Community Dent Oral Epidemiol 2016; 44; 523–530

Community Dentistry and Oral Epidemiology

Psychological, behavioral, and clinical effects of intra-oral camera: a randomized control trial on adults with gingivitis

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Araújo M-R, Alvarez M-J, Godinho C A, Pereira C. Psychological, behavioral, and clinical effects of intra-oral camera: a randomized control trial on adults with gingivitis. Community Dent Oral Epidemiol 2016; 44: 523–530. © 2016 John Wiley & Sons A/S. Published by John Wiley & Sons Ltd.

Abstract – *Objectives:* To evaluate the effects of using an intra-oral camera (IOC) during supportive periodontal therapy (SPT), on the psychological, behavioral, and clinical parameters of patients with gingivitis, outlined by evidence and a theory-based framework. *Methods:* A group of 78 adult patients with gingivitis receiving an SPT was randomized into two groups: IOC and control. Bleeding on Marginal Probing (BOMP), self-reported dental hygiene behaviors, and psychological determinants of behavior change (outcome expectancies, self-efficacy, and planning) and IOC opinion were evaluated 1 week before or during the appointment and 4 months later. Repeated-measures ANOVA was used to compare groups over time. *Results:* Almost all the patients brushed their teeth daily, while 78% either never or hardly ever used dental floss. The IOC group showed significant improvements in BOMP index ($P < 0.001$), self-reported flossing ($P < 0.05$), and self-efficacy ($P < 0.05$) compared to the control group. *Conclusions:* The use of IOC significantly improves clinical, behavioral, and psychological determinants of periodontal health 4 months after treatment.

Key words: behavior change; gingivitis; intra-oral camera; oral hygiene

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Submitted 9 May 2016;
accepted 15 June 2016

Consistent evidence makes it possible to affirm that the main etiology of periodontal diseases is the formation and persistence of bacterial biofilms on dental surfaces[1]. Thus, efficient interventions designed to improve patients' adherence to a type of oral hygiene control, capable of promoting gingival health, are needed[2,3].

Dental floss is the most recommended device to control biofilm interproximally in combination with toothbrushing to reduce gingivitis[2]. However, most patients fail to correctly use these means of controlling dental biofilm in the long term and to turn up for recall appointments[4]. Professionals, generally aware of this issue, seem to restrict their actions toward changing the dental hygiene behavior of their patients primarily by verbally transmitting information during treatment (for example, explaining the correct use of a toothbrush and dental flossing)[5]. Hence, evidence-based research aiming to understand what predicts and/or causes changes in the behaviors, and the role of new technologies, such as the intra-oral camera (IOC), that impact gingival health, are sorely needed.

The identification of strategies, other than those geared toward simply raising awareness or exhorting to action, is an important step to bring about a sustained behavioral change in patients. Behavior change techniques such as reinforcement, goal-setting, and feedback have been shown to aid the implementation of new behaviors, such as flossing[3,6]. Moreover, the use of IOC images, as a means to increase and improve communication, has

doi: 10.1111/cdoe.12245

proven to be an effective strategy in ensuring such interaction and improves the relationship with patients[7]. Use of an IOC enables patients to see the areas of greater accumulation, retention, and difficulty in removing the biofilm, as well as the inflamed areas[7], thus increasing the hermeneutics that underlie the therapeutic intervention process. The use of real, individualized images, increases the attention of the patient to the known causes and characteristics of his/her own pathological processes, seemingly boosting the correct use of toothbrushes and interproximal control methods[7,8].

Despite the apparent benefits of IOC use in the adoption of oral hygiene measures and in improving the quality of communication between patients and professionals, there is a shortage of research and theoretically, sustained studies in this field[7], and the effects of IOC use on psychological antecedents of dental hygiene behaviors remain unclear. Individuals' desire to change and adopt new behaviors is often followed by difficulty in accomplishing and maintaining actual behavioral changes. More recent models of health behavior change, such as the Health Action Process Approach (HAPA[9]), now take not only motivational, but also volitional or self-regulatory psychological mechanisms into consideration, which explain how intentions are transformed into actions (Fig. 1).

The aim of the study was to determine whether it is possible to boost the sustainability and clinical efficacy of behaviors regarded as promoters of oral hygiene and gingival health by means of the IOC. We sought to test whether the use of images, in addition to behavior change techniques such as reinforcement, goal-setting, and feedback in the context of a dental appointment, contribute to the primary outcome of increasing gingival health verified by the Bleeding on Marginal Probing (BOMP). Their effects on the self-reported frequency of dental hygiene behaviors and their relevant psychological determinants, outlined by the HAPA, were secondary outcomes.

Methods

A total of 89 patients completed the baseline questionnaire (see Fig. S1). Table S1 shows sample descriptors of the final longitudinal sample composed by 78 patients.

Individuals were recruited by advertisements in local newspapers, dental clinics, and local shops, and a snowball method for recruitment was also used. The clinical interventions took place in two private dental clinics, and the study was conducted over a time span of 4 months with two assessment

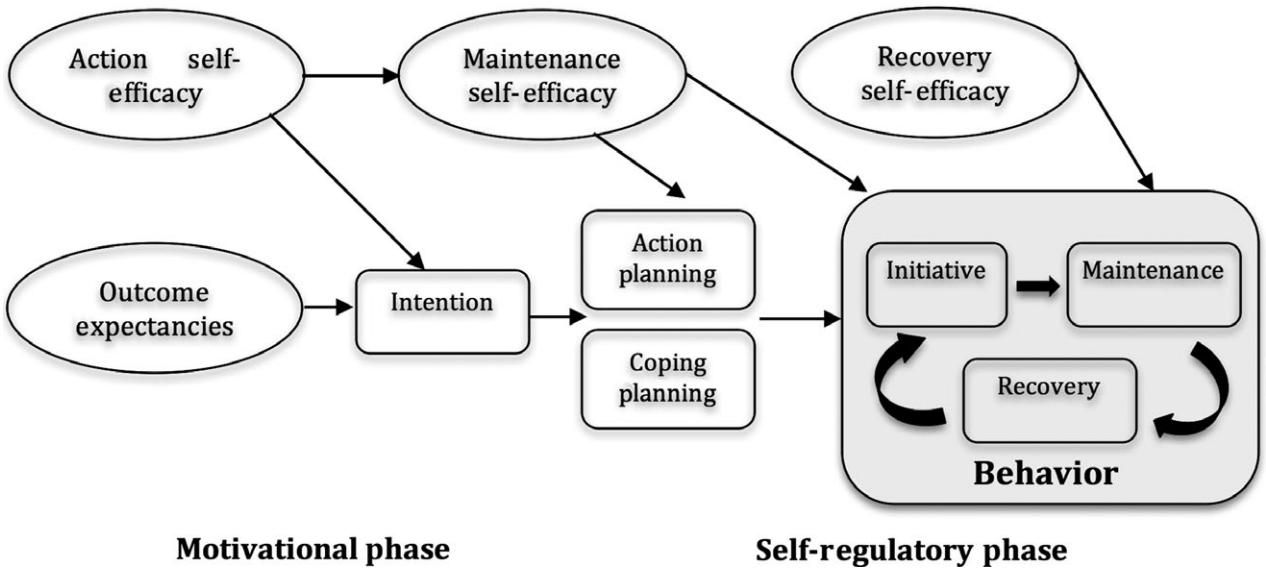

Fig. 1. The Health Action Process Approach (HAPA[9]). Outcome expectancies (for example, the pros and cons of a particular behavior) and action self-efficacy (for example, the belief in one's own personal ability to initiate such changes) are the two central motivational mechanisms. Taking action and maintaining such changes involve two important volitional self-efficacy beliefs, namely the belief in the ability to maintain a recently adopted behavior and deal with unexpected obstacles, that is, maintenance self-efficacy, and overcoming periods of inefficacy and recovering from them, that is, recovery self-efficacy. Intentions are also transformed by planning, which involves action planning, conveyed through specific plans on when, where, and how to perform the behavior and coping planning, which entails the development of strategies to be used should barriers or difficulties arise.

points between June 2014 and February 2015. Two weeks prior to the appointment, participants received an email explaining the study, read and signed an informed-consent digital form, and filled out an online questionnaire with measures on psychological determinants and behavior. Four months after the appointment, the same data were collected. Data confidentiality and anonymity were assured, and the Ethics Committees of the institutions involved approved the clinical trial (Ethic Committee Doc. No. 6/14). The study has been registered at the ClinicalTrials.gov database (NCT02725983).

In the first appointment, patients were randomly assigned by a computer-generated random sequence into one of two groups: IOC and control. During the treatments, the gingival condition was assessed as described by Van der Weijeden et al.[10] by the first author, an experienced certified dental hygienist. The patients were fully examined according to the standard care referred to by Ramseier et al.[11]. The gingival condition was collected, at baseline and 4 months later in such a way as to ensure that the researcher was blind to the patients' assigned condition. The BOMP index was validated by having a random set of 20% of participants reassessed by a second judge, a trained dentist, also blind to the patients' assigned condition, who performed the BOMP examination 30 min after, at baseline and at 4 months.

The dental consultation, which was the same for both groups, was performed by the experienced dental hygienist, lasted 1 h and included activities that are normally part of supportive periodontal therapy (SPT)[12]. It also included specific behavior change techniques[3], such as reinforcement (10.4), goal-setting (1.1), and feedback (2.2, 2.7), as described by Michie et al.[13] and considered crucial to the accomplishment of long-term behavior change. Moreover, special attention was given to patient communication and words such as 'cleaning' and 'hygiene' were replaced by therapeutic synonyms (for example, inflamed areas and controlling the inflammation) in order to focus patients' attention on the varied facets of oral health care and increase their perception of the treatment needs. Furthermore, appointments were duly organized in accordance with the specifics of each patient, such as their disease perception, habits, and expectancies regarding treatment. The control group was also an active group with a communication pathway based on the strategies outlined above. A detailed description of the appointment phases is depicted in the CONSORT (Fig. S1). In the IOC group, the device SOPROCARE® (ACTEON, La Ciotat, France) was used in the examination and diagnosis and also for the establishment of therapeutic goals, strategies, GumChucks® (OralWise, Calabasas, California, USA) and skills. For the interproximal control, the floss holder was used (Appendix S1). Two trained dental health professionals controlled the fidelity of 25% of the interventions, at random, using a four-item checklist (introduction and diagnosis, explanations, therapeutic goals, and clinical procedures). All treatment was free of charge.

In the BOMP index used for assessing gingival condition, bleeding is scored during 30 s of probing using a 3-point scale from 0 to 2 (0—no bleeding, 1—point bleeding, 2—excess bleeding).

Psychological determinants and behavioral data were collected using Qualtrics™ online survey software. To assess dental hygiene, two questions were asked on brushing and flossing habits. Two further questions on other interproximal devices, besides floss and reasons for not using floss, were also included. Individual scores for brushing and flossing were calculated, and a composite score was also computed for both (referred to as dental hygiene).

Measures adapted to oral health from previous studies with the HAPA model were used[14]. All the psychological variables were evaluated using a 7-point Likert-type scale, ranging from totally disagree (1) to totally agree (7), except in dental hygiene where a 5-point Likert scale was used. Number of items, item examples, and Cronbach's alphas are displayed in Table 1.

Satisfaction with the intra-oral camera (9 items) was measured by adapting Shaw's scale[15]. A 5-point Likert scale, ranging from totally disagree (1) to totally agree (5), was used. This scale considers that the admission of technology is based on its usefulness and acceptability.

A sample size of $n = 58$ was calculated using G*Power[16] to give 80% power to detect a statistically significant difference at $\alpha = 0.05$, whenever an effect size similar to $f = 0.33$[7] or higher was observed, and was inflated by 30% to cover the possibility of dropout.

The statistical analysis was performed using SPSS (v.22)™. To test group equivalence at baseline, a multivariate analysis of variance (MANOVA) was performed on baseline psychological determinants, behavior, and clinical gingival outcome, and ANOVA and chi-square tests were used to compare

Table 1. Number and items examples, Cronbach's alpha, behavioral, clinical, and psychological determinants at baseline and 4-month follow-up in intra-oral camera and control groups

	Item example	Number of items	Cronbach's alpha baseline (4-months)	IOC group (n = 40) M (SD)		Control group (n = 38) M (SD)		Group comparison					
								Group		Time		Group x Time	
				Baseline	4 months	Baseline	4 months	F	η2	F	η2	F	η2
Flossing	In the last 2 weeks/ 4 months how often have you flossed your teeth?	1	—	1.68 (0.76)	2.80 (0.65)	1.84 (**0**.86)	2.53 (0.51)	0.17	**0**.00	92.19**	0.55	5.47*	0.07
Toothbrushing	In the last 2 weeks/4 months how often have you brushed your teeth?	1	—	3.90 (0.63)	3.95 (0.50)	3.82 (**0**.77)	3.79 (0.62)	0.89	**0**.01	0.04	0.00	0.38	0.00
Dental Hygiene		2	—	2.79 (0.50)	3.38 (0.43)	2.83 (**0**.58)	3.16 (0.45)	0.82	**0**.01	63.52**	0.46	5.06*	0.06
BOMP				1.20 (0.29)	0.61 (0.28)	1.14 (**0**.33)	0.81 (0.33)	1.25	**0**.02	175.31**	0.70	14.15**	0.16
Outcome Expectancies	Avoiding bleeding gums/ Avoiding bad breath.	7	0.78 (0.68)	5.88 (0.95)	5.84 (0.80)	5.79 (**0**.79)	5.79 (0.59)	0.19	**0**.00	0.05	0.00	0.05	0.00
Action Self-efficacy	I believe I can clean interproximally and brush daily, even if I need to change routines.	3	0.74 (0.84)	5.64 (1.03)	5.98 (0.82)	5.81 (1.0)	5.87 (0.87)	0.02	**0**.00	3.05	0.04	1.47	0.02
Intention	In the oncoming weeks I intend to carry out interproximal cleaning and brush my teeth daily.	3	0.94 (0.78)	6.12 (0.99)	6.21 (0.68)	5.87 (1.2)	5.89 (0.88)	2.35	**0**.03	0.27	0.00	0.08	0.00
Maintenance Self-efficacy	I believe I can maintain my daily interproximal control and toothbrushing habits even if my relatives or roommate do not do so.	4	0.90 (0.86)	5.43 (1.26)	5.70 (0.95)	5.84 (1.13)	5.61 (1.23)	0.48	**0**.00	0.03	0.00	3.88*	0.05
Recovering Self-efficacy	If I didn't control interproximal areas or brush my teeth on a daily basis, I believe I could start all over again.	3	0.92 (0.77)	5.95 (1.26)	6.12 (0.96)	5.89 (1.21)	5.65 (0.98)	1.38	**0**.02	0.10	0.00	3.37†	0.04
Action Planning	I already have plans for when I should brush my teeth and use an interproximal aid.	3	0.83 (0.76)	5.05 (0.97)	5.91 (1.13)	5.18 (1.51)	5.96 (0.97)	0.13	**0**.00	24.26**	0.24	0.05	0.00
Coping Planning	I have plans for what I should do if I have difficulties in practicing my dental hygiene.	3	0.90 (0.78)	5.14 (1.39)	5.76 (**0**.96)	4.71 (1.55)	5.27 (1.33)	3.29	**0**.04	13.45	0.15	0.03	0.00

*$P < 0.05$.
**$P < 0.001$.
†$P < 0.07$.
BOMP (Bleeding on Marginal Probing), Dental Hygiene (includes brushing and flossing values).

continuous (for example, age) and categorical (for example, gender) variables, respectively. Distribution normality (Shapiro–Wilk) and variance homogeneity (Levene's test) were verified for all outcome variables.

To assess variations in performance between baseline and 4 months across the two conditions (IOC vs. control), mixed between-/within-subject repeated-measures analyses of variance were computed with dental hygiene, BOMP, and psychological variables as dependent variables and condition as the between-subjects factor.

Results

Over 97.5% of participants brushed their teeth at least once a day and the majority (72.6%) brushed twice or more often a day (M = 3.86, SD = 0.70), all using a manual toothbrush. Participants reported a low level of dental floss frequency, with 77.6% never or hardly ever using dental floss (M = 1.76, SD = 0.81). The main reasons reported by patients for not using floss involved gum pain and subsequent bleeding (M = 3.06, SD = 1.13), being considered too complicated to use (M = 2.76, SD = 1.31), lack of time (M = 2.70, SD = 1.13), and regarded as unnecessary (M = 2.42, SD = 1.16).

At baseline, the BOMP showed an overall mean of 1.17 (SD = 0.31). Also, the percentage of bleeding sites with the BOMP index for the control and IOC groups was 56.5% and 60%, respectively. The BOMP values for inter-rater agreement stability did not show significant differences.

Opinions on the IOC were highly positive in terms of enjoyment at seeing the pictures, the feelings experienced, the way it helped to check patients' mouths, how it improved oral hygiene, its usefulness, and as an overall experience. The majority of participants reported positive feelings toward the pictures, while only some described them as disturbing, and none described them as disgusting or too numerous (Appendix S2).

No differences were found regarding levels of baseline psychological determinants, dental hygiene (floss and brushing behavior), clinical gingival condition, age, and levels of schooling between the IOC and control groups ($P > 0.13$). In 80% of the checked appointments, the obtained fidelity of the intervention was 100%. For the remaining 20%, the obtained fidelity level was 90%.

A main effect of time was revealed for dental hygiene and for flossing, indicating an increase across the two periods of time (Table 1). This increase was reliable in the IOC group both for dental hygiene, $F(1,76) = 53.58$, $P < 0.001$, $\eta^2 = 0.41$, and flossing $F(1,76) = 73.17$, $P < 0.001$, $\eta^2 = 0.49$. The same trend was observed in the control group for dental hygiene, $F(1,76) = 15.96$, $P < 0.001$, $\eta^2 = 0.17$, and for flossing, $F(1,76) = 25.71$, $P < 0.001$, $\eta^2 = 0.25$. Importantly, an interaction between group and time emerged for dental hygiene and for flossing, neither of which showed any differences between the groups at baseline: $F_{\text{dental hygiene}}$ (1,76) = 0.11, ns, $\eta^2 = 0.00$; F_{flossing} (1,76) = 0.83, ns, $\eta^2 = 0.01$ (Fig. 2). An increase in dental hygiene and flossing in both groups at 4 months was observed (Table 1), which was higher in the IOC group than in the control condition: $F_{\text{dental hygiene}}$ (1,76) = 4.68, $P < 0.05$, $\eta^2 = 0.06$; F_{flossing} (1,76) = 4.29, $P < 0.05$, $\eta^2 = 0.05$.

A main effect of time was also revealed for the BOMP, with both groups showing a reduction in BOMP scores across the two periods of time (Table 1), $F(1,76) = 148.33$, $P < 0.001$, $\eta^2 = 0.66$ for the IOC, and $F(1,76) = 43.80$, $P < 0.001$, $\eta^2 = 0.37$ for the control group. An interaction between group and time was also found (Fig. 2). There was no difference between the groups at baseline, F (1,76) = 0.80, ns, $\eta^2 = 0.01$; however, there was a stronger reduction in BOMP in the IOC than in the control group, $F(1,76) = 8.32$, $P < 0.01$, $\eta^2 = 0.10$.

There was a significant interaction between group and time for maintenance self-efficacy and a marginally significant interaction effect for recovery self-efficacy (Fig. 2), neither of which showed any differences between the groups at baseline: $F_{\text{maintenance}}$ (1,76) = 2.21, ns, $\eta^2 = 0.03$; F_{recovery} (1,76) = 0.05, *ns*, $\eta^2 = 0.00$. The recovery self-efficacy was higher in the IOC group than in the control condition at 4 months, $F(1,76) = 4.73$, $P < 0.05$, $\eta 2 = 0.06$. Similarly, the maintenance self-efficacy was higher in the IOC group than in the control condition. Although this difference did not reach significance, $F(1,76) = 0.13$, $P = 0.72$, $\eta 2 = 0.00$, an increase in maintenance self-efficacy from baseline to 4-month follow-up was obtained in the IOC group (M = 2.69, SD = 1.18), while a decrease was observed in the control group (M = 0.224, SD = 1.01), $F(1, 76) = 3.00$, $P < 0.05$, $\eta 2 = 0.05$ (Table 1).

Discussion

This study set out to evaluate the importance of IOC use in a SPT with patients suffering from

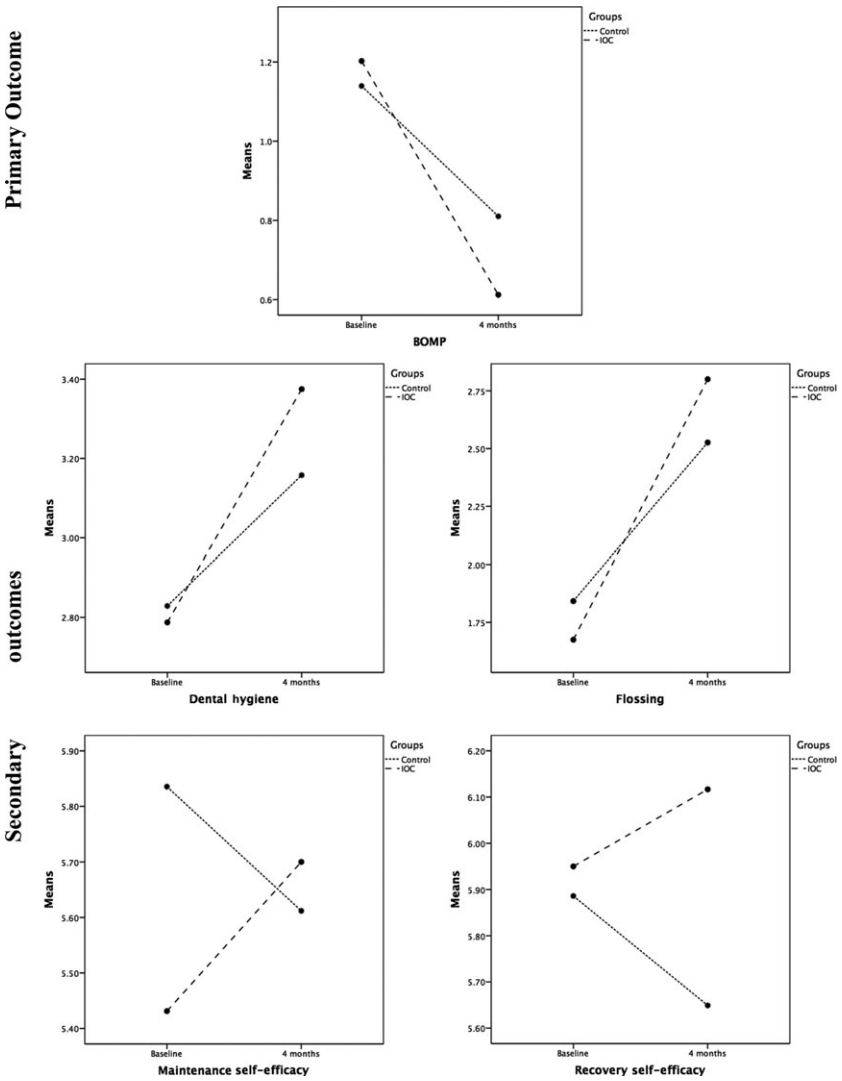

Fig. 2. Levels of Bleeding on Marginal Probing (BOMP), dental hygiene, flossing, maintenance self-efficacy, and recovery self-efficacy in the two conditions at two points in time. Dental hygiene combines the frequency of toothbrushing and flossing.

gingivitis in the reduction of bleeding and the increase of oral hygiene behaviors, and the underlying psychological antecedents of such behaviors. Both groups presented improved results after 4 months; however, significantly higher improvement was observed for the intra-oral camera group against the control group. The study provides evidence that IOC use boosted a significant reduction in bleeding as per the BOMP, an increase in the use of dental floss, and in perception of self-efficacy, which is crucial to the self-regulation process involved in the use of floss. This is relevant, as effective control of gingival bleeding is fundamental in the monitoring of periodontal diseases, namely gingivitis[10].

In line with previous studies, the positive results of IOC use in dental flossing and subsequent bleeding reduction proved that the IOC seems to act as an effective strategy, enabling patients to better understand the information provided in the appointment[7]. Despite the scarcity of oral health studies on the use of individual images and their link to the successful periodontal treatment and behavior change of the patients, interesting results with similar devices may be observed in the literature stemming from other fields of medicine. Mols et al.[17] refer to the use of images of the calcified arteries of the patients themselves as an effective way of changing risk behaviors for heart disease. In dentistry, the IOC has also proven to be used successfully in observation, diagnosis, and treatment planning, as well as in the monitoring of disease[8].

In a study in which the IOC was used, an 18.2% reduction in bleeding using the Sulcus Bleeding Index (SBI) was observed in the experimental group after 4 weeks[7]. In the present study, similar but more positive results were obtained, since after 4 months bleeding levels had dropped from 60% to 30.5% in the IOC group, corresponding to a reduction of 50%. In the same study, a reduction in

bleeding was also observed in the control group (11% less). Likewise, an increase in dental flossing and bleeding reduction was observed in the control group (26% less) in the present study, despite bigger changes being registered in the IOC group. The changes detected in both groups seemingly demonstrate the effectiveness of this approach, which was based on specific behavior change techniques and enriched communication strategies in both groups.

The changes observed in maintenance and recovery self-efficacy also point to the importance of the IOC in strengthening these beliefs, namely that behavior may be changed even if sustained flossing is hampered, and can still be resumed after a lapse in this oral hygiene behavior. Outcome expectancies, that is, beliefs regarding the pros and cons of the behavior[7] and planning, conveyed through specific plans on when, where, and how to perform the behavior and the development of strategies to be used should barriers or difficulties arise[18], have been rendered determinants of changes in oral hygiene behaviors. However, in the present study, and in keeping with that of Schüz et al.[19], the main oral hygiene predictors are related to the level of perceived self-efficacy. The changes in both types of self-regulatory self-efficacy encountered in this study suggest that IOC use may be an effective strategy in dental appointment to foster the self-regulation of toothbrushing behaviors and flossing, as well as their maintenance across time. This is remarkable as, although research has shown that it is easier to induce changes in motivation than in self-regulation processes[20], the results obtained in this study point to changes in self-regulation and not in the motivational determinants of behavior change.

There are some limitations to this study. Using the GumChucks® device for dental flossing, we may have brought about a motivating effect for many patients, which may explain why there was an increase in flossing frequency in both the IOC and control groups. The possibility of the characteristics of the dental hygienist having had an impact on the effects of this study cannot be ruled out; therefore, it is important to conduct similar studies with different oral hygiene professionals. In any case, both the GumChucks® and the oral hygienist were the same for all participants, and therefore, the differences observed between the groups cannot be attributed to these factors. In addition, conducting a blind analysis of the data could have strengthened the claim regarding the impartiality of the presented findings, despite the fact that it is not a common practice in social sciences research[21].

Notwithstanding the limitations, the measurement of the clinical parameters of gingival health and their inclusion in behavioral research is an important contribution of this study. The use of these clinical parameters, as well as the need for a sufficient time interval so that behavior change may be evaluated, are necessary characteristics that are present in this research study. Although Renz et al.[6] proposed years rather than months as the gold standard, the 4-month interval of this study is already longer than those found in most of the studies included in their systematic review. Our proposed SPT made it possible to standardize the study with the patients and to enable communication consistency, so that the main aspects of the relationship and behavioral intervention with the patient were uniform in all appointments. It was designed to include important behavioral change techniques in both conditions, representing a different way (not the usual care) of conducting a SPT. This, indeed, granted greater control over the effects of the images, not restricting their use to a simple evaluation of patients' oral hygiene behaviors, but rather transforming them into important data for the required therapy and enhancing the behavioral change techniques employed.

This study points to the potential such technology may have in effective, medium-term behavior and oral hygiene changes, namely with regard to interproximal control and the reduction of gingival inflammation. It also provides clues as to the psychological constructs responsible for the efficacy of the images in oral hygiene change. The use of images and a particularized communication and relational strategy in the session may mark the difference between success and failure in the medium-term control of periodontal pathologies. Alternative methods may also be considered. For example, the use of selfies is a promising behavior change strategy[22]. However, the IOC has the potential that these methods do not have, particularly the level of detail afforded by the displayed images. Thus, more studies are necessary to establish the added value of different image alternatives, to understand their underlying change mechanisms, and to establish how these technologies can be improved to support other treatments (for example, dental implants and orthodontic treatment).

The use of images through the IOC, in addition to behavior change techniques such as reinforcement, goal-setting, and feedback in the context of a dental

appointment, contributes to an increase in gingival health, in self-reported dental hygiene behaviors and in perceived self-efficacy responsible for helping to mobilize and maintain self-regulation processes that boost the transformation of intention into actual action. This study contributes to the increasing evidence that technologies such as the intra-oral camera can play an important role in oral health behavior interventions.

Acknowledgements

The authors express their sincere gratitude to Dagmar E. Slot for their comments on this manuscript.

Conflict of interest and Sources of funding

This study received material support from Oral Wise, Inc. This company, located in Calabasas, California, USA, supplied the total amount of GumChucks® used in this study. These products are not commercialized in Portugal.

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Supporting Information

Additional Supporting Information may be found in the online version of this article:
Figure S1. CONSORT flowchart.
Table S1. Demographic characteristics of the sample.
Appendix S1. GumChucks ©.
Appendix S2. Intra-oral camera opinions.