system, the adjustment must be passive to the implants.^[6] The structure of the overdentures consists of thermoplastic poly methacrylates which are derived from ethylene and contain a vinyl group resulting

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from the polymerization of methacrylic acid or its derivatives.^[7] These polymethacrylates must be resistant to fracture and flexion, properties that can be increased through zirconia or amorphous silica particles.^[8,9] Possibly, the immersion of some oral restorations in agents cleaners alters their structural stability.^[10] It is considered that the absence of porosity and dimensional stability increases the surface quality of the restorations, influencing the preservation of the mucous tissues through surfaces that facilitate the patient's oral hygiene. Therefore, an important factor in reference to the quality of the mouth restorations is the surface roughness (R_a) with importance in the preservation of the oral health in relation to the surrounding tissue.^[11-13] There are differences in roughness values in various thermoplastic methacrylates.^[14] The surface quality of the restorations and their relationship with the gingival tissues enable smoother surfaces to maintain the health of oral tissues, avoiding the inflammation of them. The surfaces of the overdentures are available as substrates for the development and growth of microorganisms. The oral cavity presents more than 700 bacterial species,^[15] and overdentures implant-retained are susceptible to the accumulation of microorganisms with adhesion capacity such as mold and yeast and mesophyll aerobe. The yeasts are unicellular fungi which reproduce by budding and transverse division and the mold is formed by hyphae, the whole of which forms a mycelium. The mold and yeast which cause pathology in humans are dimorphic and 2–4 μm in diameter.^[16] Other microorganisms with adhesion capacity are mesophyll aerobes which include bacteria that develop in the presence of free oxygen of 0.5–2 μm in diameter.^[17,18] The permanence of BOD and BJOD depends on several factors, one of them being the R_a and its relation with the adhesion of microorganisms. The objective of the study was to compare the R_a of BOD compared to BJOD in relation to the adhesion of mold and yeast and mesophyll aerobe at 30 and 180 days of permanence in the oral cavity in order to establish if there are differences in R_a and which of these overdentures are characterized by their lower roughness and adherence of mold and yeast and mesophyll aerobe, which is an important aspect to be considered in the rehabilitation of mandibular total edentulous patients with implants due to their influence on oral health.

MATERIALS AND METHODS

The study presents the results of a sample of ten patients randomly assigned to receive implant-retained overdentures and divided into two parallel groups of

five participants in a single-blind trial at a follow-up period of 30 and 180 days permanence in the mouth. Five overdentures were made for each group: BOD: Five-systems titanium bar CARES® and synOcta® Straumann® Dental Implant System, Holding AG Inc., Basel, Switzerland (BOD). BJOD: Five-systems ball joint Klockner® Implant System; Soadco Inc., Escaldes-Engordany, Andorra, were used in two parallel groups of five participants, in an essay to simple blind (ClinicalTrials.gov: NCT03256409). The protocol was approved by the Institutional Review Boards affiliated with the researchers. All participants gave informed consent. The inclusion criteria of the patients for the study were total edentulous mandible from 50 to 60 years of age and absence of systemic conditions. The exclusion criteria of the patients for the study were hyperplasia and history of periodontal disease, patients with local and/or systemic antimicrobial treatment within 72 h prior to evaluation during the study, and signs of severe oral parafunction [Figure 1]. Selected patients underwent surgery with Tapered Effect Implants Straumann and Klockner Implant System. For the fabrication process of the overdentures in both groups, Lucitone 199® (Dentsply International

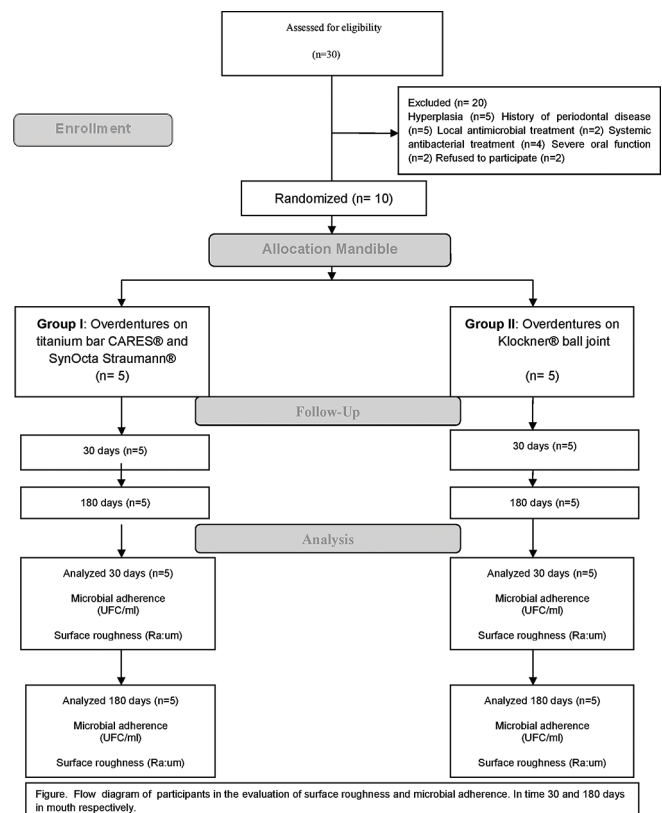


Figure 1: Flow diagram of participants in the evaluation of surface roughness and microbial adherence in time 30 and 180 days in mouth, respectively

Inc., York, PA) was used as the material of choice and for the adaptation of the retention systems Softreliner ToughSoft® Tocuyama Dental Corporation Inc., Japan, was used. The working protocol for determining the BOD R_a and BJOD R_a and the adhesion of molds and yeasts and mesophyll aerobics was carried out entirely by the investigators and the following working methodology was considered: Information to the patient of the research work to be performed, obtainment of clinical data and patient informed consent. Patients were randomly assigned to Group 1 and Group 2. The saliva sample was obtained in each patient for the microbiological evaluation before the installation of the overdentures. BODs and BJODs were installed in each patient and according to each case. The BOD and BJOD were removed at 30 days for R_a evaluation (R_a : μm) and the evaluation of the adhesion of mold and yeast and mesophyll aerobe (colony-forming unit [CFU]/ml). For the study at 180 days, the BODs and the BJODs were installed in each patient. BODs and BJODs were removed after this time to proceed to the evaluation of R_a and adhesion of mold and yeast and mesophyll aerobe under the same parameters mentioned above.

Adherence mold and yeast and mesophyll aerobe to bar overdenture and bar joint overdenture, surface roughness, and statistical analyses

Microbial populations have been controlled in the saliva at initial time and adherence at 30 and 180 days after the overdentures in the mouth. The saliva sample was obtained from the patient in a sterile sputum collection bottle through a sterile solution. The overdenture samples were extracted and processed for analysis. Each sample was submerged in $\frac{1}{4}$ sterile Ringer and subjected to vigorous ultrasound shaking. From each of the microbial suspensions, successive dilutions were made to determine the total number of viable microorganisms present. Total count of mold

and yeast and total count of mesophyll aerobe were performed.

The R_a of BOD and BJOD was determined with the Surfest SJ-301® rugosimeter (Mitutoyo Corporation Inc., Kanagawa, Japan), through a displacement force of 4 mN and of the tray to 0.5 mm/s and back to 1 mm/s.^[19] The roughness profile R_a was evaluated and determined in microns (μm) through five readings for each of the samples in the study.

The results of BOD and BJOD were compared for the determination of R_a and the adherence of mold and yeast and mesophyll aerobe. For this, we used the statistics Shapiro-Wilk test, *t*-test, and the Pearson's correlation coefficient to determinate the relationship between the study variables ($P < 0.05$) at 95% confidence interval. For data processing and analysis, the IBM Statistical Package for the Social Sciences, SPSS Statistics 24 (IBM® Company, Chicago, United States of America) was used.

RESULTS

The trial enrolled ten participants randomly assigned to BOD ($n = 5$) and BJOD ($n = 5$). All participants received treatments with overdentures according to the groups to which they were assigned. The average R_a BOD: 30 days was 0.965 μm (0.937–0.992) at 95% confidence interval. The average R_a BOD: 180 days was 1.351 μm (1.223–1.479) at 95% confidence interval. The correlation of independent test ($P < 0.05$) showed that BODs present different R_a at 30 and 180 days [Table 1]. The average R_a BJOD: 30 days was 1.325 μm (1.262–1.389) at 95% confidence interval. The average R_a BJOD: 180 days was 2.384 μm (2.216–2.55) at 95% confidence interval. The correlation of independent test ($P < 0.05$) showed that BJODs present different R_a in 30 and 180 days [Table 2].

Table 1: Average values of surface roughness and correlation of independent test in implant-retained mandibular bar overdentures in 30 and 180 days

Group	95% CI	Statistical	Dv	Shapiro-Wilk (significant)	Levene (significant)	T significant (bilateral)	95% CI
R_a Group 1: 30 days	Mean	0.965	0.02217	0.940	0.005	0.000	
	95% CI						
	Lower limit	0.937					-0.495216
	Upper limit	0.992					-0.277984
R_a Group 1: 180 days	Mean	1.351	0.10296	0.000	0.398	0.005	0.001
	95% CI						
	Lower limit	1.223					-0.513121
	Upper limit	1.479					-0.260079

The average R_a Group 1: BOD titanium bar CARES® and synOcta® Straumann® in 30 days: 0.965 μm . In 180 days: 1.351 μm . 95% confidence and Shapiro-Wilk ($P > 0.05$), determines normal distribution. Correlation of independent test ($P < 0.05$) 30 days ($P = 0.000$) and 180 days ($P = 0.001$) determined different R_a . CI: Confidence interval, BOD: Bar overdenture, R_a : Surface roughness

The average value of adherence of mold and yeast for BOD: 30 days was 2.6×10^2 CFU/ml (2.3×10^2 – 2.9×10^2) at 95% confidence interval. The mean initial salivary count was 1.2×10^2 CFU/ml. For BJOD: 30 days it was 3.0×10^2 CFU/ml (2.7×10^2 – 3.2×10^2) at 95% confidence interval. The mean initial saliva count was 1.1×10^2 CFU/ml. The independent test correlation ($P > 0.05$) indicated that BOD and BJOD did not exhibit different adherence of mold and yeast at 30 days. The average value of adherence of mold and yeast for BOD: 180 days was 4.6×10^3 CFU/ml (4.0×10^3 – 5.1×10^3) at 95% confidence interval. For BJOD: 180 days was 5.3×10^4 CFU/ml (4.8×10^4 – 5.7×10^4) at 95% confidence intervals. The independent test correlation ($P < 0.05$) indicated that BOD and BJOD

exhibit different adhesion of mold and yeast to 180 days. At 30 days of study, there were no differences in R_a and adherence of mold and yeast between BOD and BJOD ($P = 0.489$). At 180 days of study, there were differences in R_a and adherence of mold and yeast between BOD and BJOD ($P = 0.723$) [Table 3].

The mean adherence value of mesophyll aerobe for BOD: 30 days was 3.8×10^6 CFU/ml (3.3×10^6 – 4.2×10^6) at 95% confidence intervals. The mean initial saliva count was 2.2×10^6 CFU/ml. For BJOD: 30 days was 4.3×10^6 CFU/ml (3.8×10^6 – 4.8×10^6) and the mean initial saliva count was 2.4×10^6 CFU/ml. The correlation of independent test ($P > 0.05$) indicated that BOD and BJOD do not exhibit different adherence

Table 2: Average values of surface roughness and correlation of independents tests in implant-retained ball joint overdentures in 30 and 180 days

Group	95% CI	Statistical	Dv	Shapiro-Wilk (significant)	Levene (significant)	T significant (bilateral)	95% CI
R_a Group 2: Mean		1.325	0.050923	0.272	0.087	0.000	
30 days	95% CI						
	Lower limit	1.262					-1.207621
	Upper limit	1.389					-0.909179
R_a Group 2: Mean		2.384	0.135439	0.967	0.087	0.000	
180 days	95% CI						
	Lower limit	2.216					-1.223683
	Upper limit	2.552					-0.893117

The average R_a Group 2: BJOD Klockner® in 30 days: 1.325 μ m. 180 days: 2.384 μ m. 95% confidence and Shapiro-Wilk ($P > 0.05$), determines normal distribution. Correlation of independent test ($P < 0.05$) 30 days ($P = 0.000$) and 180 days ($P = 0.000$) determined different R_a . CI: Confidence interval, BJOD: Ball joint overdenture, R_a : Surface roughness

Table 3: Average values of mold and yeast adhesion and correlation of independents tests in implant-retained mandibular bar overdentures and implant-retained mandibular ball joint overdentures in 30 and 180 days

Group	95% CI	Statistical	Dv	Shapiro-Wilk (significant)	Levene (significant)	T significant (bilateral)	Pearson (R_a)
Adherence	Mean	2.6	0.2702	0.427	0.744	0.051	
Mold and Yeast	95% CI						
Group 1: 30 days	Lower limit	2.3					0.489
	Upper limit	2.9					
Adherence	Mean	3.0	0.2236	1.000	0.744	0.052	
Mold and Yeast	95% CI						
Group 2: 30 days	Lower limit	2.7					0.489
	Upper limit	3.2					
Adherence	Mean	4.6	0.4690	0.795	0.501	0.025	
Mold and	95% CI						
Yeast Group 1:	Lower limit	4.0					0.723*
180 days	Upper limit	5.1					
Adherence	Mean	5.3					
Mold and	95% CI		0.3493	0.976	0.501	0.027	
Yeast Group 2:	Lower limit	4.8					0.723*
180 days	Upper limit	5.7					

Average adhesion values of mold and yeast. Group 1 (BOD): 30 days: 2.6×10^2 CFU/ml. Group 2 (BJOD): 30 days: 3.0×10^2 CFU/ml. Group 1 (BOD): 180 days: 4.6×10^3 CFU/ml. Group 2 (BJOD): 180 days: 5.3×10^4 CFU/ml. 95% confidence and Shapiro-Wilk ($P > 0.05$), determines normal distribution. Correlation of independent tests 30 days ($P > 0.05$) BOD ($P = 0.051$) and BJOD ($P = 0.052$) showed no different adherence. For 180 days ($P < 0.05$), BOD ($P = 0.025$) and BJOD ($P = 0.027$) presented different adherence. *The correlation is significant at the 0.05 level (bilateral). At 30 days of study, there were no differences in R_a and adherence of mold and yeast and mesophyll aerobe ($P = 0.489$). At 180 days of study, there were differences in R_a and adherence of mold and yeast and mesophyll aerobics ($P = 0.723$). BOD: Bar overdenture, BJOD: Ball joint overdenture, CI: Confidence interval, CFU: Colony-forming unit

of mold and yeast at 30 days. The mean adherence value of mesophyll aerobe in Group 1: 180 days was 5.8×10^6 CFU/ml (5.6×10^6 – 6.1×10^6) at 95% confidence interval. In Group 2: 180 days was 7.1×10^7 CFU/ml (6.8×10^7 – 7.4×10^7) at 95% confidence interval. The independent test correlation ($P < 0.05$) indicated that BOD and BJOD exhibited different adherence of mesophyll aerobe at 180 days. At 30 days of study, there were no differences in R_a and adherence of mesophyll aerobe between BOD and BJOD ($P = 0.489$). At 180 days of study, there were differences in R_a and adherence of mesophyll aerobe between BOD and BJOD ($P = 0.723$) [Table 4].

DISCUSSION

The trial included ten participants randomly into two parallel groups of five participants each to receive implant-retained overdentures such as BOD = 5 and BJOD = 5 in a single-blind trial. The sample is limited by the inclusion and exclusion criteria considered for the present study as a function of time during 30 and 180 days of permanence in the mouth. The average results of R_a in the BOD showed increases in R_a as a function of time. This roughness is increased possibly due to the physical structural changes in the structure of the polymethacrylate of the overdenture, which increases its porosity when exposed to oral

fluids, and acidic or basic solutions and changes in temperature in foods, including chewing that would decrease the hardness of these structures.^[11,12,20] Increases of R_a have been found in restorations based on polymethacrylates when stored *in vitro*.^[11] Increases in R_a would alter surface properties.^[12] The chewing of food, brushing, and toothpaste and cleaning agents cause abrasion of the surfaces of the restorations, making them rougher.^[10,21,22] However, the physical structure of the polymers has a chain length which increases stiffness and resistance to solvents.^[7] The average R_a measurement in BJOD showed the highest increase at 30 and 180 days. If we compare the results, the BJODs have a R_a average greater than BOD. This is possibly due to the structural changes of BJOD caused by the imbibition process with the absorption of water in relatively small quantities. This process could have significant effects on the mechanical and dimensional properties in the structure of BJOD. In addition, the polarity of the polymethacrylate molecules facilitates the absorption of water by molecular diffusion so that the water molecules penetrate the polymer chains causing their separation and expansion. This process probably increased the BJOD R_a . Another possible explanation for the increase of R_a in the polymethacrylate-based overdenture is the median fracture and flexural strength of these polymers.^[7] Some authors recommend increasing the resistance

Table 4: Average values of mesophyll aerobe adhesion and correlation of independents tests in implant-retained mandibular bar overdentures and implant-retained mandibular ball joint overdentures in 30 and 180 days

Group	95% CI	Statistical	Dv	Shapiro-Wilk (significant)	Levene (significant)	T significant (bilateral)	Pearson (R_a)
Adherence mesophyll aerobe Group 1: 30 days	Mean	3.8	0.3421	0.814	0.541	0.052	0.489
	95% CI						
	Lower limit	3.3					
	Upper limit	4.2					
Adherence mesophyll aerobe Group 2: 30 days	Mean	4.3	0.4037	0.708	0.541	0.053	0.489
	95% CI						
	Lower limit	3.8					
	Upper limit	4.8					
Adherence mesophyll aerobe Group 1: 180 days	Mean						0.723*
	95% CI						
	Lower limit						
	Upper limit						
Adherence mesophyll aerobe Group 2: 180 days	Mean	7.1	0.2387	0.899	0.593	0.000	0.723*
	95% CI						
	Lower limit	6.8					
	Upper limit	7.4					

Average adhesion values of mesophyll aerobe. Group 1 (BOD): 30 days: 3.8×10^6 CFU/ml. Group 2 (BJOD): 30 days: 4.3×10^6 CFU/ml. Group 1 (BOD): 180 days: 5.8×10^6 CFU/ml. Group 2 (BJOD): 180 days: 7.1×10^7 CFU/ml. 95% confidence and Shapiro-Wilk ($P > 0.05$), determines normal distribution. Correlation of independent tests 30 days ($P > 0.05$) BOD ($P = 0.052$) and BJOD ($P = 0.053$) showed no different adherence. For 180 days ($P < 0.05$), BOD ($P = 0.000$) and BJOD ($P = 0.000$) presented different adherence.*The correlation is significant at the 0.05 level (bilateral). At 30 days of study, there were no differences in R_a and adherence of mold and yeast and mesophyll aerobe ($P = 0.489$). At 180 days of study, there were differences in R_a and adherence of mold and yeast and mesophyll aerobics ($P = 0.723$). BOD: Bar overdenture, BJOD: Ball joint overdenture, CI: Confidence interval, CFU: Colony-forming unit, R_a : Surface roughness

and hardness properties of polymethacrylates.^[8,9] The total count of mold and yeast in BOD and BJOD shows increases from the initial time to 30 and 180 days. Comparing these data establishes an increase of the population mean in BOD and BJOD in relation to the exposure time. Our results are related to *in vitro* studies that tested the adhesion of mold and yeast to materials based on polymethacrylates.^[23] In addition, *in vitro* studies showed more adhesion of mold and yeast to materials based on polymethacrylates compared to metals and fiberglass. On the other hand, the saliva decreases the adhesion of all the yeasts to the surfaces of methacrylates, whereas the R_a does not interfere with the adherence of these species.^[13,24] Wetter surfaces of polymethacrylates would cause adherence of mold and yeast species,^[16,25-27] a property that could justify the increase of the mold and yeast population in BJOD. However, we considered that the R_a of the overdentures would be more associated to the adhesion of mold and yeast and that the adhesion of these species is greater in rough surfaces than in smooth surfaces. Considering that polymethacrylates are not bacteriostatic and that *in vitro* studies suggest that the R_a threshold for bacterial retention is $R_a = 0.2 \mu$, it is suggested that if there were an increase in roughness surface, bacterial plaque accumulation would also increase.^[13,24] In reference to the adhesion of mesophyll aerobe in BOD and BJOD, these increase from initial time to 30 and 180 days. These results allow us to determine that both types of overdentures present an increase in the adhesion of mesophyll aerobe. Comparing these data, an increase in the population average is established, which presents its highest number at 180 days. This is probably due to the structural properties of imbibition, lower strength, and higher porosity, which probably increase the R_a that allows the adhesion of mesophyll aerobe in greater quantity. Mesophyll aerobe uses hydrogen peroxide from salivary sediments and dental plaque,^[15,28,29] in such a way that by the mechanism of absorption of water obtained from the saliva, they facilitate their predilection by this substrate. The proximity to the oral tissues would allow greater adhesion to BJOD, and the high proportion of mesophyll aerobe would be explained by its property of bacteriostatic inhibition for other species.^[17] In addition, if we observe that the BODs have a R_a : 0.965 μ m at 30 days and 1.351 μ m at 180 days in comparison to BJOD that have a R_a : 1.325 μ m at 30 days and 2.384 μ m at 180 days and we related these results to the dimensions of the mesophyll aerobe in approximately 0.5–2 μ m, it is possible that these microorganisms adhere more efficiently to BJOD because they would find niches that allow

them to withstand the cutting forces such as chewing and swallowing, favoring their retention. Polymers exhibit increases in colonization by mesophyll aerobe^[17,30] and saliva does not interfere with the adhesion of these microorganisms to the surfaces of the oral cavity.^[18] Prevalence of nutritional conditions during cutting- forces.^[28] In addition, less plaque has been reported in hydrophobic polymers than in hydrophilic polymers.^[27,31] Other *in vitro* studies have shown high adherence of mesophyll aerobe in polymethylmethacrylate intraocular lenses,^[30,31] sanded surfaces, and steel^[23] saliva and tongue associated with gingivitis^[28] and periodontitis.^[29]

The structures of the buccal cavity contain various microbial species.^[23,28] BODs and BJODs, as observed in our study, are surfaces available in the oral cavity for the adhesion of mold and yeast and mesophyll aerobe. The adhesion of these microorganisms to these implant-retained mandibular overdentures found in our study could be related to those reported by Waltimo *et al.*,^[25] who found retention of microorganisms in polymethacrylates. In our study, BODs and BJODs have been used because of their acceptable properties, characteristics, manufacturing methods, and structure, which make them eligible for the rehabilitation of total edentulous patients of the lower jaw.^[1-6] By the other side, studies have been made of materials and R_a measurement techniques in order to achieve an adequate surface quality which will influence esthetics and their relationship with oral tissues.^[14]

CONCLUSIONS

The evaluation of the ten participants was limited by the study criteria. Parallel treatments were assigned with ball implant-retained overdenture (BOD) and ball joint implant-retained overdenture (BJOD). BJOD presented different R_a values at 30 and 180 days of study, being higher in BJOD. The higher R_a average in BJOD is possibly due to the structural changes of its polymers caused by imbibition and proximity to the oral tissues allowing the absorption of water, which would exert significant effects on the mechanical and dimensional properties of the polymer. In reference to the adhesion of mold and yeast and mesophyll aerobe in BOD and BJOD, they did not present different adherence at 30 days but did present differences in adherence for 180 days. The BJOD presented greater adhesion of mold and yeast and mesophyll aerobe. It is likely that the R_a of polymethacrylate-based overdentures will influence more than other factors in the adhesion of mold and yeast and mesophyll aerobe.

The rougher surfaces will have a greater impact on the adhesion and retention of microorganisms, causing a faster colonization of the surfaces of both types of overdentures, increasing the risk to mucosal tissue infections. However, this characteristic could be associated to the effect of the structural nature of the overdentures to explain the mechanisms of adhesion of mold and yeast and mesophyll aerobe to these surfaces, with clinical importance in the preservation of oral health of the total edentulous of the mandible rehabilitated with overdentures.

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Conflicts of interest

There are no conflicts of interest.

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