

Effectiveness of Brushing Associated With Oral Irrigation in Maintenance of Peri-Implant Tissues and Overdentures: Clinical Parameters and Patient Satisfaction

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Hygiene of implant-supported prostheses and the health of peri-implant tissues are considered to be predictive factors of successful prosthetic rehabilitation. Therefore, the purpose of this study was to evaluate the effectiveness of brushing associated with oral irrigation measured as biofilm-removing capacity, maintenance of healthy oral tissues, and patient satisfaction. A randomized, crossover clinical trial was conducted with 38 patients who wore conventional maxillary complete dentures and mandibular overdentures retained by the O-ring system. The patients were instructed to use the following hygiene methods for 14 days: mechanical brushing (MB; brush and dentifrice, control) and MB with oral irrigation (Waterpik [WP], experimental). Biofilm-removing capacity and maintenance of healthy oral tissues were evaluated by the modified plaque index (PI), gingival index (GI), probing depth (PD), and bleeding on probing index (BP) recorded at baseline and after each method. In parallel, patients answered a specific questionnaire using a visual analog scale after each hygiene method. Data were analyzed by Friedman and Wilcoxon tests ($\alpha = .05$). The results showed significantly lower PI, GI, PD, and BP after application of the hygiene methods ($P < .001$) than those observed at baseline. However, no significant difference was found between MB and WP. The responses to the satisfaction questionnaire for both methods showed high mean values for all questions, with no statistically significant difference found between the answers given after the use of MB and WP ($P > .05$). The findings suggest that WP was effective in reducing PI, GI, PD, and BP indices and provided a high level of patient satisfaction.

Key Words: dental implants, overdenture, oral hygiene, denture cleansers

INTRODUCTION

Inadequate denture hygiene can lead to staining, biofilm and calculus accumulation, as well as halitosis and inflammatory changes in the oral mucosa.¹ Biofilm and calculus can also accumulate on the denture attachment systems, and an effective daily hygiene method is crucial for cleaning and maintaining the implant and retained overdentures. Therefore, overdenture and conventional complete denture wearers should receive appropriate guidance and adhere to daily hygiene instructions in order to keep their dental prostheses well cleaned and maintain the health of oral mucosal tissues.² Together, these care behaviors could promote the longevity of rehabilitation treatment.

Inflammatory processes affecting peri-implant tissues are frequently implant-related complications.^{3,4} Peri-implant mucositis is defined as an inflammatory reaction of the marginal

mucosal tissue, with signs and symptoms similar to those of gingivitis. If the inflammatory processes are not adequately treated, progression of the condition may occur and result in destruction of the bone support, leading to peri-implantitis and even loss of the implant.^{4,5} Peri-implant diseases also affect completely edentulous patients and mandibular overdenture wearers.⁶

Prosthetic rehabilitation with implants often creates areas that are hard to reach, making it difficult to perform proper oral hygiene.^{7,8} Thus, materials and hygiene protocols that allow access to these areas are desirable. Nowadays, a wide range of materials are being offered for oral hygiene purposes, including toothbrushes (manual or powered), interdental brushes, dental floss, toothpaste, and mouth rinses.^{8–11} However, there is little solid evidence about effective hygiene methods for long-term maintenance of healthy tissue after dental implant insertion.^{9,12,13} Implant-supported prostheses wearers can take advantage of oral irrigation devices, which are indicated in cases of decreased manual dexterity, presence of periodontal or peri-implant pockets, very close implants, and orthodontic treatment.¹⁴ These devices allow better biofilm control in areas that are difficult to access.^{13,15,16}

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Oral irrigation, for cleaning natural teeth, has been shown to be effective for supra- and subgingival biofilm removal, reduction of inflammation clinical signs, and production of inflammatory mediators in gingival fluid and blood and to be an effective alternative to flossing.^{14,17-23} Moreover, the device is considered easy to handle,¹³ and the jet it produces does not cause tissue injury or discomfort to patients.^{15,16,18} Although studies have shown that oral irrigation is effective in the maintenance and recovery of peri-implant health,^{15,16,24} there is scarce scientific data in the literature to support it.

Analysis of clinical parameters is a fundamental step in determining the health status of implants, which, in turn, is one of the main factors that will ensure their long-term stability.^{25,26} Furthermore, the satisfaction of patients and their perception of hygiene methods are aspects that are directly related to patient acceptance and adherence to treatment.²⁷⁻²⁹ Therefore, the aim of this study was to evaluate the efficacy of mechanical brushing and its association with oral irrigation in the maintenance of healthy peri-implant tissues and overdenture hygiene, by means of evaluating the clinical parameters relative to modified plaque index (PI), gingival index (GI), probing depth (PD), and bleeding on probing index (BP) and patient satisfaction. The null hypothesis was that the two methods would have the same influence on both clinical parameters and patient satisfaction.

MATERIALS AND METHODS

Subjects

The sample size, based on a previous study,³⁰ was estimated considering the PD. A total of 35 participants were considered sufficient to detect relevant differences ($\alpha = .05$; $\beta = .20$). In addition, to allow for possible withdrawals and losses that may happen in clinical studies, 20% was added to the estimated sample size, so that a total of 42 patients were included.

The patients selected for this study were not directly associated with the Ribeirão Preto School of Dentistry. Participants were enrolled by means of an open invitation to the population. Recruitment strategies involved media (television, radio, and newspapers), advertisements, and invitation letters sent by mail. For all recruitment approaches, a telephone number was provided to enable volunteers to contact the project management team. The inclusion criteria were as follows: healthy adults and completely edentulous subjects, both genders, use of maxillary conventional complete dentures and mandibular overdentures retained by 2 to 4 implants, with an O-ring-retained system. The maxillary and mandibular dentures had to be clinically satisfactory and fabricated from heat-polymerized acrylic resin and acrylic artificial teeth. The implants and overdentures had to be in function for at least 6 months and the retention rings from 1–6 months. Uncontrolled diabetic patients; immunosuppressed patients; patients who had used antibiotic, antifungal, or corticosteroid medications in the past 3 months; patients currently using anticoagulant, anticonvulsant, and immunosuppressant agents; and patients with relined, repaired, or fractured dental prostheses were excluded from this study.

Ethical considerations

The study was approved by the Institutional Review Board of the Ribeirão Preto School of Dentistry (FORP/USP; Brazilian Ethics System registration No. CAAE: 35321514.1.0000.5419), in accordance with international protection guidelines and Helsinki Declaration. In compliance with ethical principles involving research in human subjects, signed terms of free and informed consent were obtained from the participants before the study began.

Denture and implant hygiene procedures

We used a computer program to randomly assign patients to groups using the following 2 methods: (1) mechanical brushing (MB, control), which included a specific brush for dentures (Bitufo, Itupeva, SP, Brazil), a soft-bristle toothbrush (Oral B Indicator Plus, Procter & Gamble, São Paulo, SP, Brazil), and dentifrice (Trihydral, Perland Pharmacos Ltda, Cornélio Procópio, PR, Brazil), and (2) the association of MB with oral irrigation (WaterPik [WP], experimental), which included all of the items used for the MB hygiene method in addition to a classic low-pressure jet tip (Waterpik, model WP-360, Waterpik, Fort Collins, Colo).

All participants used each method for 14 days in a crossover sequence. A washout period of 7 days between methods was established. In this period, the patients were instructed to use their habitual hygiene method. Participants were instructed to brush their dentures and peri-implant tissues after breakfast, lunch, and dinner (for 2 minutes) and not use any hygiene products other than those supplied by the researchers during the study period.

In the WP period, patients were instructed to use oral irrigation once a day after performing the last daily brushing. During oral hygiene, the tip of the irrigator had to be placed close to the peri-implant tissues and prosthetic abutments without touching them. The water jet should be uniformly directed toward the gingival margin surrounding the implant, for 20 seconds. The procedure was repeated for each implant. During overdenture hygiene, patients were instructed to direct the water jet uniformly toward the region of the capsules and retaining rings, at a distance of approximately 0.5 cm, onto each capsule/ring for 20 seconds.

Biofilm and calculus present on the implant surfaces and prosthetic abutment were removed by curettage, and prostheses were also properly cleaned and returned to their owners. Thus, all patients had an initial clinical condition (baseline) before beginning with the hygiene method.

Efficiency of the MB and WP hygiene methods were measured as biofilm-removal capacity, maintenance of oral tissue health, and patient satisfaction.

Measurement of biofilm-removal capacity and maintenance of oral tissue health

At baseline and 14 days after the application of each method, the clinical parameters of 4 sites per implant (ie, buccal, lingual, mesial, and distal) were registered. One trained examiner, blinded to the assignment of subjects to the hygiene methods, performed the clinical measurements as follows.

- Modified plaque index (PI)³¹: score 0, no biofilm detected; 1, biofilm detected by running a probe across the implant surface at the soft-tissue margin level; 2, biofilm seen by the naked eye; 3, abundance of biofilm material.
- Gingival index (GI)³²: score 0, normal soft tissue; 1, mild inflammation with a slight change in color and slight edema, without bleeding on probing; 2, moderate inflammation with redness, edema, and bleeding on probing; 3, heavy inflammation with a tendency for spontaneous bleeding and ulcerations.
- Probing depth (PD): measured from the free gingival margin to the bottom of the periodontal pocket, using a plastic millimeter probe (Colorvue, Hu-Friedy Co, Chicago, Ill).
- Bleeding on probing (BP): Evaluated as present (score 1) or absent (score 0) of bleeding noticed within 30 seconds of probing.

Patient satisfaction measurement

The patients answered a specific self-administered questionnaire based on their satisfaction after the use of each of the proposed hygiene methods. The instrument was developed by a qualified committee, composed of 5 experts on oral hygiene in edentulous patients, and prosthesis hygiene in denture wearers. Nine questions (Q1–Q9) were answered on a numerical scale from 0 to 100 (visual analog scale, 100.0 mm), with 0 representing a completely negative response and 100 a completely positive response. Questions were designed to measure patient satisfaction, including the level of comfort after use, feeling of cleanliness of the implants and prostheses, ease of daily use, continuation of use, and indication of use of the evaluated method to other people. An open question (Q10) that addressed inquiry about difficulties or complaints regarding the method completed the questionnaire.

Statistical analysis

The methodology and results of the study were reviewed by an independent statistician. The researchers involved in all steps of the study were blinded; it was, however, impossible to blind the participants to the methods used. A researcher (A), who was not involved in other operational stages of the research, obtained a list with random numbers generated by a computer program. These numbers corresponded to the possible sequences of the treatment, which had the same probability of being assigned. Another researcher (researcher B), carrying the randomization list, distributed the products to the patients and collected the prostheses. Researcher C collected data of the clinical parameters. Researcher D tabulated variables and forwarded the data to the statistical analyst.

To analyze clinical parameters, the patient was considered a statistical unit. The mean values of the PI, GI, and PD parameters at baseline and after the use of each hygiene method were calculated for each patient. BP was calculated from the percentage of sites with bleeding in relation to the total number of sites found in the patient at baseline and after the use of each hygiene method. The values did not adhere to a normal distribution, as verified by using the Kolmogorov-Smirnov test (which quantifies a distance between the empirical distribution function of the sample and the cumula-

tive distribution function of the reference distribution). The influence of the hygiene methods on clinical parameters was analyzed by the Friedman test (nonparametric statistical test used for 1-way repeated-measures analysis of variance by ranks), followed by Wilcoxon test (nonparametric statistical hypothesis test used to compare 2 related samples, matched samples, or repeated measurements), and the results were corrected using the Bonferroni method (one of several methods used to counteract the problem of multiple comparisons). Responses to the satisfaction questionnaire were analyzed by using the Wilcoxon test. The internal consistency of the questionnaire was evaluated by Cronbach's alpha coefficient (used to estimate the reliability of a psychometric test), and the unidimensionality was checked by a factor analysis. All statistical tests were performed using SPSS Statistics 20.0 (SPSS Inc, Chicago, Ill) with a significance level of .05.

RESULTS

After screening and examining 77 patients, 35 were excluded for the following reasons: 4 patients presented mandibular overdentures with fractures or repairs, and 5 other patients had injuries or pain caused by overdenture instability, which were previously established exclusion criteria. Eighteen patients reported difficulty in attending the return visits due to health and locomotion problems and difficulties with ensuring leave of absence from work. Six patients declined to participate in the study because of a lack of interest in the subject, and 2 were excluded because of difficulties with understanding the information noted during the initial interview. Thus, 42 patients were selected. Of these, 4 were lost: 1 due to the presence of pain in the lesion, which appeared during the research period, thereby causing difficulties with using the overdenture and adhering to the follow-up schedule of the proposed hygiene protocol and 3 because they did not return for follow-up appointments for the purpose of data collection. Data regarding all losses were excluded from the statistical analyses. Thus, the final study sample consisted of 38 patients (29 women and 9 men) with a mean age of 60.8 ± 7.1 years.

Clinical parameters

Table 1 presents the mean rank and the results of the comparison between pairs (Wilcoxon test). The Friedman test showed a statistically significant difference in values between baseline and after MB and WP use ($P < .001$) for all evaluated clinical parameters. At baseline, the values of the evaluated indices were significantly higher than those observed after the use of the tested methods. This result demonstrated that the hygiene protocols proposed in the research promoted an improvement in the peri-implant tissue health. However, no significant difference was reported between MB and WP (PI, GI, and PD: $P = 1.000$; BP: $P = .828$).

Figure 1a through d shows box plots of PI, GI, PD, and BP, respectively, at baseline and after the use of the evaluated hygiene methods. In comparison with the MB method, the WP method promoted a slight reduction in all the values of the indices evaluated. The MB method showed results that were

TABLE 1

Mean rank (MR), results of the Friedman test (Fr), and multiple comparisons of clinical parameters at baseline and after the use of each hygiene method†

Method	PI		GI		PD		BP	
	MR	Fr (P Value)	MR	Fr (P Value)	MR	Fr (P Value)	MR	Fr (P Value)
Baseline	2.64 ^A	27.95	2.75 ^A	37.97	2.62 ^A	24.99	2.54 ^A	28.15
MB	1.70 ^B	<i>df</i> = 2	1.67 ^B	<i>df</i> = 2	1.78 ^B	<i>df</i> = 2	1.86 ^B	<i>df</i> = 2
WP	1.66 ^B	(<.001)*	1.58 ^B	(<.001)*	1.61 ^B	(<.001)*	1.61 ^B	(<.001)*

*Significant difference (*P* < .05).

†Comparison between pairs: different letters indicate a significant difference (Wilcoxon test). MB indicates mechanical brushing; WP, association of mechanical brushing with oral irrigation; PI, modified plaque index; GI, gingival index; PD, probing depth; BP, bleeding on probing index.

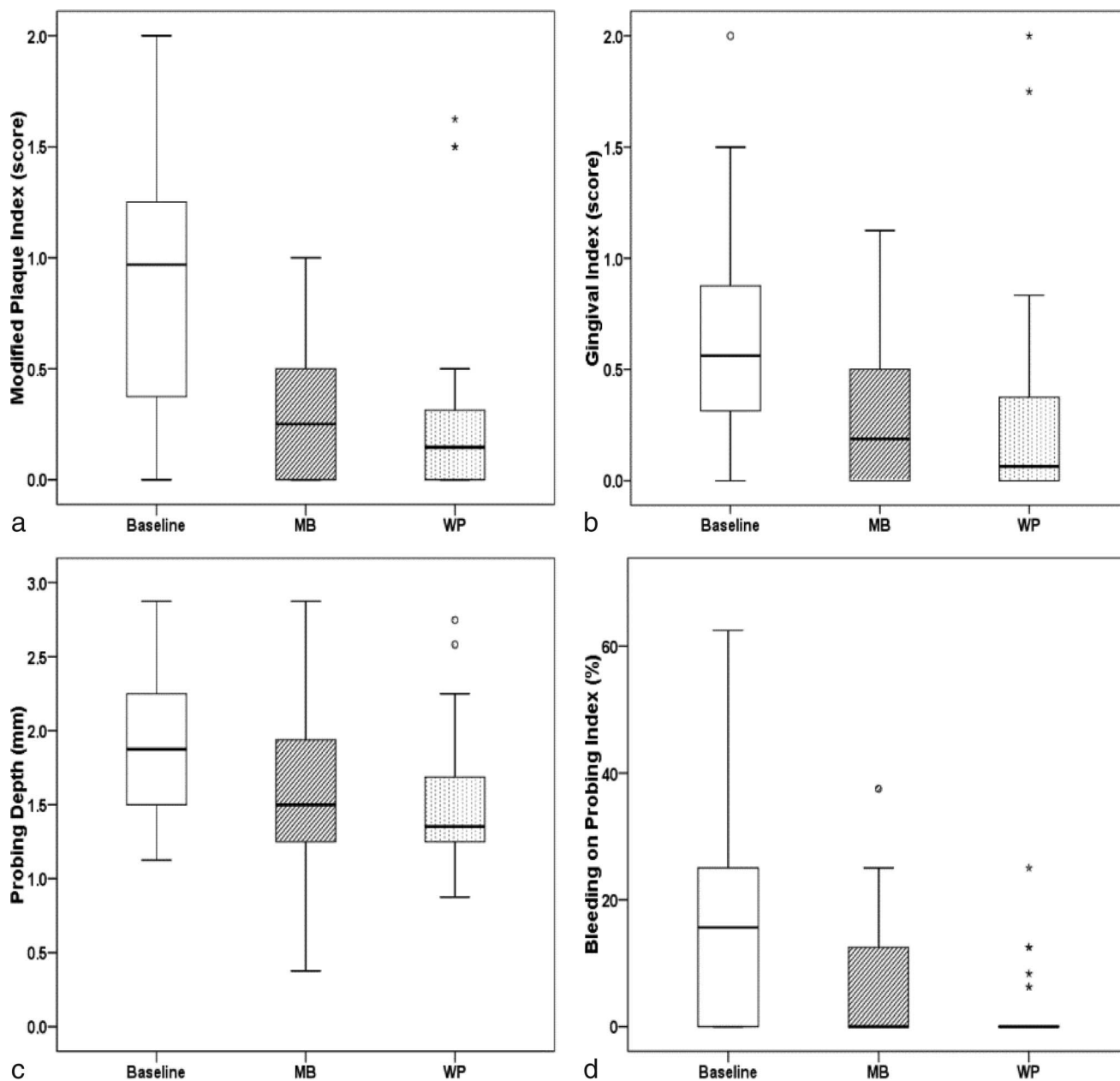


FIGURE 1. Box plot of modified plaque index (a), gingival index (b), probing depth (c), and bleeding on probing index (d) at baseline and after use of each hygiene method. MB (control): mechanical brushing (specific brush for dentures and dentifrice); WP (experimental): association of MB with oral irrigation (Waterpik).

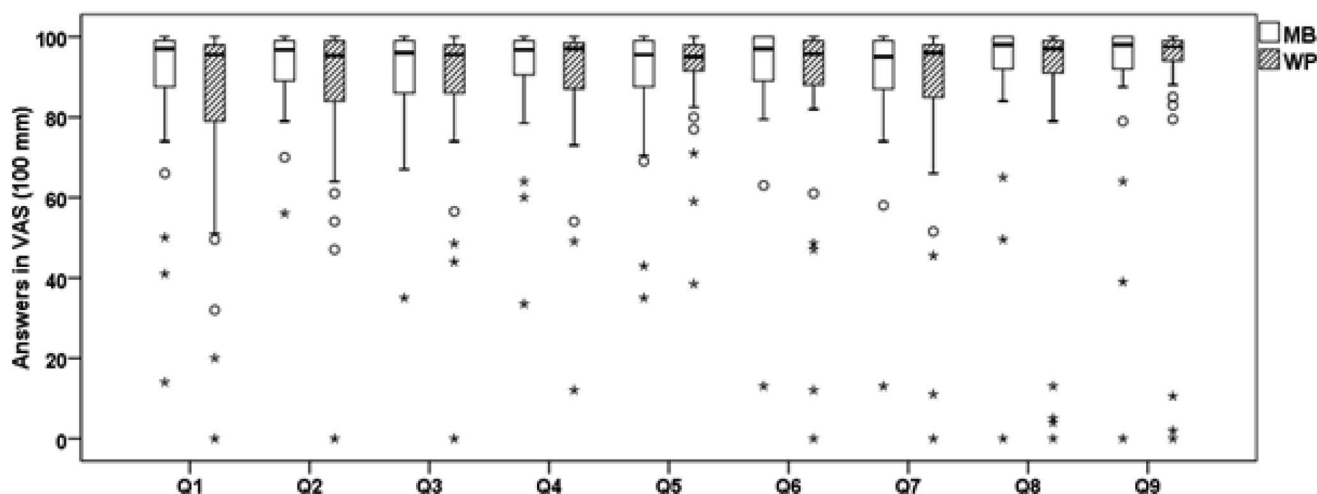


FIGURE 2. Box plot for patient satisfaction, after use of each hygiene method. MB (control): mechanical brushing (specific brush for dentures and dentifrice); WP (experimental): association of MB with oral irrigation (Waterpik).

comparable with those at baseline. Nonetheless, the difference between the methods was not statistically significant.

Patient satisfaction

The Cronbach alpha coefficient for the 9 items was .913, suggesting that the items had relatively high internal consistency. The main component analysis demonstrated that the questionnaire was unidimensional. In general, the responses to both methods yielded high values. Only 5 patients complained after using the WP method. When analyzing the answers to the open question (Q10), the main complaints of these patients were that the gums around the implants were painful soon after using the WP and that they found the device difficult to use.

Figure 2 shows the box plot of the responses for each to

the questions, after application of the MB and WP hygiene methods. The responses to the satisfaction questionnaire after the use of the 2 methods showed high scores (greater than 80.0 mm) for all questions, which meant that most of the patients were satisfied with both methods.

Table 2 presents each of the questions and their *P* values relative to the answers given after the use of MB and those after WP. The Wilcoxon test showed no statistically significant difference ($P > .05$) between the answers given to all questions (Q1 to Q9) after MB and WP.

DISCUSSION

Evaluation of the tissues around the implants is extremely important, because it enables the diagnosis of peri-implant diseases and determines the most appropriate therapeutic interventions.^{4,8} In addition, the peri-implant condition can be recorded and used to evaluate the patient's oral hygiene. Clinical parameters, such as the PI, GI, PD, and BP indices are considered important for monitoring the function of osseointegrated implants.^{25,26}

The null hypothesis was accepted because the results showed that both methods promoted a significant reduction in clinical parameters compared with the baseline values. Of the 2 methods evaluated, the WP method resulted in slightly reduced values of the clinical parameters, which reflected improvements in oral hygiene achieved after establishing the hygiene protocols for patients.

The WP method promoted an improvement in peri-implant gingival health, by significantly reducing the values of the clinical parameters after implementing the protocols, when compared with baseline values. These results agreed with findings obtained in previous studies in which oral irrigation was used in natural teeth to reduce the clinical signs of gingivitis and periodontitis.^{14,17–20,22,23} Clinical studies showing the effect of oral irrigation on peri-implant health are scarce and describe different methodological aspects regarding time of use, established control group, association with antimicrobial

TABLE 2

Wilcoxon test for patient satisfaction after using mechanical brushing and association of mechanical brushing with oral irrigation

Question	Statistical Analysis	
	Z	P
Q1 (Comfort after using the method)	−1.609	.108
Q2 (Cleansing sensation around the implants after using the method)	−1.540	.123
Q3 (Cleansing sensation of overdenture after using the method)	−0.022	.983
Q4 (Ease of use in the daily hygiene of implants)	−0.432	.665
Q5 (Ease of use in the daily hygiene of overdentures)	−0.402	.687
Q6 (Level of satisfaction after using the method on implants)	−0.504	.614
Q7 (Level of satisfaction after using the method on overdentures)	−0.098	.922
Q8 (Continuity of use in daily hygiene)	−0.196	.845
Q9 (Indicating use of the method to friends and relatives)	−0.358	.721

agents, and type of rehabilitation treatment performed in the participants. Felo et al¹⁵ showed that subgingival irrigation with chlorhexidine promoted a significant reduction in PI and GI when compared with chlorhexidine solution mouthwash. This finding indicated that irrigation allowed chlorhexidine to reach areas that would otherwise have been inaccessible to mechanical hygiene procedures. Compared with the effect of dental floss, the use of oral irrigation promoted a significant reduction in tissue bleeding around crown implants, and the latter has been indicated as an aid to maintaining dental implants.¹⁶ The effect of oral irrigation with chlorhexidine in the treatment of peri-implant diseases, when compared with conventional hygiene practices, promoted a significant reduction in PD and bleeding indices, thus suggesting that its use can be implemented in preventive programs.²⁴ Reductions in inflammation could also be explained by the action of irrigation on the selective modulation of inflammatory cytokine levels, thereby inhibiting disease progression.^{17,19}

No significant difference between MB and WP hygiene methods was observed. This result can be explained by the fact that oral irrigation was performed with water only, because the antimicrobial effect of the irrigant solution could mask the effect of the device. To maximize the effect of oral irrigation, further studies should consider the application of antimicrobial agents, such as chlorhexidine solution, instead of water as irrigant solution.^{15,24} Furthermore, the use of a specific tip for subgingival irrigation could effectively deliver the irrigant solution directly into the gingival sulcus, thereby expanding the extent and depth of its action.¹⁵ A previous study reported that oral irrigation was more effective in reducing peri-implant bleeding than flossing after 30 days of use.¹⁶

Patient adherence is an essential aspect of implementing a successful program for maintaining peri-implant health.^{27,29} The mean scores of responses to all questions were high, which showed patient satisfaction with mechanical brushing and its association with oral irrigation. The positive responses obtained demonstrated patient adherence to the methods evaluated, which was confirmed by noticeable improvements in peri-implant health after they applied the methods.²⁷⁻²⁹

Positive evaluations of the use of the 2 peri-implant tissue and overdenture hygiene methods may be related to the fact that removing the prosthesis provides access to the implant surfaces, prosthetic abutments, and peri-implant tissues, thus allowing more effective oral hygiene.²⁸ Removal of the prosthesis allows the overdentures to be more thoroughly cleaned extraorally, thereby facilitating visualization, something that patients who use fixed implants are unable to do. Patient satisfaction may also be associated with the absence of adverse events; this was confirmed by responses regarding the continued use and indication of the products. Several studies have emphasized the importance of the association between clinician and patient-centered parameters for assessing oral health. However, there are no validated questionnaires available in the scientific literature that are specifically intended for measuring patient satisfaction according to a hygiene protocol. Although the purpose of this study was not to develop or validate a construct, we endeavored to develop a questionnaire to measure acceptance of the proposed hygiene methods. We showed a high Cronbach alpha coefficient,

suggesting that the items had internal consistency. Principal component analysis demonstrated that the questionnaire was unidimensional. We fully agree that the validation process is a crucial step in determining whether an instrument really measures what it aims to assess. Nonetheless, because the number of participants of this study made it impossible to do this, further validity and psychometric tests should be conducted.³³⁻³⁵

A limitation of the study was the short period of use of each hygiene method. A longer duration of use and follow-up would allow better examination of the effects of the evaluated methods on the long-term maintenance of peri-implant tissues and overdentures. An additional limitation of the study was that we did not use the oral irrigation method alone (ie, without being associated with mechanical brushing). Therefore, further studies using the WP alone should be conducted to provide data about its biofilm-removal capacity. Moreover, a comparison between antimicrobial solutions and water when used in the oral irrigation devices would be an important consideration to investigate in future studies evaluating the effect of associating hydrodynamic action with the efficacy of the chemical solution.

Although this study demonstrated the effectiveness of oral irrigation in the maintenance of peri-implant tissues and its potential applicability for daily hygiene, other aspects should be analyzed to provide a decisive patient orientation. The literature has shown that incorporation of these antimicrobial solutions improves the cleaning effectiveness of hydrodynamic action. However, O-ring retention can be affected by using chemical solutions,^{31,32,36} and to date, no research has been conducted concerning the effect of insertion/removal cycles associated with oral irrigation performed with chemical solutions.^{37,38} Therefore, studies evaluating the action of different materials and hygiene methods on the control of biofilm on overdenture components and their influence on peri-implant health are considered a necessary and unavoidable requirement in the field of oral health care. In addition to assessing biofilm control by plaque score, the studies should evaluate the microbial load to determine whether the hygiene methods would remove periodontopathogenic species. Furthermore, the possible adverse effects caused to the materials constituting overdentures, such as the loss of O-ring retention, must also be analyzed.

CONCLUSION

Within the limitations of this randomized crossover clinical trial, it could be concluded that brushing associated with oral irrigation was effective in maintaining the health of peri-implant tissues, promoting a significant reduction in PI, GI, PD, and BP indices and providing a high level of patient satisfaction after its use.

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NOTE

The authors declare that they have no conflict of interest.

ABBREVIATIONS

BP: bleeding on probing index
 GI: gingival index
 MB: mechanical brushing
 PD: probing depth
 PI: modified plaque index
 Q1-Q9: Questions 1–9
 Q10: Question 10
 WP: association of mechanical brushing with oral irrigation

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