UNIVERSIDADE DE LISBOA

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Mário Rui Gabriel Araújo

Orientadores: Profª Doutora Maria João Alvarez

Profª Doutora Cristina Isabel Albuquerque Godinho,

Tese especialmente elaborada para a obtenção do grau de Doutor em Psicologia, Especialidade Psicologia da Educação

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2021

“Help me, Obi-Wan Kenobi. You’re my only hope.”
(George Lucas, 1977)

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Dedicado ao Pai e à Mãe...

The Road Not Taken

Two roads diverged in a yellow wood,
And sorry I could not travel both
And be one traveller, long I stood
And looked down one as far as I could
To where it bent in the undergrowth;

Then took the other, as just as fair,
And having perhaps the better claim,
Because it was grassy and wanted wear;
Though as for that the passing there
Had worn them really about the same,

And both that morning equally lay
In leaves no step had trodden black.
Oh, I kept the first for another day!
Yet knowing how way leads on to way,
I doubted if I should ever come back.

I shall be telling this with a sigh
Somewhere ages and ages hence:
Two roads diverged in a wood, and I—
I took the one less travelled by,
And that has made all the difference.

Robert Frost

RESUMO

A Saúde Oral é fundamental para a saúde, bem-estar e qualidade de vida. A prevalência e a recorrência das doenças orais constituem uma epidemia silenciosa. Um controlo eficaz do biofilme dentário é um pilar da saúde gengival. Por isso, ajudar a melhorar e manter os níveis de higiene oral dos pacientes, deve ser o principal objetivo dos profissionais de saúde oral que se dedicam ao tratamento das doenças periodontais e manutenção da saúde. A investigação descrita envolveu 246 pacientes e teve por objetivo explorar os efeitos de novas tecnologias, nomeadamente a câmara intraoral (CIO) e o telemóvel, através da utilização de mensagens de texto (SMS), na promoção de comportamentos de higiene oral, em adultos com gengivite. As intervenções foram baseadas em teoria sobre a mudança de comportamentos de saúde e o modelo teórico utilizado foi o *Health Action Process Approach* (HAPA). Foram realizados quatro estudos, no primeiro investigou-se a utilidade da CIO numa consulta de saúde oral; no segundo a utilidade das SMS e no terceiro os benefícios da utilização conjunta de ambas as tecnologias (SMS e CIO) para comportamentos de higiene oral. Nestes três primeiros estudos demonstrou-se a importância da utilização de diferentes tecnologias no decorrer da consulta de saúde oral e o seu efeito em variáveis comportamentais, clínicas e psicológicas. No quarto estudo verificou-se a utilidade do modelo HAPA, bem como os constructos mais importantes para os comportamentos de higiene oral. Os estudos apresentados permitiram compreender a importância das teorias psicológicas nas intervenções em saúde oral, bem como a utilização de novas tecnologias como parte de uma estratégia com vista a uma maior eficácia no controlo da gengivite e na promoção de mudanças e manutenção de comportamentos em saúde oral. As intervenções educacionais em saúde oral devem, portanto, prestar atenção especial a estratégias baseadas em intervenções psicológicas de mudança comportamental e na utilização de tecnologias que possam facilitar e melhorar a sua eficácia em pacientes adultos com doenças gengivais.

Palavras-chave: higiene oral; gengivite; mudança de comportamento; ICT; camara intraoral; SMS; mHealth; HAPA; autorregulação.

ABSTRACT

Oral Health is fundamental to health, well-being, and quality of life. The prevalence and recurrence of oral diseases is a silent epidemic. Effective control of the dental biofilm is a pillar for gingival health. Therefore, helping to improve and maintain patients' oral hygiene levels should be a goal for all oral health professionals who are dedicated to treating periodontal disease and maintaining health. This research, involving 246 patients, aimed to explore the impact of new technologies, including the intraoral camera and mobile phones, through the use of text messaging to promote oral health behaviors in adults with gingival disease. The interventions were theory-based and the theoretical framework used was the Health Action Process Approach (HAPA). Four studies, described over 4 chapters, were conducted. The first study investigated the usefulness of the intraoral camera in an oral health appointment; the second, the usefulness of text messages; and the third, the usefulness of the coaction of both technologies (intraoral camera and text messages). The first three studies demonstrated the importance of using different technologies during the oral health appointments, showing their effect on behavioral, clinical, and psychological variables. In study 4, the utility of the model was verified, as were the most important constructs for oral hygiene behaviors. The studies presented here demonstrate the importance of psychological theories in oral health interventions, as well as of using new technologies as part of a strategy aimed at promoting the change and maintenance of oral health behaviors for greater effectiveness in controlling gingivitis. Oral health educational interventions should therefore pay particular attention to strategies based on psychological determinants of behavior change and the use of technologies that can facilitate and improve the effectiveness of those determinants in adult patients with gingival diseases.

Keywords: oral hygiene behaviors; gingivitis; behavior change; ICT; intraoral camera; text messages; mHealth; HAPA; self-regulation.

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FOREWORD

A great number of patients need to change their oral health behaviors. One of the challenges that healthcare professionals have to face is that the motivation for change is not an all-or-nothing phenomenon, and people often have ambivalent feelings about it. The pleasant side of this process is the feeling that when there is a real change in behavior, this depended in part on the type of relationship that we were able to build with our patients. There are countless comments that remind us of this: "*I felt that I realized where the problem was and I will be able to treat my gums...*"; "*It was very important for me to see and talk about the pictures that you took of my mouth...*"; "*Why did nobody never tell me about my gums like that?*"; "*When I saw the messages, I start remembering about using dental floss...*".

Patients may have reasons for changing, but they also have reasons for not doing so.

Our work as health professionals involves assuming the role of health educators and providing the tools that can contribute to this change. However, we might assume that if people were simply told what is good for them and what they need to protect their health, they would follow these instructions without question. However, the evidence tells us that it doesn't happen that easily. The resilient reaction we hope for is not just the responsibility of patients – it depends in part on how we approach them. Accepting the fact that patients are not simply passive recipients of our recommendations, it is fundamental to build an evidence-based relationship around a set of strategies for behavioral change.

There are many authors who argue that communication is a weapon. From what I have experienced over a 28-year career in oral health, I would say: communication is therapeutic.

This is the story I want to share.

1. INTRODUCTION

Gingivitis and periodontitis constitute a continuum of the same inflammatory disease of the supporting structures of the periodontium. Although not all patients with gingivitis develop periodontitis, controlling gingivitis is considered essential in preventing it (Chapple et al., 2015). The development of periodontitis is partly related to a genetic predisposition and to several factors related to lifestyle, such as smoking, type II diabetes mellitus, stress, and nutritional factors (Bui et al., 2019; Jin et al., 2016; Nazir, 2017). However, the main risk factor is the accumulation of dental biofilm (dental plaque) on dental surfaces, taking into consideration the host's own response to the inflammatory process. The control of dental plaque is therefore fundamental in the prevention and control of periodontal diseases (Chapple et al., 2015; Chapple et al., 2018; Frencken et al., 2017; Wilder & Bray, 2016). The research presented here centres around patients' difficulties in maintaining behaviors that allow long-term effective control of the biofilm – essential for periodontal health – plus the need to understand these difficulties and to use new methodologies and tools that put behavior change strategies into practice.

Due to their specific characteristics, inflammatory diseases of the periodontium are directly related to individuals' behavior (oral hygiene, diet, smoking). With regard to oral hygiene (control of dental biofilm), the measures considered most effective are tooth brushing, control of plaque in interproximal spaces (through the use of dental floss, interdental brush, toothpick, or other), and regular visits to oral health professionals (Jepsen et al., 2017). However, effective use of the means to control plaque requires daily habits that are sometimes difficult to initiate and maintain over time. Low adherence to the routines necessary to create correct oral hygiene habits can thus carry negative consequences for the individual's oral health (Petersen & Ogawa, 2012).

The need to change our patients' behavior can be viewed in the following ways: without assigning it any importance; by simply acting according to common sense; or by understanding

that the main pillar for the treatment and control of periodontal diseases is the patients' own behavior. To borrow a phrase from James Carville during Bill Clinton's 1992 re-election campaign, "It's the behavior, stupid!" He might have added that it is the big difference between "change or more of the same" (Kelly, 1992).

Making intervention for behavior change a priority means recognizing the importance of the intervention's content, its theoretical bases, and what we personally give of ourselves to it (Dombrowski, O'Carroll, & Williams, 2016). These authors state that the way professionals engage in the process underlying change in behavior is the fundamental part of this intervention, an "active ingredient" of it. Some of the main characteristics of this personal investment are: one's professional education (one tends to believe in the process if it was an original part of one's training), the type of intervention, the materials used, the location itself, the emphasis put on the intervention, the way the intervention is individualized, and professional's personal style. In fact, and still according to these authors, these characteristics are more important for the final result of the intervention than the content (the theoretical "classes" that some professionals like to impose) or the underlying theory itself. In an area where common sense reigns, but where evidence-based intervention should be present, it is essential that oral health professionals be trained, starting in university so that the theoretical concepts of behavioral sciences are translated into strategies that they can integrate into their consultations. Only in this way, as noted by Dombrowski et al. (2016), can these interventions have a greater chance of success with patients.

Most oral health care professionals are trained to offer the "best" treatment possible to patients. But this idea must be, at at times, forgotten when it comes to intervening for behavior change, given that the best solution in the eyes of the professional is not always what's actually best for the patient. Sometimes treatments are proposed that do not meet the expectations or needs of the patient; therefore, however correct they may be, they have a high risk of failure.

For example, in a patient who has always brushed his teeth several times a day, proposing in a hygiene consultation that we have to "teach" him to brush his teeth properly is a risky proposition if we do not consider the specifics and background of the patient.

On the other hand, the usual approach that a health professional takes for changing behavior related to oral hygiene involves giving advice or trying to persuade patients that their opinion is more valid and unquestionable. This is an approach with immense limitations. If we look upon of the theory of psychological reactance (Brehm & Brehm 1981), there are individuals who, when they feel they are being pressured towards a certain idea or attitude, tend to react in the opposite direction. Often, the result of these interventions is the opposite of what is desired. This helps to explain the reality that traditional educational interventions are, in most cases, ineffective in changing patients' behavior (Järvinen, Stolt, Honkala, Leino-Kilpi, & Pollanen, 2018; Newton & Asimakopoulou, 2015; Renz, Ide, Newton, Robinson, & Smith, 2007). However, we do not mean that oral health professionals should not advise or give information to their patients, but they must consider above all how to do it. Even in the best-case scenario, research has shown that compliance with health professionals' advice tends to be low; 40 to 60% of information provided in the consultation is forgotten in a short period of time (Delatola, Adonogianaki, & Ioannidou, 2014; Suvan, Fundak, & Gobat, 2010). It is important to adapt this information to patients' expectations and possibilities for change. At the same time, the way in which the information is made available (for example, through a directive style vs. a consultative style) and the scenario in which these conversations take place can make all the difference in the way information is received and later used (Järvinen et al., 2018; Pentapati & Siddiq, 2019; Salter, Holland, Harvey, & Henwood, 2007).

It is therefore not surprising that the teaching of biofilm control strategies by health professionals is typically supported by simple ways of transmitting information to patients. These strategies are often based on the professional's perspective, without taking the specific

characteristics of individual patients into account. Evidence-based, structured, and individualized behavioral change strategies and techniques are seldom used (Ramseier & Suvan, 2010). Thus, oral hygiene behaviors are not properly inculcated and – if they even begin – often end up abandoned by patients in the medium or long term (Gobat, Bogle, & Lane, 2010; Sambunjak et al., 2011). Strategies are needed for helping patients change and maintain their behavior in order to control periodontal diseases, prevent them when possible, and effectively promote oral health.

Topics that will be addressed throughout the next chapters include communication techniques, new methodologies for changing behaviors based on existing theory, and the need to think about new tools that can be easily used by professionals in the dental office.

There is an urgent need to transpose to clinical reality those theories and behavioral techniques already known and studied, but rarely used in professional practice (Newton & Asimakopoulou, 2015). Aspects such as empathy, feedback, reinforcement, goal setting, self-efficacy, and self-regulation are widely referred to in the literature, but they seem to have no practical meaning for oral health professionals (Newton & Asimakopoulou, 2015).

In order to create a set of effective strategies for the control of oral diseases, namely gingivitis, there are questions that must be asked and which we have tried to answer throughout this thesis. What behavioral and psychological mechanisms will determine behavioral changes in oral health? What behavior change tools might be specified for promoting patient empowerment, with a particular focus on patients affected by chronic conditions, such as periodontal diseases? What means can help professionals in their clinical practice to make these behavioral strategies more feasible for patients?

This thesis will therefore address the topic of information and communication technologies (ICT) and the use of those for health (e-Health) through the utilization of an

intraoral camera (IOC) and text messages (TM), considering their use in the therapeutic process against gingival diseases and in the promotion of oral health, in patients with gingivitis.

The use of images is a strategy that may prove itself useful in overcoming some obstacles, especially where verbal communication is more difficult or less successful. Using an intraoral camera, it is possible to observe the patient's mouth and to show him or her the places of plaque retention – initial stages of inflammation and areas subject to treatment – thereby increasing the patient's level of awareness concerning his or her oral health (Willershausen, Schlösser, & Ernst, 1999). On the other hand, mobile digital environments (mobile phones, tablets, apps, etc.) are inseparable from our lives. The constant presence of these technologies is central to the success they enjoy when used in educational and health projects (mobile learning) (Dunleavy et al., 2019). The use of these means in the area of oral health still has a high growth margin – deployments are relatively recent and the number of projects is still relatively small (Toniazzo, Nodari, Muniz, & Weidlich, 2019).

The contribution of psychological variables is essential in explaining health behaviors and reactions to illness (Conner & Norman, 2005). With this in mind, this work also provides a multidisciplinary contribution, linking fields of knowledge – psychology, education, and oral health – that can be complemented according to the different needs that the treatment and control of periodontal diseases require. The educational area has an important role because the health professional, being more than just a clinician, should understand his or her role as a tutor and manager of behavior. Thus, it is important to use conceptual frameworks for a reasoned reflection on behavior change, learning processes in oral hygiene, and the development of health habits. Through the organization and analysis of specific communication strategies, as well as the use of the technologies mentioned, we sought to find ways to facilitate communication between professionals and patients in order to enhance the changes in health behaviors necessary for more effective oral health.

Socio-cognitive theories for explaining change in health behaviors have served as a framework for various studies attempting to determine the psychological variables that best predict oral hygiene behaviors (Newton & Asimakopoulou, 2015). The Health Action Process Approach (HAPA) is a socio-cognitive model, proposed by R. Schwarzer (2008), which suggests that the initiation and maintenance of health behaviors should be explicitly conceived as a process divided into a motivational phase and a volitional phase. Besides motivation, this model requires self-regulatory processes that have been posited as psychological mechanisms that help to transform intentions into effective actions.

The interest in psychological approaches for behavior change in oral health arises from several studies showing that interventions are more effective when they are based on these types of approaches (Newton & Asimakopoulou, 2015, 2018; Renz et al., 2007). However, this type of intervention is often not present in an oral health consultation (Newton & Asimakopoulou, 2015). On the other hand, research in this area is poor from a methodological point of view, presenting insufficient information for the replication of these interventions. The specific details of the intervention are not always clear; many studies state that their approach was based on socio-cognitive principles but do not mention the active ingredients used in that approach (Newton & Asimakopoulou, 2015). It is hoped that the studies carried out in the scope of this thesis can contribute to sustain different strategies for behavior change in oral health.

The second chapter, Theoretical Framework, describes the main components of oral health and presents health behavior models that explain behavior change, with special emphasis on the HAPA model. It also contextualizes the importance of using digital technologies, especially the use of intraoral cameras and text messages by mobile phone in the service of behavior health change. The chapter concludes with the general objectives of the dissertation.

The five chapters that follow are essentially of an empirical nature; the set of studies is described and articles published are presented. The eight and last chapter provides integrated

discussion of the investigation, where the general results are considered and reflected upon. This chapter also discusses the main limitations of this thesis and suggestions for future investigations. Finally, in the section of final considerations we highlight the most relevant aspects to take from this thesis.

2. THEORETICAL FRAMEWORK

2.1. PERIODONTAL DISEASES

Oral health is essential for general health, well-being, and quality of life. According to the International Dental Federation (FDI, 2019), oral health "is multifaceted and includes the ability to speak, smile, smell, taste, touch, chew, swallow, and transmit countless emotions through facial expressions with confidence and without pain or discomfort, as well as without diseases of the craniofacial complex. The impact of oral diseases on people's daily lives is subtle but real – they make their influence felt in our most basic needs, altering social roles, being reflected in the physiological, social, and psychological attributes essential for life" (p.1).

The prevalence and recurrence of oral diseases in the lives of individuals are considered a silent epidemic (Benjamin, 2010), since dental caries and periodontal diseases (gingivitis and periodontitis) are the most common non-communicable diseases worldwide (Calado, Ferreira, Nogueira, & Meco, 2017; Frencken et al., 2017; Jepsen et al., 2017). The enormous prevalence of periodontal diseases worldwide has multiple concerns: the number of individuals affected, the impact on quality of life, the financial pressure on health services, and other implications for economic and social impact (Tonetti, Jepsen, Jin, & Otomo-Corgel, 2017).

According with Lang & Bartold (2018): "a definition of periodontal health would be a state free from inflammatory periodontal disease. This, in turn, means that absence of inflammation associated with gingivitis or periodontitis, as assessed clinically, is a prerequisite for defining periodontal health" (p. S9). Current evidence suggests that periodontitis is associated with the main chronic inflammatory diseases: cardiovascular diseases, type II diabetes mellitus, rheumatoid arthritis, chronic kidney disease, obesity, erectile dysfunction, and chronic obstructive pulmonary disease (Bui et al., 2019; Jin et al., 2016; Linden et al., 2013; Nazir, 2017). Periodontitis is thought to increase the risk of cardiovascular disease by 19%, and this increase in relative risk can reach 44% among individuals aged 65 and over

(Meurman, Sanz, & Janket, 2004). Individuals who suffer from type II diabetes mellitus have a risk of mortality 3.2 times higher with uncontrolled periodontitis, compared to those without periodontitis or with mild periodontitis (Linden et al., 2013). Periodontal diseases have a positive association with erectile dysfunction (Kellesarian et al., 2018), Alzheimer's disease (Díaz-Zúniga et al., 2019; Ide et al., 2016), and oncological diseases (Söder, Yakob, Meurman, Andersson, & Söder, 2012).

Data on the prevalence of periodontal diseases are dispersed and present multiple methodological inconsistencies. It is therefore difficult to assess the prevalence of these diseases and specially to make comparisons between studies. These inconsistencies include the use of different periodontium examination protocols, the use of different periodontal indexes and materials (periodontal probes), the lack or insufficient calibration of the examiners, and the subjectivity inherent in the reports of different clinical situations of periodontal disease when based on self-reporting (Holtfreter, Schützhold, & Kocher, 2014). The European Federation of Periodontology (EFP) says that it is not possible to guarantee that there have been improvements in the prevalence of periodontal diseases (Frencken et al., 2017; Jepsen et al., 2017). Furthermore, with the increase in the world population and with the increase in longevity of tooth retention, periodontal pathologies are becoming more and more of a global problem. According to data from the Global Burden of Disease Study (GBD, 2016), the number of people affected by periodontal problems increased by 25.4% between 2005 and 2015. More recent data show that diseases of the periodontium affect more than 50% of the world population (Jepsen et al., 2017). Though under-recognized, periodontitis is the 6th most prevalent global disease, affecting 743 million people worldwide (Kassebaum et al., 2014), representing the main cause of tooth loss in adults (Frencken et al., 2017). In Portugal, more than 60% of the adult population suffers from some type of periodontal inflammation (DGS, 2015).

The term “periodontal disease” usually refers to the two most common gum diseases, gingivitis and periodontitis (Chapple et al., 2018). In this thesis we will focus on the importance of controlling gingivitis as a fundamental condition for maintaining oral health. Gingival health is currently defined as gingiva without loss of insertion, without radiographic bone loss, where a probing depth of up to 3 mm produces bleeding levels less than 10% (Lang & Bartold, 2018).

Gingival inflammation is clearly a risk factor for individuals' oral health. For Chapple et al. (2015) “It is widely reported that mechanical plaque control is the mainstay of primary prevention of gingivitis and managing gingivitis as a primary preventive strategy for periodontitis” (p. S76). According with Lang, Schätzle, & Löe (2009) ‘‘Teeth always surrounded by healthy or slightly inflamed gingiva had an 8.4 times lower risk of being lost as compared with teeth surrounded by an inflamed gingiva that occasionally bled on probing, and a 45.8 times lower risk than teeth that were always surrounded by an inflamed gingiva that bled on probing. Teeth with slightly inflamed gingiva had a 5.4 times lower risk of tooth loss than those that showed bleeding on probing.” (p.8)

As an inflammatory lesion of the gingival tissues, gingivitis is reversible, but if left unchecked, it may progress into periodontitis (Chapple et al., 2018). According to Trombelli, Farina, Silva, & Tatakis (2018), gingivitis induced by the accumulation of biofilm (the type specifically of interest in this thesis) can be defined as: “Gingivitis is generally regarded as a site-specific inflammatory condition initiated by dental biofilm accumulation and characterized by gingival redness and edema and the absence of periodontal attachment loss.” (p. s46).

It is widely accepted that certain microorganisms and their by-products being present in the bacterial plaque are fundamental factors for periodontal inflammation (Pihlstrom, 2014). All surfaces of the mouth are covered with bacterial biofilm. This biofilm is called dental plaque when it accumulates on dental surfaces. In the 1960s, Löe and his team published a study that changed the understanding of the aetiology of gingivitis. This study demonstrated

for the first time that the bacterial deposits that accumulate on the teeth are responsible for the appearance of gingivitis. Since then, plaque control has been considered a fundamental strategy in preventing periodontal diseases and maintaining a healthy periodontium (Löe, Theilade, & Jensen, 1965).

The understanding of periodontal diseases has thus changed over time. Today these cannot be considered simple bacterial infections, but complex multifactorial diseases involving complex interaction between the subgingival microbiota, the host's immune/inflammatory responses, and environmental causes (Lang & Bartold, 2018). This balance between biofilm and host response is the agreed-upon basis for new therapeutic intervention strategies for periodontal diseases and promotion of periodontal health (Sanz et al., 2017). Chapple (2009) notes that gingivitis can be defined as an unresolved inflammation that is ineffective in eliminating the initial pathogens, and Van Dyke (2008) states that periodontitis "is an inflammatory condition initiated by the oral microbial biofilm" (p.1601). That is why we have previously stated that the approach used in the prevention, treatment, and maintenance strategies for periodontal health is increasingly based on the disruption of biofilm, rather than the total removal of plaque. There is also more and more focus on host response factors: "The most successful treatments need to attack the integrity of the periodontal biofilm and suppress the destructive host inflammatory response" (Berezow & Darveau, 2011, p.45).

The inflammation treatment model is nowadays understood as opposed to the infection model (Bartold & Van Dyke, 2017). Biofilm is therefore the main target of control in the prevention and treatment of periodontal diseases. Biofilms are microbial communities that have significant differences in their behavior. For example, bacteria can communicate with each other through quorum sensing, can exchange nutrients, and can help protect each other. These biofilms, or biological mega-structures, may be chemically resistant, but they are physically vulnerable. More effective and less invasive approaches are a priority in periodontal therapy,

so the disruption of biofilm is promoted (Kilian et al., 2016). What's most interesting is that betting on these strategies, which are less invasive from a clinical point of view, has been a reality in the literature since the 1980s: "In order to promote less accumulation of biofilm, the intentional removal of cementum during root planning to eliminate endotoxins from the exposed root is not justified" (Nakib, Bissada, Simmelink, & Goldstine, 1982, p. 376). Traditionally scaling and root planning have been the basis for periodontal treatment to reduce the ability of harmful bacteria to adhere to the periodontium. However, what seems to be most effective for the treatment is the disruption of the biofilm, keeping it in its symbiotic form as much as possible (Bartold & Van Dyke, 2017).

2.2. CONTROL AND TREATMENT

The primary treatment for patients with plaque-induced gingivitis is thus based on the disruption of the etiological factors in order to reduce or eliminate inflammation and subsequently allow the gingival tissues to remain healthy through biofilm controlling behaviors. Although there are forms of gingivitis not induced by plaque, the severity of clinical manifestations always depends on the accumulation of biofilm (Chapple et al., 2018).

Control of bacterial biofilm is mainly accomplished through daily oral hygiene and evaluated in regular consultations by the dentist or dental hygienist (Jepsen, et al., 2017). The addition of topical chemical agents, in the form of toothpastes or mouthwashes to treat gingivitis, is a form of treatment that can also be used as an adjunct to mechanical action (Luís, 2011).

Natural physiological forces (suction, swallowing, muscle activity, etc.) and masticatory patterns can influence the growth of biofilm in human teeth. These physiological forms of biofilm self-control are, however, limited to regions with lower risk of periodontal diseases, such as incisal and occlusal surfaces. The movement of the tongue, especially at the

level of its lateral surfaces, also plays an important role in the control of biofilm on the lingual surfaces and, to a lesser extent, on the buccal areas of the posterior teeth. The cheek mucosa also helps to limit the growth of plaque on the buccal surfaces of posterior teeth (van der Bilt, Engelen, Pereira, van der Glas, & Abbink, 2006). Saliva has a limited effect on controlling food debris in the interdental spaces and occlusal surfaces and is not effective in removing plaque. As these natural cleaning mechanisms are insufficient for preventing inflammation, periodontal health is mainly influenced by the quality and effectiveness of mechanical control of plaque undertaken by the patient (Chapple et al., 2015; Dodds & Johnson, 1993).

It is therefore clear today that toothbrushing and other mechanical removal procedures can control plaque to the point where it is not harmful to the periodontium, as long as their use is technically effective and performed with appropriate intervals and durations (Tonetti et al., 2015). Brushing your teeth, when performed correctly, removes supragingival plaque from dental surfaces. The frequency with which the teeth should be brushed and the amount of plaque that must be removed to prevent periodontal disease have not been exactly determined. However, as the brushes do not reach all areas of the teeth, namely the interproximal areas, brushing alone is not enough to control the biofilm in its entirety. It is therefore necessary to use additional devices to control the biofilm that accumulates in areas not accessible to the toothbrush: interdental brushes, dental floss, wooden toothpicks, rubber/silicone toothpicks, and irrigators, among others (He, Qu, Chang, & Wang, 2018; Kotsakis et al., 2018; Worthington et al., 2019).

General recommendations for daily plaque control include daily toothbrushing with fluoride toothpaste (Jepsen et al., 2017) and using one of the aforementioned accessories once a day to control the biofilm in the interdental areas (i.e. the space that lies between teeth). However, in patients with more serious conditions, it will certainly take more time, more techniques, and more materials (Sanz et al., 2015).

Since most oral hygiene devices do not sufficiently reach all niches and angles of the teeth, interproximal regions are often missed. The challenge is to efficiently control dental plaque from the interproximal spaces.

2.3. CONTROL OF INTERPROXIMAL DENTAL BIOFILMS

The means of controlling interproximal plaque are thus very important for achieving good gingival health. Based on the results of the latest systematic reviews and review articles, interproximal brushes appear to offer the best benefit for controlling biofilm in these areas (Worthington et al., 2019). The traditional use of dental floss does not seem to achieve similar results, especially when used by the patient. Clinical data demonstrate that the levels of gingival bleeding and plaque are lower in patients using interproximal brushes when compared to flossing, with the added benefit of these being easier to use and more easily accepted by patients (Sälzer, Slot, Van der Weijden, & Dorfer, 2015).

However, there is currently no effective means of removing interproximal plaque that is effective for all patients. The ultimate choice of which means to recommend to the patient is influenced by the ease of use and the size of the interproximal spaces, plus the willingness, dexterity, and motivation of the patient (Kotsakis et al., 2018; Worthington et al., 2019).

Despite the current tendency to point to the interproximal brush as the most effective means of controlling interproximal biofilm, some authors call attention to the lack of well-designed studies capable of understanding the clinical value of flossing, arguing that it may be premature to stop relying on the use of dental floss based only on these results (Sambunjak et al., 2011; Vernon, Da Silva, & Seacat, 2017). In addition, current evidence continues to demonstrate that toothbrushing accompanied with flossing has a significant (albeit small) effect on gingivitis control when compared to toothbrushing alone (Kotsakis et al., 2018; Sälzer et al., 2015; Worthington et al., 2019).

In view of this evidence, many researchers argue that it is advisable that oral health professionals choose the best methods according to their patients' skill levels and preferences, not based only on results of comparative effectiveness (Sälzer et al., 2015; Vernon et al., 2017).

The fact that an individual uses dental floss or a toothbrush does not mean that its use is clinically effective. It is essential that the technique used is the most correct. For example, according to Imai and MacDonald (2012), the use of floss *per se* is not a sufficient factor for effective plaque removal. Technical details that will define the effectiveness of using the dental floss include the curvature around the tooth, the length of floss spaced between the fingers, the way of inserting the floss, and the patient's dexterity. This means that the frequency of use does not directly relate to the effectiveness of the technique.

Floss holders have long been used in an attempt to facilitate the use of dental floss. Several studies exist on the benefits that these materials have for patients without the necessary dexterity and also as a strategy to make it easier for patients to more firmly establish their habits of flossing (Blanck, Mankodi, Wesley, Tasket, & Nelson, 2007; Kleber & Putt, 1990). When compared with traditional dental floss, the results usually show similar levels of effectiveness between the two, but with better rates of motivation and satisfaction for the floss holder, this being a way to facilitate use and increase curiosity, improving control over technique and thus promoting higher frequency of flossing (Blank et al., 2007; Kleber & Putt, 1990). Although there are no recent studies, floss holders have continued to be invented and innovated. One of the most recent floss holders to be invented was the GumChucks™, a floss system similar to miniature Nunchaku (the martial arts weapon), which have disposable tips connected by a piece of dental floss. The two-loop system apparently increases dexterity and control, allowing "C" shaped floss to wrap around the tooth, as recommended for effective use (Lin, Tseng, Kritz-Silverstein, Silva, & Tran, 2017).

The various studies done on behaviors related to the removal and control of biofilm show that there is a correlation between effective oral hygiene and a stable gingival situation, but they also show that there is great difficulty in maintaining these behaviors over time, in perceiving their importance and the need to employ specific techniques in order to be effective (Jepsen et al., 2017; Tonetti et al., 2015). Thus, oral hygiene behaviors are vital to the individual's oral health, and although this fact is widely recognized, these behaviors are not always effective (Jepsen et al., 2017). They will only be so if there is an individual, daily plan for the control of biofilm, a plan made in collaboration with the patient (Tonetti et al., 2015).

2.4. BEHAVIOR AND CONTROL OF PERIODONTAL DISEASES

Periodontal therapy has evolved considerably in recent years. The control of biofilm and the resulting symbiotic balance of the oral cavity is the factor that most influences the stability and longevity of periodontal therapies, bone and tissue grafts, implants, and prosthetic rehabilitation, among others (Sanz et al., 2017). However, it is also important to recognize the influence of several other factors, including genetics, smoking, stress, diabetes, nutrition, obesity, personality, and social factors in the appearance of periodontal pathologies (Sanz et al., 2017).

Understanding patients and helping them to manage their behaviors are elementary factors for periodontal health. These strategies should not be based on professionals' common sense – the idea that human behavior is so obvious that it requires little or no scientific knowledge to intervene. Using only common sense in addressing relationships with patients is deliberately anti-intellectual and unscientific (Kelly & Barker, 2016). Health habits are often difficult to start and maintain, even though patients recognize their importance (Kelly & Barker, 2016; Marteau, Hollands, & Fletcher, 2012; Strack & Deutsch, 2004). Indeed, it is essential that health professionals are prepared with the proper communication skills to change

behaviors for controlling and preventing oral diseases, maintaining the indicated treatments and thereby promoting patients' health (Suvan et al., 2010; Tonetti et al., 2015).

Recent systematic reviews show that individualized behavior change strategies, supported by psychological approaches (planning, reinforcement, goal setting, self-monitoring, and feedback), can improve professionals' performance in the management of patients' oral hygiene behaviors (Newton & Asimakopoulou 2015, 2018; Werner et al., 2016). Specific professional support, based on patients' individual knowledge and the creation of long-term self-regulatory strategies, which help them to understand and manage their oral hygiene behavior, proved to be effective strategies in the prevention and control of periodontal diseases (Webb & Sheeran, 2006; Werner et al., 2016).

Strategies based on the transmission of information only, without adapting that information to the reality and beliefs of patients, have been revealed in several studies; it is a weak strategy in changing health behaviors. However, it is still the strategy most used by dentists and dental hygienists (Newton & Asimakopoulou, 2015; Ramseier & Suvan, 2010). Knowledge of the mechanisms underlying behavior change and maintenance is fundamental knowledge for the treatment and prevention of periodontal diseases (Järvinen et al., 2018).

2.5. THE CHALLENGE OF BEHAVIOR CHANGES IN THE TREATMENT OF PERIODONTAL DISEASES

In view of the scenario outlined above, solutions for the prevention and treatment of periodontal diseases are generally achieved through effective control of biofilm which depends on set of attitudes and behaviors that must be acquired and maintained by patients (Ramseier & Suvan, 2010).

Many of individuals' daily activities address self-care. Showering and brushing teeth are common examples of behaviors that are often self-initiated, self-maintained, and self-

monitored. In these examples it is the socialization and educational process that most contributes to the habits of one's daily life. In fact, the standardization of toothbrushing makes it a daily activity for most cultures, part of the primary processes of socialization (Ramseier & Suvan, 2010).

Habits can be considered automatic responses, guided in their performance by contextual aspects (environment, previous actions). They are formed through processes where repetition is responsible for the progressive attunement of the cognitive processors of procedural memory, the memory system that supports conscious control of action (Gardner, 2015; Gollwitzer & Sheeran, 2006; Graybiel & Grafton, 2015; Orbell & Verplanken, 2010). Habits are regulated by processes usually not raised to conscious attention, thereby obtained with a minimum of cognitive effort, awareness, control, or intention. When frequent behavior becomes habitual, the initiation of that behavior is transferred from conscious motivational processes to another area of behavior, guided by impulses sensitive to the context of the behavior. In that way, behaviors that have developed a high level of habit strength are endorsed with slight conscious deliberation and need for self-regulation (Wood & Neal, 2007). The regulation of action is thereby detached from motivational or volitional control. When an associated context is encountered, it spontaneously triggers the behavior and the alternative behavioral responses become less cognitively accessible (Graybiel & Grafton, 2015).

Once formed, habits become automatic and difficult to change (Graybiel & Grafton, 2015; Kelly & Barker, 2016). Changing behaviors, requires effort, as conscious actions will be needed to change (often unconscious) habits and daily comfort patterns. Simply being motivated or having knowledge does not suffice to change the lifestyle or health behavior (Godinho, Alvarez, Lima, & Schwarzer, 2014). When a dental hygienist or dentist suggests preventive activities, such as flossing, without considering the patient's personal habits and cultural contexts, it tends to be ineffective. This fact should prompt reflection on the role that

oral health professionals' more conservative communication strategies have – or fail to have – on changing behaviors (Wilder, 2013).

In an older study by Weinstein, Getz and Milgrom (1983), it was possible to verify that when oral health professionals recognized and understood the existing oral hygiene methods practiced by their patients, this contributed in a more positive way to the necessary changes, as opposed to more directive strategies in which professionals suggested changing existing behaviors and taught new oral hygiene methods based only on their knowledge as technicians. Behaviors occur in individualized social and personal environments and efforts to change them must include the social, personal, and economic factors that directly affect people's health, regardless of the individual judgment that the professional may make about the patient's conduct (Ramseier & Suvan, 2010). The evidence has shown that chronic diseases, including periodontal diseases, are difficult to manage and specific factors are envolved (Zwar et al., 2006). Getting sick and being ill implies a psychological adjustment to a new situation. The way in which this process takes place depends on the subject's personality characteristics and adaptation style, on the nature of the physical illness in question, on its meaning for the subject at that point in his or her existential trajectory, and on the characteristics of family and social support that the subject has available (Teixeira, 1997). Mounting evidence shows that behavioral management is fundamental for the control of these diseases (Newton & Asimakopoulou, 2018). Prioritizing clinical activities or transmitting information and knowledge to patients is something that has been shown to be ineffective in changing behaviors, creating a reductionist perspective on oral health without an active role for the patient (Järvinen et al., 2018; Newton & Asimakopoulou, 2015; Ramseier & Suvan, 2010; Renz et al., 2007).

There is a maxim for health professionals that must not be forgotten: "serving is a relationship between equals". However, sometimes the attitude of health professionals is based

on the idea of "We are not equals – We know what is best for you" (Ramseier & Suvan, 2010). Depending on the nature of the problem, oral health professionals may decrease the self-esteem of their patients while increasing confusion about their real role in the disease and in the healing or health control process. The relationship of trust is fundamental for success in periodontal treatments (Cafiero, 2014; Newton & Asimakopoulou, 2015).

For Peduzzi (2000), a given intervention process does not occur in isolation, but is the result of a network of procedures that sustain each other. In this network, there is a chain of work processes – distinct and complementary due to the special connection of their elements – that is integrated through the relationships established by the objectives to be achieved. This occurs in the domain of health, in which different professional areas, each carrying out its own work process, find the point of convergence in the patient's health needs. The importance of psychology in the field of oral health is such an example. Psychology has several points in common with oral health: sharing new dynamics and knowledge, identifying barriers to adherence to health-promoting behaviors, evaluating and studying beliefs and attitudes, conceptualizing models with which to represent health behaviors and the process of adapting to therapies for acute and/or chronic situations (Ribeiro, 2011).

2.6. MODELS OF HEALTH BEHAVIOR CHANGE

Over the years, various models have been proposed in order to identify the variables that are involved in the process of behavior change in the health field, as well as the set of predictors that affect health behaviors directly or indirectly (Abraham & Sheeran, 2000; Braarud & Olsen, 2007).

As previously mentioned, it is not easy to change behaviors, but it is possible to change behaviors not beneficial to health through self-regulation of efforts to change and through the adoption of healthier, more preventive behaviors. This change, however, involves a variety of

social, emotional, and cognitive factors. It is therefore essential to identify the set of factors that allow us to predict and promote this change (Schwarzer, 2008).

Models from social, clinical, and health psychology have been developed to describe the socio-cognitive factors responsible for the development of behaviors that influence health (Conner & Norman, 2005). In addition to attitudes, all of these models include social and/or cognitive constructs, some of which are considered proximal determinants of behavior (e.g., intention). The focus on social and cognitive determinants of health behaviors is relevant from the point of view of public health, considering that these are the determinants potentially subject to modification. Socio-cognitive models offer a theoretical basis for changing health behaviors, providing a framework for the development of strategies for health communication (Conner & Norman, 2005; Newton & Asimakopoulou, 2018).

Given the multiplicity of models and theories of behavior change, Armitage and Conner (2000) proposed organizing the socio-cognitive models as continuous models and models by stages, the former being divided into motivational models and models of behavioral action.

Motivational models focus on the pros and cons of the outcome of a decision; these are suited for predicting isolated behaviors over time, such as vaccination. They were designed with the aim of identifying the variables that support certain health-related decisions, and to predict behavior. These models contribute to the understanding of how motivation turns into action. For some authors, however, these models provide an incomplete description of health behaviors (Armitage & Conner, 2000). The motivational models in which the Health Belief Model (HMB) is integrated, the Theory of Planned Behavior (TPB), the Social Cognitive Theory (SCT), the Theory of Reasoned Action (TRA) and Protection Motivation Theory (PMT), among others, have the common characteristic of studying the determinants of motivation for change, considering motivation as sufficient to trigger a behavioral response (Armitage & Conner, 2000).

The majority of these models therefore assume that the intention to change is the best predictor of change (Sheeran, 2002). An intention is an objective, purpose, or focus, something that is intended to be accomplished, regardless of whether we achieve it. Intention proved to be a close predictor of behavior change (Sheeran, 2002). However, behavior is often at variance with existing intentions, which may be due to the appearance of unforeseen obstacles (Sheeran & Webb, 2016).

For this reason, a set of criticisms was aimed at these models. Armitage and Conner (2000) criticized the fact that these models do not take into consideration the interaction that may exist between the variables that predict behaviors, thus not explaining how this interaction can influence the action process. On the other hand, by better predicting variation in intention than in behavior itself, they leave out the volitional processes that help translate intentions into action (Schwarzer, 2008). Furthermore, most models do not contemplate a post-intentional phase, and what happens between intention and behavior constitutes a new black box, called the intention-behavior gap, which remains to be explained. (Sheeran & Webb, 2016; Webb & Sheeran, 2006).

As a way of addressing these criticisms of the motivational models, newer models emerged that integrate volitional variables (models of behavioral action) and that seek above all to understand how intentions can be translated into behaviors. Examples of these models are Gollwitzer's Implementation Intentions theory and Bagozzi's Goal theory (Armitage & Conner, 2000). In turn, behavioral action models are characterized by the search for information related to the realization of behavior as soon as it is mentally defined. They describe the factors that can influence behavior change and provide additional variables that allow the intention-behavior relationship to be mediated (Armitage & Conner, 2000). These models are effective in predicting behaviors, but they are less effective in explaining change as a process. In other words, they are models of behavior rather than models of behavioral change,

given that they are “static” models (for example, they do not include recursive or “feedback” processes). They assume additive processes in behavioral change without considering the possibility of there being qualitative differences in the importance of certain factors, to the detriment of others, at a certain stage of the change process (Armitage & Conner, 2000).

Models by stages represent an attempt to fill these gaps, conceptualizing the behavior change process as involving various phases or stages that individuals have to go through. Different cognitive processes occur in these stages; consequently, the variables that favour transition to the next stage are different at each of these points (Schwarzer, 2008; Schüz, Sniehotta, Mallach, Wiedemann, & Schwarzer, 2009; Weinstein, Rothman, & Sutton, 1998). Conceiving behavioral change in stages allows us to understand that returning to a previous phase does not necessarily imply a complete restart. The characteristic recursive patterns of these models represent the way in which most patients are involved in change processes. This involvement may be continuous or not, and individuals can start, abandon, or resume behaviors at any time. Individuals are classified in terms of their progress across the stages of readiness for change, in conjunction with other dimensions. This fact must be pondered when we want to tailor educational messages to the needs of the individual (Kraft & Yardley, 2009; Schwarzer, 2008). However, these models by stage show some limitations and are not free from criticism. For example, in the case of the Transtheoretical Model (Prochaska & DiClemente, 1983), using merely temporal indicators is a somewhat arbitrary way of classifying individuals in the phases of behavior change (pre-contemplation, contemplation, preparation) (Schwarzer et al., 2003; Sutton, 2008). A model that responds to some of these criticisms is the Health Action Process Approach (HAPA) proposed by R. Schwarzer, 2008 with the purpose of articulating these two perspectives (Figure 1).

2.7. THE HEALTH ACTION PROCESS APPROACH

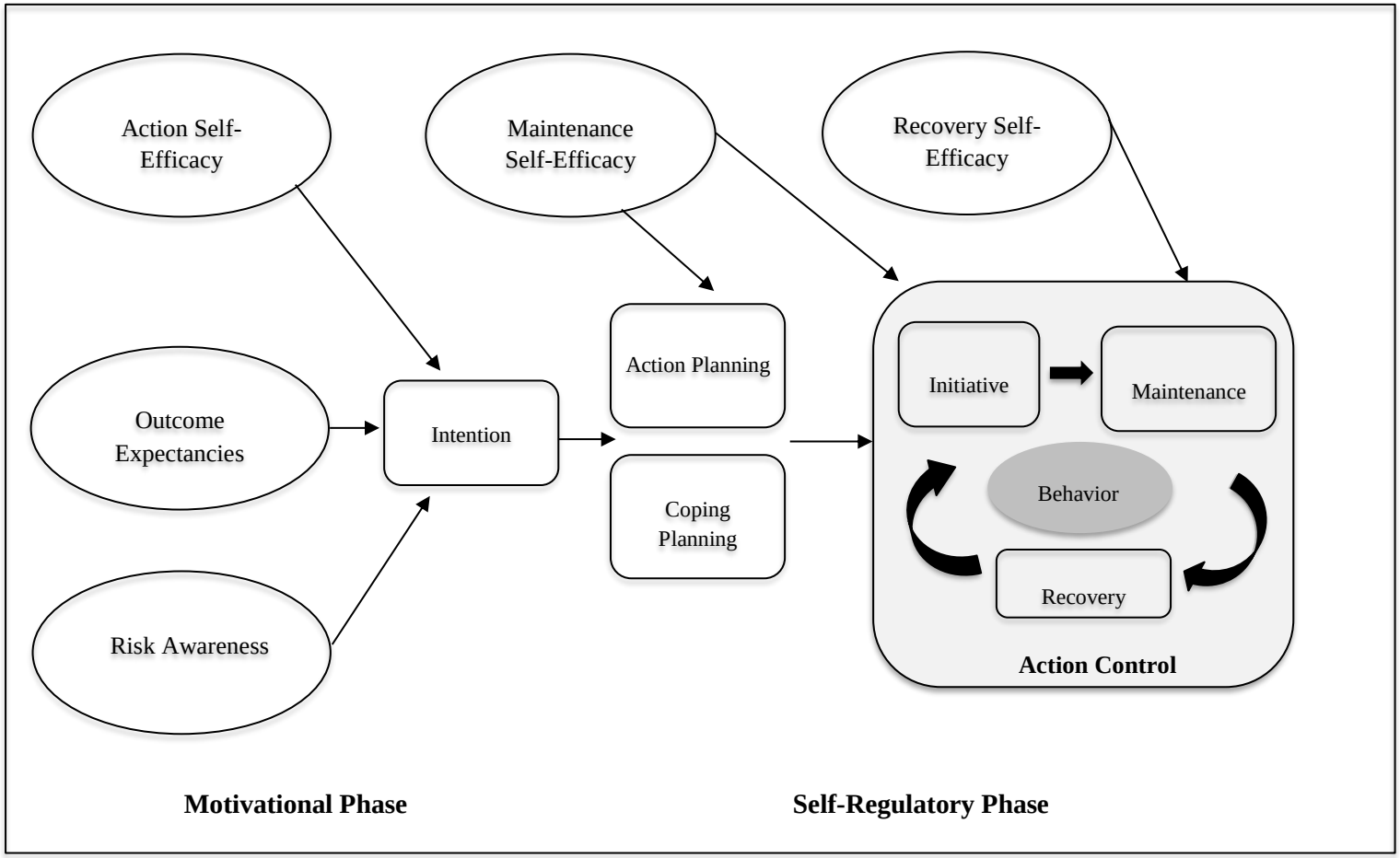

Figure 1. The Health Action Process Approach (HAPA). Adapted from Schwarzer, 2008.

This model suggests that behavioral change is a process composed of a motivational phase (which precedes the establishment of an intention to change) and a volitional phase consisting of two stages: one where the individual develops action strategies and the other where intention moves to action, encompassing the initiation and maintenance of behavior (Schwarzer, 2008) (Figure 1).

The HAPA model is one of the models that explicitly include the possibility of post-intentional factors that explain and can alter the relationship between the intention to perform a certain behavior and the realization of that behavior. Health approaches based on this model suggest the distinction between a pre-intention phase that generates an intention and a volitional, post-intentional phase that will generate the effective means of change. Across these two distinct phases, different sociocognitive patterns may emerge as predictors of behavior (Schwarzer, 2008). In the initial motivational phase, the individual develops the intention to act. Risk perception is sometimes a "first step" to change (e.g. *"The way I brush my teeth can increase my risk of gingivitis, right?"*). However, in most cases, this is not enough for behavioral change (Craciun, Schulz, Lippke, & Schwarzer, 2012), since knowledge of the risks involved does not, as a rule, change behaviors. The perception of risk is therefore considered a distal predictor in the motivational phase, in the sense that it can stimulate thoughts about change, but it is not enough for the formation of intention (Schwarzer, 2008). However, this information creates different levels of perception and can help to prepare future attitudes, as it is responsible for raising some thoughts about consequences of the behavior.

Expectations of positive results (Ex. *"If I brush my teeth and use dental floss, I will have healthy gums"*) are seen as a close and important factor for the initial phase of motivation, when an individual reflects on the pros and cons resulting from certain behavior. In addition to these factors, the ability we have to "believe" that we are able to change, even in the face of some obstacles to initiate action, is essential for the realization of a certain behavior (e.g.: *"I*

am capable of brushing my teeth twice a day, despite having little time"). These are optimistic beliefs about the capacity for involvement in what is necessary for change. Self-efficacy of action in conjunction with positive expectations for the consequences of a given behavior are proposed as the main determinants of the intention to change (Caudroit, Stephan, & Scanff, 2011; Schwarzer, 2008).

These self-efficacy beliefs also influence the cognitive construction of plans for action, for example through the visualization of scenarios that can help the individual in achieving their goals. After the individual develops the necessary motivation to change the behavior, that intention must give rise to a set of internal rules that will be transformed into concrete actions. Based on motivation, the change will involve the ability to self-regulate through different strategies. Thus, the post-intentional phase involves factors represented by volitional constructs, such as other beliefs about self-efficacy and planning (Schwarzer, 2008). In addition, in order to have an impact on oral health, the initiated actions must be maintained over time, which raises some challenges.

Intentions can be realized when the individual is able to define his or her goal and anticipate how he or she will overcome the barriers that may arise. If the motivation phase is described as what people choose to do, the subsequent phase of volitional action is described as what they actively try to do (Schwarzer, 2008). If someone wants to start using dental floss, planning how to do it, what material to buy, and when to do it will help ensure it is actually used.

Some individuals choose more challenging goals and focus more on opportunities than obstacles. This is associated with higher levels of maintenance and recovery self-efficacy – the belief that one will be able to maintain the behavior, even in the face of some obstacles, or to recover from a period of inaction.

Maintenance self-efficacy is important for planning and initiating behavior, especially when there are difficulties, thus helping to maintain elevated intention, since it permits the regulation of effort and persistence in the face of difficulties. In turn, recovery self-efficacy refers to the individual's belief that he or she is able to re-initiate the behavior in the event of a lapse (Schwarzer, 2008).

Gollwitzer & Sheeran's meta-analysis (2006) summarized that certain volitional determinants of health behaviors, such as planning, can better explain the variability of behaviors, being more proximal factors for their change. Some studies have documented positive results of interventions based on planning as a way to increase adherence and maintenance of behavior (Hagger & Luszczynska, 2014; Schüz et al., 2009).

For Schwarzer (2008), action planning concerns the development of a detailed plan that includes where, when, and how the desired behavior will be carried out. Action planning often defines the actual implementation of the action. An example would be *"To be able to brush my teeth twice a day, I will take the toothbrush to work and start brushing my teeth every day after lunch"*. Planning also involves another type of anticipation, called coping planning. It is an important psychological process, as it involves the development of strategies to be used when the individual faces barriers. Coping planning is considered a self-regulatory strategy that prepares the individual to deal with obstacles that may arise in the future.

There are many attempts to change behaviors that fail in the first weeks of implementation, before they have taken root as habits. Action control therefore contributes to the volitional phase, being seen as the most proximal predictor of behavior, involving awareness of the behavioral patterns to be achieved, self-monitoring of behavior, and making efforts to achieve the respective behavioral patterns. (Sniehotta, Scholz, & Schwarzer, 2005). Awareness of standards refers to evocation of the intended criteria. In other words, the individual will have to recall the objectives outlined in memory (ex: *"I want to use dental floss*

once a day"). Self-monitoring, in addition to informing the patient about his past and current behavior (ex: *"I haven't used dental floss for 5 days"*), also has the function of comparing it with the standards previously defined. Lack of self-monitoring can lead to failure in the self-regulatory process. Finally, the self-regulatory effort is applied when divergences are found between the actual behaviors and the patterns previously outlined (Sniehotta et al., 2005).

There is a variety of evidence supporting the usefulness or explanatory value of this model for different health behaviors, such as breast cancer screening (Luszczynska & Schwarzer, 2003), healthy eating, (Renner et al., 2008) reduction in smoking habits (Schwarzer et al., 2003), physical exercise (Barg et al., 2012), and use of sunscreen (Craciun et al., 2012), among others.

There have already been a set of studies in the field of oral health that used the HAPA model. In Schwarzer et al. (2007) self-efficacy and planning proved to be proximal predictors of the use of dental floss, while risk perception proved to be a distal factor for altering this behavior. The authors concluded that, in addition to intention, other types of variables, such as self-regulatory variables, should be used to help predict this health behavior. Another study showed that an important part of the variance in oral hygiene behavior is related to motivational factors (Schüz, Sniehotta, & Schwarzer, 2007). Specifically, it was found that when using dental floss, the intervention groups in which the motivational variables of the HAPA model described above were manipulated, they tended to obtain better results than the control groups. However, dental floss rates returned to their initial values after the intervention was completed, so it is not possible to translate good intentions into oral self-care behaviors that are sustainable in the long term (Schüz et al., 2007). These authors also showed that the use of dental calendars (where the participant was asked to indicate the use of dental floss daily) was an effective self-monitoring tool. However, the use of this instrument did not affect the formation of the

intention – that is, they had no motivational effect, and only the participants with a previous intention benefited from interventions focused on self-regulation.

In fact, improved levels of planning, action control, and oral hygiene have been found after interventions to encourage self-regulation in patients seeking oral health services (Zhou, Sun, Knoll, Hamilton, & Schwarzer, 2015). Additionally, the use of planning as a mediator between experimental conditions and levels of oral hygiene, with self-efficacy and action control as moderators, helped to explain the mechanisms underlying change. It was possible to conclude that self-efficacy, planning, and action control were involved in improving oral hygiene habits. Hamilton et al. (2017) reinforced the importance of self-regulatory components for changing oral hygiene behaviors, namely planning and self-efficacy. In this study, the effect of intention on behavior was mediated by self-efficacy and planning, with 64% of the variation in flossing being explained by this set of predictors. The role of self-efficacy was also related to the control of biofilm in interproximal spaces. More specifically, a chain of sequential mediation was found to have an indirect effect from self-efficacy and intent to floss (Lhakhang et al., 2016).

A recent systematic review and associated meta-analysis by Scheerman et al. (2016) has provided some data on psychosocial factors related to this model, with action planning, coping planning, intention, and self-efficacy being the predictors most associated with oral hygiene behavior.

Although there is evidence on the importance of psychology in the field of oral health and in the management of patient behavior this area remains mostly unexplored and little-known to professionals in the field. The knowledge to develop structured and long-term changes in oral hygiene behaviors – as well as the capacity to conduct psychological and holistic reading in this vital area – is lacking in the curricula of oral health professionals (Carey, Madill, & Manogue, 2010; Field et al., 2020; Mann, Gordon, & MacLeod, 2009). Some of the

difficulty oral health professionals have in understanding this importance stems from the traditional nature of their training, which makes little room for the scientific components of social and communicational (Field, Cowpe, & Walmsley, 2017; Field et al. 2020).

Although the scientific literature and the recommendations of many academics aim to enhance these components in the academic training of oral health professionals, it is not known to what extent these ideas are really transferred to future professionals (Field, Kavadella, Szep et al., 2017). For example, although we know that the most important risk factor for periodontal disease is the accumulation of biofilm at or below the gingival margin and that the removal and/or control of plaque is essential in the prevention and treatment of periodontal diseases (Tonetti et al., 2015; Tonetti et al., 2017), the emphasis in the treatment of these diseases is located in clinical practices. These are based on biomedical models of learning, where the main therapeutic role is taken by the health professional through his or her instructions and clinical interventions.

One way this attitude is acquired is during the training process, based on the biomedical model that has been privileged in training – it is still in the "*oral health professionals DNA*" transmitted by universities (Mann et al., 2009). This way of being and thinking is conveyed to students from the beginning of their training, often as they copy the behavior of their professors, creating the assumption from an early age that they are more important than the patient and that they are the main part of the solution. The process does not reflect equality between peers (and patients are peers in the process), an important factor in decision-making processes (Batt-Rawden, Chisolm, Anton, & Tabor, 2010; Carey et al., 2010; Pine & McGoldrick, 2000). The interrelation of behavioral sciences and clinical education does not exist or exists very rarely (Field et al., 2017; Field et al., 2020). One example is the Motivational Interviewing (MI), which is actually a method of communication rather than a set of techniques, a facilitative approach that evokes natural changes in the patient's behaviors (Rollnick, Miller, & Butler,

2008). This is the methodology most studied in the area of communication for oral health, but, in practice, it not often used in a conscious and consistent way in the clinical environment (Söderlund, Madson, Rubak, & Nilsen, 2011).

The learning of MI techniques takes place in the early training of psychologists and other behavioral technicians (Rollnick et al., 2008). In these areas, solutions are constructed with and by the patient. In the domain of oral health, methodologies such as the MI, despite being widely disseminated and studied, are not taught until after the basic training of oral health professionals, not treated as part of the core business of the profession of dentist or dental hygienist (Mann et al., 2009; Neville, Zahra, Pilch, Jayawardena, & Waylen, 2019). It is thus an attachment, not a pillar.

If, on one hand, oral health interventions can benefit from the understanding of constructs developed in psychology, changing behavior may be a tussle. According with Gobat et al. (2010) oral health delivery professionals who are skilled enough to help patients understand this struggle are clearly better equipped to help them resolve it, and these same behavioral interventions can be driven by information and communication technologies. The use of technologies such as intraoral cameras or text messages may furnish the clinical practice with other ways of intervening and enhancing treatments in oral health, making the processes of behavioral regulation clearer and easy for professionals.

2.8. COMMUNICATION TECHNOLOGIES AND ORAL HEALTH

Communication with patients during the consultation is inherently problematic. The terminology used is at times incomprehensible, the content of the information is dense, and patients have difficulty in processing the information because they are concerned with a set of situations (in most cases not perceived by professionals) that disturb their concentration (Houts, Doak, Doak, & Loscalzo, 2006).

Information about oral health is widespread in daily life today, via magazines, television, radio, the internet, and dental clinics, among other sources. Initiated in 1995, the National Oral Health Promotion Program (PNPSO) of the Directorate-General for Health (DGS) has shown positive results and effective implementation in the field in reducing levels of caries, but not of periodontal diseases (Calado et al., 2017; Simões et al., 2018). According to data from DGS (2015), despite the improvement in dental caries, more than 60% of Portuguese have unresolved periodontal problems.

As described earlier, a patient's oral health depends on a number of variables. Social and psychological factors, such as confidence building and effective communication, are essential components for success (Ramseier & Suvan, 2010). The lack of confidence in professionals may simply be due to insufficient exchange of information. Some authors emphasize the importance of working with the patient's perceptions about the reality of the disease, the proposed treatment, their expectations, and the severity of the dangers involved (Weinstein et al., 1983) in order to create interventions that are more effective, with long-term results.

Between our desires and abilities, between what we want to do and what we really do, life is full of discrepancies. This gap, between the desire to act and actually doing so, is what some authors call “performance discrepancy” (Weinstein et al., 1983). We know that there is a gap between intention and behavior; the current evidence suggests that we manage to translate our intentions into action about 50% of the time (Sniehotta et al., 2005). A clear analysis of the problems people can find when trying to turn their intentions into actions suggests that there are three tasks that should be carried out to increase the success rate of turning intention into action: patients need to be helped to commence, complete, and to maintain the objectives they set out to achieve (Newton & Asimakopoulou, 2015; Sheeran, 2002).

Many health professionals remain unaware of the importance of using information communication technologies in health (eHealth). However, these are already used for a wide variety of purposes, and in several different ways, to motivate patients, to educate them, ultimately to improve their health (Godinho, Araújo, & Alvarez, 2016). Although not many oral health studies exist that explore these tools, the use of technologies such as smart power toothbrushes, intraoral cameras, applications for mobile phones, text messages (TM), and games have started to be researched (Alkiş & Findik-Coşkunçay, 2018; Jadhav et al., 2016; Perri-Moore et al., 2016; Toniazzo et al., 2019). However, there is still little evidence about the success of these technologies in changing oral health behaviors, and further studies are needed in this regard (Toniazzo et al., 2019). There are reasons to believe that the results available justify a more careful look at the use of these strategies as a way to help positively influence the health of patients (Granja, Janssen, & Johansen, 2018).

One of the biggest challenges in using these technologies is their rapid evolution, which is constantly changing between different user demographics (Granja et al., 2018). In this context, the use of intraoral cameras and interventions based on "mobile learning" with the use of TM may offer important approaches. Providing multiple communication techniques, these different approaches can help oral health care professionals positively distinguish themselves in their role in behavior change.

2.9. INTRAORAL CAMERAS

Health professionals now have at their disposal, in a relatively accessible way, new methods and technologies (intraoral cameras, digital scanners, 3D digital radiographs) that seem to be important in the interaction with patients, mainly in the change of perception about diagnoses, treatments, and results (Feuerstein, 2004). However, more research is needed to understand the value of these technologies in maintaining and promoting oral health. Aside from this, the

psychological mechanisms that make these technologies good instruments for changing attitudes and behaviors have not been explored (Feuerstein, 2004; Ramseier & Suvan, 2010).

Successful treatment is made more likely by effective and empathic communication between the health professional and the patient (Ramseier & Suvan, 2010). It is essential that communication works in both directions and that it creates an *interaction* between the sender and the recipient. One way to promote this interaction is through the use of images, as they increase the effectiveness of educational interchange, simplifying language, with potential for significant benefits in important areas such as attention, understanding, memory, and intention/collaboration (Houts et al., 2006).

In today's world, daily life is flooded with images. They are a central part of how we represent the world to ourselves, how we give it meaning and communicate with others. It may be said that we live in an increasingly visual culture (Sturken & Cartwright, 2009). Over the past two centuries we have witnessed the advancement of the visual over oral and written communication. The images no longer serve as mere illustration, but as containers of important content. This increasingly visual culture should be understood analytically and perhaps adopted by all of us, faced as we are with a surprising variety of images in our clinical life, especially when these images may change the course of diseases, attitudes, and habits (Sturken & Cartwright, 2009).

The use of photography may prove useful in enhancing communication with the patient, especially where verbal communication is more difficult or less successful. Using a system of intraoral cameras, it is possible to travel through the patient's mouth, pointing out sites of plaque retention, initial stages of inflammation, and areas amenable to reconstructive treatments (Willershausen et al., 1999) (Figure 2).

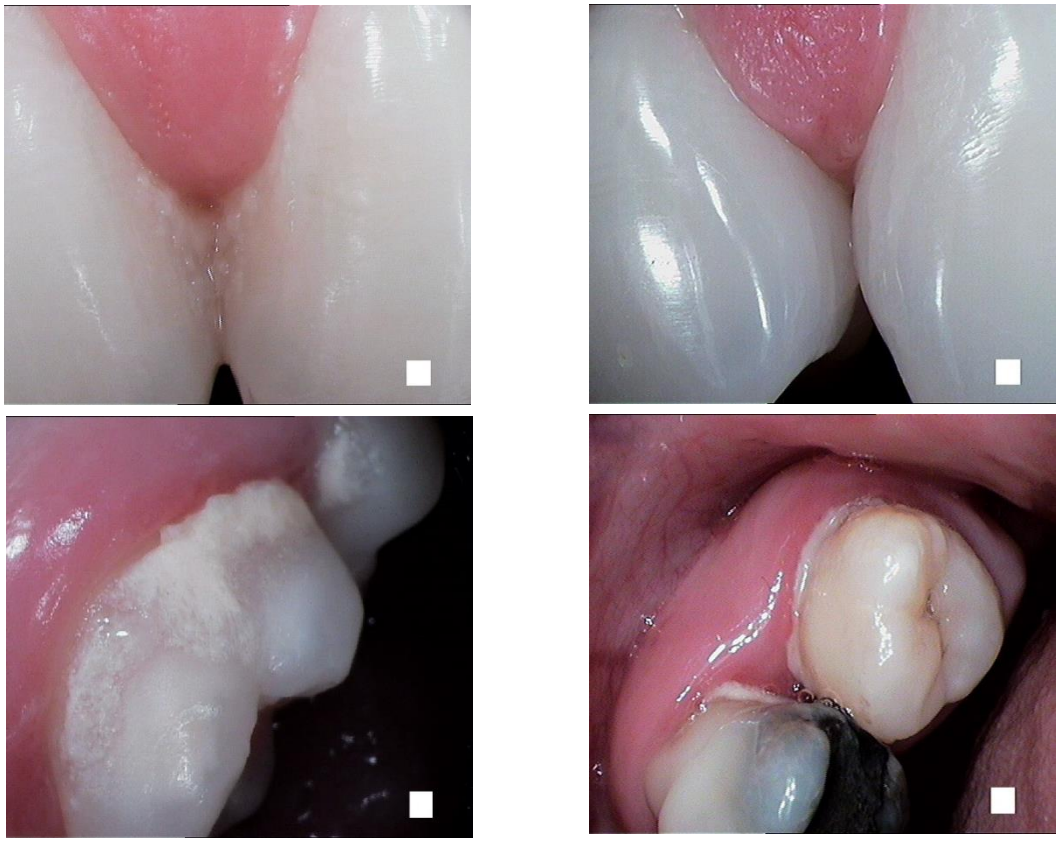

Figure 2. Images taken during consultations. These images were used to explain the least visible sites of biofilm accumulation. ACTEON Soprocare camera.

For these authors, patient education is a vital aspect of oral health practice and current technologies must be part of this process. The intraoral camera can be one of the most effective of these tools. Using these resources for patient assessment helps to improve patient compliance with recommendations from the oral health consultation. Oral health care professionals can use the intraoral camera to show "live" images on the computer monitor (Figure 3), and this provides visual proof of the actual state of the mouth, as well as the treatment needs of patients, which can be especially useful for patients with low compliance or fear (Shorey & Moore, 2009; Willershausen et al., 1999).

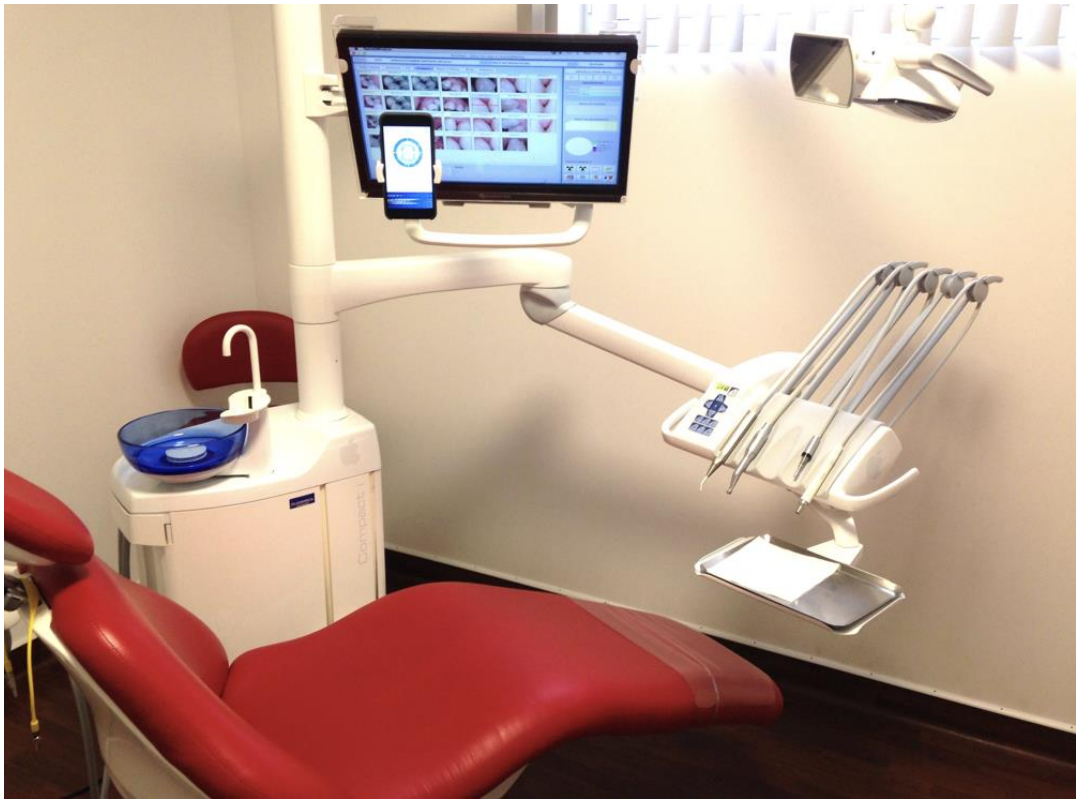

Figure 3. A dental office prepared for the use of the intraoral camera. The screen at front permits discussion of the images with patients.

Further according to Willershausen et al., (1999), intraoral cameras allow professionals to compare images from routine visits in order to reassess the strategies used by patients. In spite of the increase in availability of intraoral cameras and their proliferation in dental practices, little research exists on the advantages of using them. There are several studies on the use of photography in dental appointments, but always with a clinical focus – the registration of caries, oral lesions, orthodontic evaluation, aesthetic situations, or evaluation of dental treatments (Murrell, Marchini, Blanchette, & Ashida, 2019; Signoria et al., 2018; Willershausen et al., 1999). Most of these studies treat the use of photography in dentistry as an easy and accurate way to record specific situations (Amhad, 2009a; Desai & Bumb, 2013).

It is also noted that the importance of oral photography is being increasingly recognized by dentists as a way to improve their clinical records and thus avoid legal disputes (Wander, 2014). However, the interaction and the effect of the photographs on patients have not been evaluated in a way that considers their impact on the patients' behaviors and psychological

factors (Amhad, 2009b). Little data exists regarding the use of intraoral photography from an educational point of view, and most studies address the use of photography as a tool for the training of oral health care professionals, not specifically for patients (Stieber, Nelson, & Huebner, 2015). To our knowledge, no studies exist on the relationship of photography with changing habits in oral hygiene or with influence on the psychological variables of patients.

2.10. MHEALTH – TEXT MESSAGES

According to the organization Water (www.water.org), there are currently more people in the world with mobile phones than with bathrooms. This shows the mass adoption of this technology, 62.9% of the world population has a mobile phone. In 2019 the estimated number of these devices worldwide was 5.13 billion (United Nations Department of Economic and Social Affairs Division for Public Administration and Development Management). In Portugal, according to data from ANACOM, there are about 10.6 million mobile phones, a number higher than the total Portuguese population. The user penetration of mobile phones reached 96.5% for Portuguese homes in 2018, according to Marketeer, and the national percentage of users who accessed the web through mobile phones and/or smartphones was around 70% according to the National Statistics Institute (INE, 2018). In 2018, again according to the INE, 67% of people in Portugal used or installed applications on their smartphones.

Due to the unprecedented global spread of mobile technologies, the term mHealth was born. There are various definitions of mHealth, none of them official. The WHO (2014) refers that we cannot expect consensus, but we can realize that most researchers and educators use in their definition of mHealth a health intervention coupled with a mobile device, namely a cell phone. According with a more recent document (WHO, 2017), mHealth may be defined as a medical and public health practice that is supported by mobile devices, such as mobile phones,

patient monitoring devices, personal digital assistants (PDAs), and others wireless devices. Also, according to this organization, mHealth is a component of eHealth.

In the definition adopted by the Direção Geral da Saúde (General Directorate of Health) (George & Plantier, 2007), eHealth refers to the use of modern information and communication technologies to meet the needs of citizens, patients, health professionals, health service providers, and policy makers in relation to health. In turn, mHealth sees the health service making use of voice and text messages as well as more complex features and applications, including General Radio Services, third and fourth generation mobile telecommunications (3G and 4G systems), global positioning systems (GPS), and Bluetooth technology (WHO, 2014).

Some authors have asserted that health promotion would benefit from the use of new communication technologies and so, inevitably, it would expand beyond the most well-known resources (leaflets, brochures, posters, newspapers, magazines, radio, etc.) to reach new ones: smartphones, social networks, internet resources, among others (BinDhim, Hawkey, & Trevena, 2015; Toniazzo et al., 2019). In fact, the use of mobile phones has shown advantages when used as an education methodology, notably in health (Koszalka & Ntloedibe-Kuswani, 2010). Access to information is facilitated, there is interaction with the user, and it is in most cases a simple process (Zurovac, Talisuna, & Snow, 2012). In addition, it facilitates the individualization of processes, as people are not the same and require different learning and educational strategies (Free et al., 2013). Especially if the strategy is simple, such as the use of text messages, its reach is easily generalized, (Armanasco, Miller, Fjeldsoe, & Marshall, 2017).

There are several reasons why text messaging is a promising strategy in health promotion and education. Text messages are widely disseminated and accessible; according to the Statista.com (2019) it is estimated that 97% of the more than 7 billion mobile phone users used text messages daily and the majority of mobile phone users do not turn them off during working hours. Messages can be sent to multiple different users at the same time. Also,

according to this website, in 2018, it was observed that: “According to the Cellular Telecommunications and Internet Association (CTIA), 6 billion SMS are sent every day in the USA, more than 180 billion are sent per month and 2.27 trillion messages are sent per year”. Worldwide, 8.3 trillion SMS were sent in 2017, according to data from Portio Research (Portio Research, 2017).

The use of text messaging is an appealing way to contact patients and remind them of scheduled appointments (Nelson, Berg, Bell, Leggott, & Seminario, 2011), as well as to exchange information with health professionals (Free et al., 2013). This technology is helpful in programs for change and maintenance of behavior, especially because it is a confidential, non-confrontational communication method (Toniazzo et al., 2019). Recent studies have concluded that text messages can be used successfully to promote behavioral change in areas such as smoking cessation, maternal and child services, and physical exercise (Head, Noar, Iannarino, & Harrington, 2013; Ludwig, Arthur, Sculthorpe, Fountain, & Buchan, 2018; Noordam, Kuepper, Stekelenburg, & Milen, 2011; Orr & King, 2015; Sahin, Courtney, Naylor, & Rhodes, 2019). The majority of these interventions were short, from 4 to 16 weeks, and, for the most part, they were able to produce positive changes in health behaviors.

It is also important to note that results have been achieved concerning the self-regulatory variables at play in behavior change, such as the fact that the effect of interventions is maintained, even after their interruption. (Armanasco et al., 2017). The challenge will be to understand how the characteristics of these interventions affect other psychological constructs and health behaviors, so that future interventions adopt evidence-based best practices.

Interventions using text messages are based on the creation of short communications of information and reminders relevant to the behavior in question. The messages may be sent randomly by computer systems and may be customized for each case or for similar patterns of behavior. The type of messages and their content have been the subject of research in order to

understand how these characteristics affect the acceptance, usefulness, and effectiveness of the communication (Gold, Lim, Hellard, Hocking, & Keogh, 2010; Head et al., 2013; Orr & King, 2015). In the composition of the message content, characteristics such as the message size, the use of humour, assertiveness, comprehensibility, originality, and individualization are considered essential for having an impact on the recipient (Gold et al., 2010).

Few studies exist on the use of text messages in oral health (Perri-Moore et al., 2016; Ross et al., 2019; Toniazzo et al., 2019); in the review by Orr and King (2015), none of the 38 studies included were in the area of oral health. However, there are indications that the use of text messaging is more effective at capturing attention, cementing behaviors and information, compared to traditional ways such as information pamphlets (Guy, 2010, p.185). More current evidence suggests that the use of these technologies has provided significant results in the reduction of bacterial plaque and gingivitis, so there is strong evidence that this strategy can help promote oral health behaviors (Toniazzo et al., 2019). It will therefore be important to look at the results of behavioral interventions in the field of oral health with text messages and ensure that they are accurately evaluated (Fjeldsoe, Marshall, & Miller, 2009; Orr & King, 2015; Toniazzo et al., 2019).

2.11. OVERVIEW

Although evidence exists about the importance of certain socio-cognitive constructs for oral health, as well as about the use of specific communication strategies based on new information technologies, some questions remain unanswered. In addition, there is also a marked lack of data about the effects of these interventions combined with intraoral cameras and text messages. How and why do they work? What effects do they have on the key psychological variables for changing oral health behaviors? What repercussions do they have on the patient's health? Can they be really helpful tools for oral health care professionals?

Bear in mind the theoretical framework presented, the present study sought as its main objective to explore the use of an intraoral camera and text messages as optimizers of self-regulatory processes and gingival status in patients with gingivitis. In addition, we sought to understand the mechanisms of action in the interventions, through a theory of behavioral change.

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3. OVERVIEW OF EMPIRICAL STUDIES

3.1. INTRODUCTION AND OBJECTIVES

Despite the apparent benefits of using the IOC in improving the quality of communication between patients and professionals and in the adoption of oral hygiene behaviors (Willershausen et al., 1999), studies in this area are scarce. In particular, the effects of using the IOC on the psychological determinants of dental hygiene behavior remain unclear. The use of text messages (TM) to change and manage health behaviors is more frequent (Cole-Lewis & Christian, 2003; Fedele, Cushing, Fritz, Amaro, & Ortega, 2017; Hall, Cole-Lewis, & Bernhardt, 2015), although little has been published in the area of oral health behaviors so far, their use is beginning to be studied (Toniazzo et al., 2019).

From a behavioral point of view, there is a body of evidence that attests to the relevance of psychosocial factors in explaining the adoption of different health behaviors, especially those of oral hygiene (Scheerman et al., 2016), as mentioned before. We know that motivational factors are good predictors of behavioral intention, but they only provide a partial explanation for behavioral changes (Webb & Sheeran, 2006). For this reason, volitional factors were studied in an attempt to understand the processes of self-regulation in changing health behavior (e.g., Hagger & Luszczynska, 2014).

Considering the scarcity of intervention studies and evaluation of the effectiveness of using new technologies in self-regulatory processes in promoting periodontal health, the present research aimed to explore the impact of individual intervention, adapted to the recipient, with the use of an intraoral camera and mobile phone text messages (TM). We sought to study their effects on optimizing self-regulatory processes and gingival status in patients with gingivitis, specifically regarding behavior around brushing and flossing.

We therefore defined the following objectives, which are addressed in chapters 4, 5, and 6:

1. Check for changes in self-regulatory processes and gingival health status resulting from the use of the intraoral camera (IOC) and/or text messages (TM) in the service of brushing and flossing, through a randomized and controlled clinical trial.
2. Understand the psychological mechanisms involved in behavioral change and explore their role in the effectiveness of the interventions under study.

In order to investigate the role of the HAPA model variables in oral hygiene behaviors –specifically whether they sequentially mediate the relationship between intention and these behaviors – the following objective was defined and is addressed in chapter 7:

3. Verify the applicability of the HAPA model for oral hygiene behavior in a sample of adult patients with gingivitis.

3.2. GENERAL DESCRIPTION AND CHRONOLOGY

Four studies were carried out to meet these objectives: three experimental/longitudinal studies (chapters 4, 5, and 6) and a quantitative longitudinal study (chapter 7).

The set of three longitudinal experimental studies took place in two dental clinics (Caldas da Rainha and Lisbon). The sample was obtained through advertisements in newspapers, dental clinics, and local companies. After giving their informed consent, the participants answered an online questionnaire about sociodemographic data and socio-cognitive determinants of oral health behaviors (i.e., constructs of the HAPA model), through scales adapted from previous studies (Godinho, Alvarez, Lima, & Schwarzer, 2015) for oral health behaviors. In addition, clinical data were collected to assess gingival health status over the course of the study.

A total of 297 individuals volunteer to participate. Of these, fifty-one were excluded under the exclusion criteria: number of teeth in the mouth fewer than 20, no bleeding on

probing, attachment loss greater than 3mm, smokers, use of orthodontic appliances and/or removable prostheses, pregnancy, or systemic disease affecting the periodontium. Two patients missed the appointment and did not complete the questionnaire at four months, and 61 did not complete it at eight months (see Figure 4).[1]

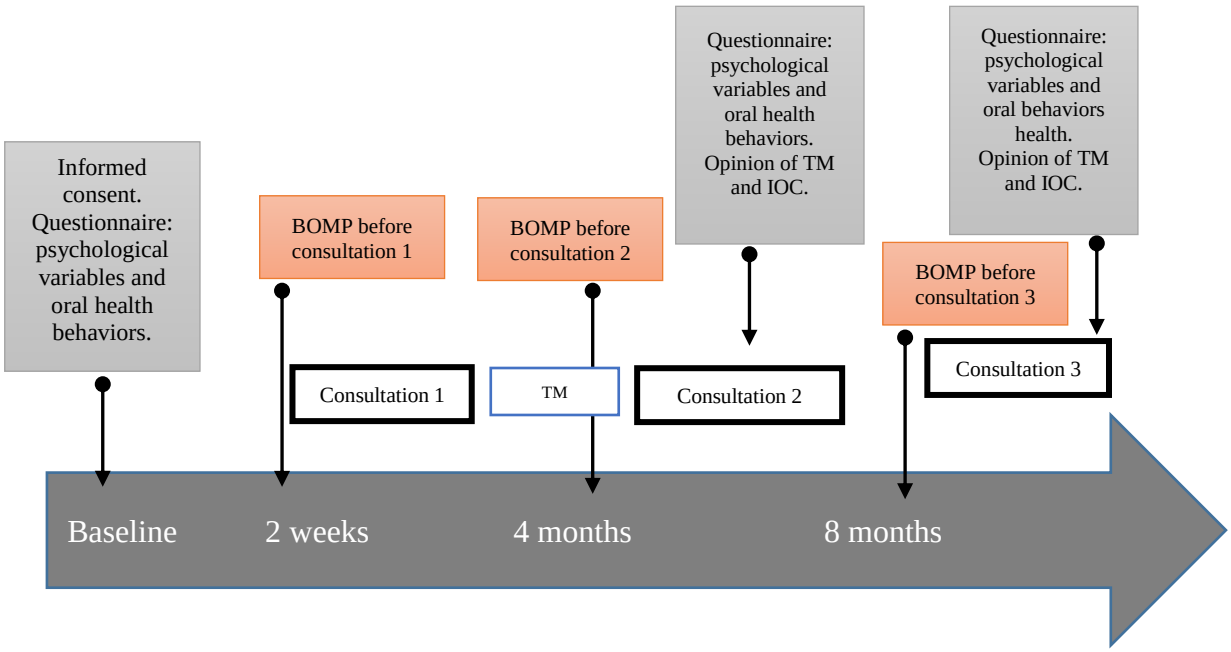

Figure 4. Chronology with points of data collection. TM = text messaging; IOC = intraoral camera; BOMP = Bleeding on Marginal Probing Index.

3.3. PROCEDURE AND DESIGN

This study was approved by the Ethics Committee of the Faculty of Psychology at the University of Lisbon (Doc. No. 6/14). Its chronology can be viewed in Figure 4. All consultations in the study were free of charge, in order to compensate the participants for their participation.

[1] Chapters 4, 5, 6, and 7 provide criteria and flowcharts specific to each study.

The questionnaire was carried out using the software Qualtrics, Inc.[TM/R] Provo, UT, USA and made available on this platform. To assess oral hygiene habits, two questions were created about brushing habits and interproximal control. The individual results for brushing and interproximal control were calculated; a result composed of the averages observed and referred to as oral hygiene was then used in the final calculations. The psychological determinants of behavior change according to the HAPA model were assessed by patients using the questionnaire at two or three points in time, depending on the study: two weeks before the first consultation, upon completion of the second consultation at four months, and/or upon completion of the third consultation at eight months. All the antecedent/determinant psychological variables of behavior change were assessed using a 7-point Likert scale, ranging from strongly disagree (1) to strongly agree (7). The questionnaire is presented in Appendix 1.

Satisfaction with the IOC and TM was measured by adapting the Shaw scale (2012) (9 items), which considers the acceptance of technology based on usefulness and acceptability. A 5-point Likert scale was used, ranging from strongly disagree (1) to strongly agree (5).

Two weeks before the consultation, participants received an e-mail explaining the study, read and signed a digital informed consent form, then completed the questionnaire. The levels of gingival bleeding were obtained using the BOMP (Bleeding on Marginal Probing) index (Van der Weijden, Timmerman, Nijboer, Reijerse, & Velden, 1994) in the first, second, and (depending on the study) third consultations. The collection of the BOMP was carried out in such a way that the experimental condition attributed to each patient was unknown to the investigator.

At the beginning of the first consultation, after collecting the BOMP values, patients were randomly divided into four groups: Control; Intra-Oral Camera (IOC); Text Messages (TM) and IOC + TM. In groups where the intraoral camera was used, this was the SOPROCARE© camera (ACTEON, La Ciotat, France).

Figure 5. SOPROCARE© intraoral camera (ACTEON, La Ciotat, France). Definition: 470p. Weight: 78g

The consultation was similar for the different groups and was performed by a dental hygienist with over 20 years of practice. It was free, lasted one hour, and included activities that are normally part of a dental hygiene appointment, namely:

1. Greetings, introduction to the consultation. Assessment of clinical oral health status (15 min).
2. Motivation. Discussion of needs and expectations regarding treatment; negotiation of oral hygiene strategies. In the IOC group, the ACTEON SOPROCARE® was used to enhance the diagnosis and to help patients

understand the proposed objective and explanation of oral hygiene strategies. The IOC was used to capture photographs of areas of inflammation (gingivitis) and plaque that were then shared and discussed with the patient. In the TM group, messages were used to reinforce the importance of gingival health and oral hygiene techniques (interproximal control). These consisted of an average of 170 characters per message, sent weekly during the first four months, with a total of 16 messages received by each patient (Appendix 2). Instrumentation. Scaling and polishing, if necessary (30 min).

3. Summary. Goal-setting. Scheduling the next appointment (15 min).

The consultation was organized according to the characteristics of each patient: their gingival condition, perception of gingivitis, habits, and expectations about treatment.

In the consultation, specific behavior change techniques were used: reinforcement (10.4), goal-setting (1.1), and feedback (2.2, 2.7), as described by Michie et al. (2013). In addition, special attention was paid to communication with the patient and commonplace language (words such as “cleanliness” and “hygiene”) was replaced by more therapeutic language (for example, “inflamed areas” and “inflammation control”) in order to focus the patient’s attention on the various facets of oral health, to increase their perception of the need for treatment (Appendix 3). The active control group received an identical communication strategy.

The bleeding index was assessed at the beginning of the consultation. This index was validated through random reassessment of 20% of the patients by another oral health professional (a dentist with more than 20 years of experience), trained for this purpose. This reassessment was carried out 30 minutes after the initial evaluation, at four and eight months (depending on the specific design of the study in question).

The consultation sequence (Ramseier & Suvan, 2010, p. 138) followed a script specifically developed for this study. Its fidelity was randomly evaluated in 15% of the interventions by two oral health professionals trained for this purpose, using a checklist of four items: introduction and diagnosis, explanations, therapeutic objectives, and clinical procedures (Appendix 3).

The studies were registered in the ClinicalTrials.gov database. Statistical analysis was performed using SPSS™ (v.22).

Chapters 4, 5, 6, and 7 present the four empirical studies. These chapters result from articles written for scientific publications and already published. The rationale for each study is presented in each chapter independently, as are the hypotheses and specific bibliographical references, so that they can be read independently.

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4. EMPIRICAL STUDY 1

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

This chapter is based on the paper:

Araújo, M.R., Alvarez, M.-J., Godinho, C.A., & Pereira, C. (2016). Psychological, behavioral, and clinical effects of intra-oral camera: a randomized control trial on adults with gingivitis. *Community Dentistry & Oral Epidemiology*, *44*, 523–530. doi: 10.1111/cdoe.12245

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

4.1. INTRODUCTION

Consistent evidence makes it possible to affirm that the main aetiology of periodontal diseases is the formation and persistence of bacterial biofilms on dental surfaces1. Thus, efficient interventions designed to improve patients' adherence to a type of oral hygiene control, capable of promoting gingival health, are needed (Newman, Takei, & Carranza, 2012; Newton & Asimakopoulou, 2015; Sambunjak et al., 2011).

Dental floss is the most recommended device to control biofilm interproximally in combination with toothbrushing to reduce gingivitis (Sambunjak et al., 2011). However, most patients fail to correctly use these means of controlling dental biofilm in the long term and to turn up for recall appointments (Chapple et al., 2015). 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) (Gobat et al., 2010). 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 (Newton & Asimakopoulou, 2015; Renz et al., 2007). Moreover, the use of IOC images, as a means to increase and improve communication, has proven to be an effective strategy in ensuring such interaction and improves the relationship with patients (Willershausen et al., 1999). 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 (Willershausen et al., 1999), 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 (Ahmad, 2009; Willershausen et al., 1999).

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 and the effects of IOC use on psychological antecedents of dental hygiene behaviors remain unclear (Willershausen et al., 1999). 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) (Schwarzer, 2008), now take not only motivational, but also volitional or self-regulatory psychological mechanisms into consideration, which explain how intentions are transformed into actions (Figure 1 – Page 25).

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.

4.2. METHODS

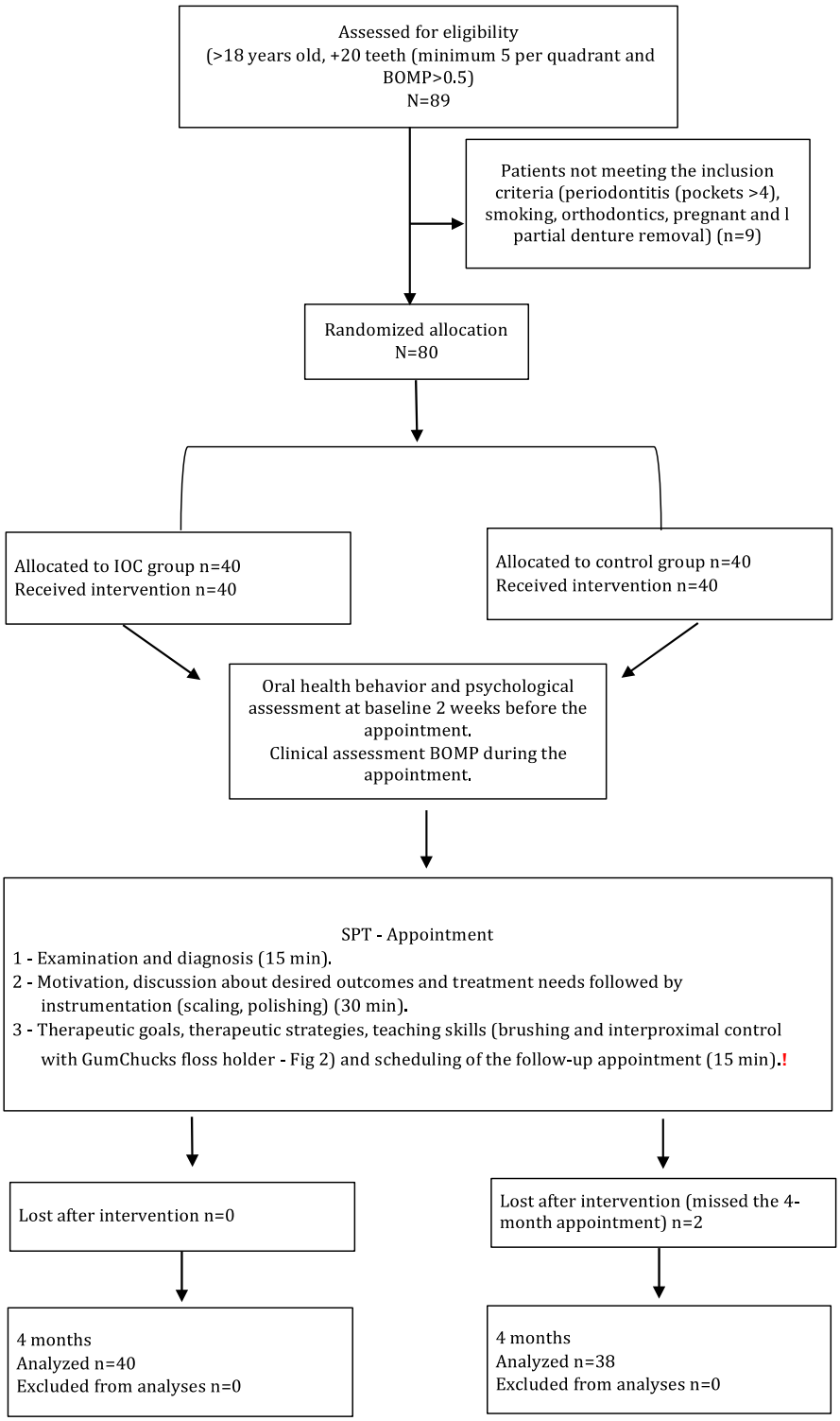

Figure 6. CONSORT flow chart.

A total of 89 patients completed the baseline questionnaire (see Figure 6). Table 1 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 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.

Table 1. Demographic characteristics of the sample

Demographic characteristics	**IOC group Number / Proportion of the sample *n* (%)** (*N* = 40)	**Control group Number / Proportion of the sample *n* (%)** (*N* = 40)
Sex		
Women	24 (60%)	21 (52.5%)
Men	16 (40%)	19 (47.5%)
Age		
18-24 years	9 (22.5%)	5 (12.5%)
25-34 years	11 (27.5%)	10 (25%)
35-44 years	9 (22.5%)	11 (27.5%)
45-54 years	8 (20%)	8 (20%)
55-75 years	2 (5%)	5 (12.5%)
> 75 years	1 (2.5%)	1 (2.5%)
Highest qualification		
Basic education	4 (10%)	6 (15%)
Secondary education	5 (12.5%)	4 (10%)
Higher secondary education	7 (17.5%)	16 (40%)
University and tertiary education	24 (60%)	14 (35%)
Occupation		
Actively working	30 (75.6%)	30 (75%)
Unemployed	8 (19.2%)	8 (20%)
Retired	2 (5.2%)	2 (5%)

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. (1994) 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. (2014). 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 hour and included activities that are normally part of supportive periodontal therapy (SPT) (Bardet, Suvan & Lang, 1999). It also included specific behavior change techniques (Newton & Asimakopoulou, 2015), such as reinforcement (10.4), goal-setting (1.1), and feedback (2.2, 2.7), as described by Michie et al. (2013) 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 flow chart (Figure 6). 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 (Figure 7).

Figure 7. GumChucks. This flossing system resembles miniature nunchucks, featuring disposable tips connected by a piece of dental floss. The two-handle system apparently increases dexterity and control, enabling the recommended "C" shape with the floss.

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 seconds 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 TM 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 (Godinho et al., 2015). 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 2.

Satisfaction with the intra-oral camera (9 items) was measured by adapting Shaw's scale15. 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*Power16 to give 80% power to detect a statistically significant difference at a = 0.05, whenever an effect size similar to f = 0.337 or higher was observed, and was inflated by 30% to cover the possibility of dropout.

The statistical analysis was performed using SPSS (v.22) TM. 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 clinical, and psychological determinants at baseline and 4-month follow-up in intra-oral camera and control groups 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.

4.3. 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 (Figure 8).

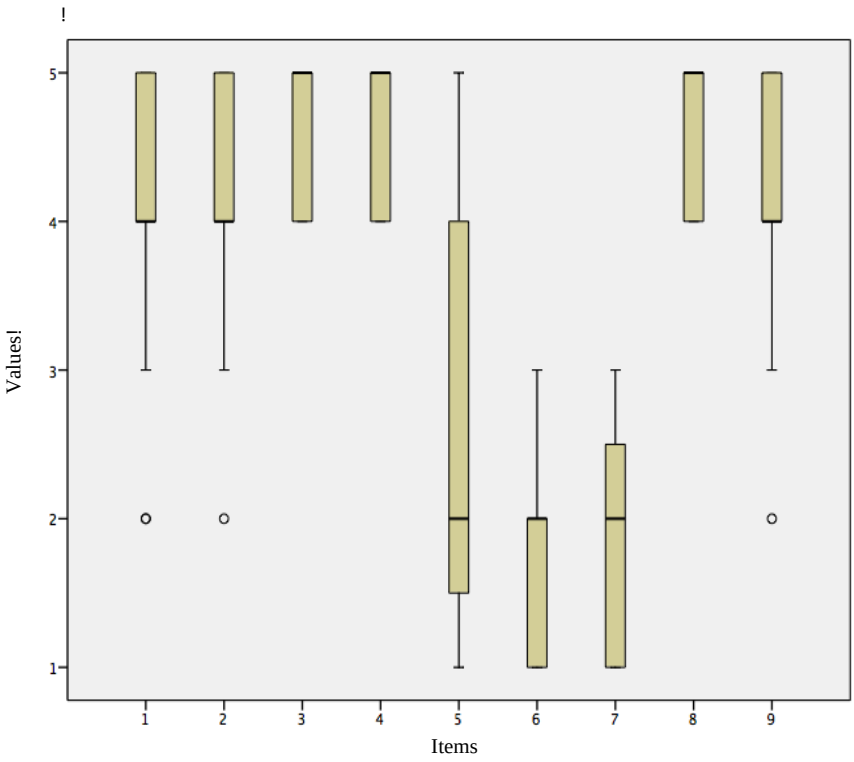

Figure 8. Items legend: (1) I enjoyed looking at the pictures. (2) A pleasant experience. (3) Helpful for checking my mouth. (4) They helped improving my oral hygiene. (5) The pictures were disturbing. (6) Too many pictures. (7) The pictures were disgusting. (8) Useful for the appointment. (9) A positive overall experience. No statistically significant differences were found in comparison to 4 months' data, t (39) = -1.9, ns.

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 2). 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, $\eta^2 = 0.01$ (Figure 9). An increase in dental hygiene and flossing in both groups at 4 months was observed (Table 2), 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 2), 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 (Figure 9). 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 (Figure 9), 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 2).

Table 2. 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.

				IOC group (n = 40) M (SD)		Control group (n = 38) M (SD)		Group comparison					
								Group		Time		Group x Time	
	Item example	Number of items	Cronbach's alpha baseline (4-months)	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).

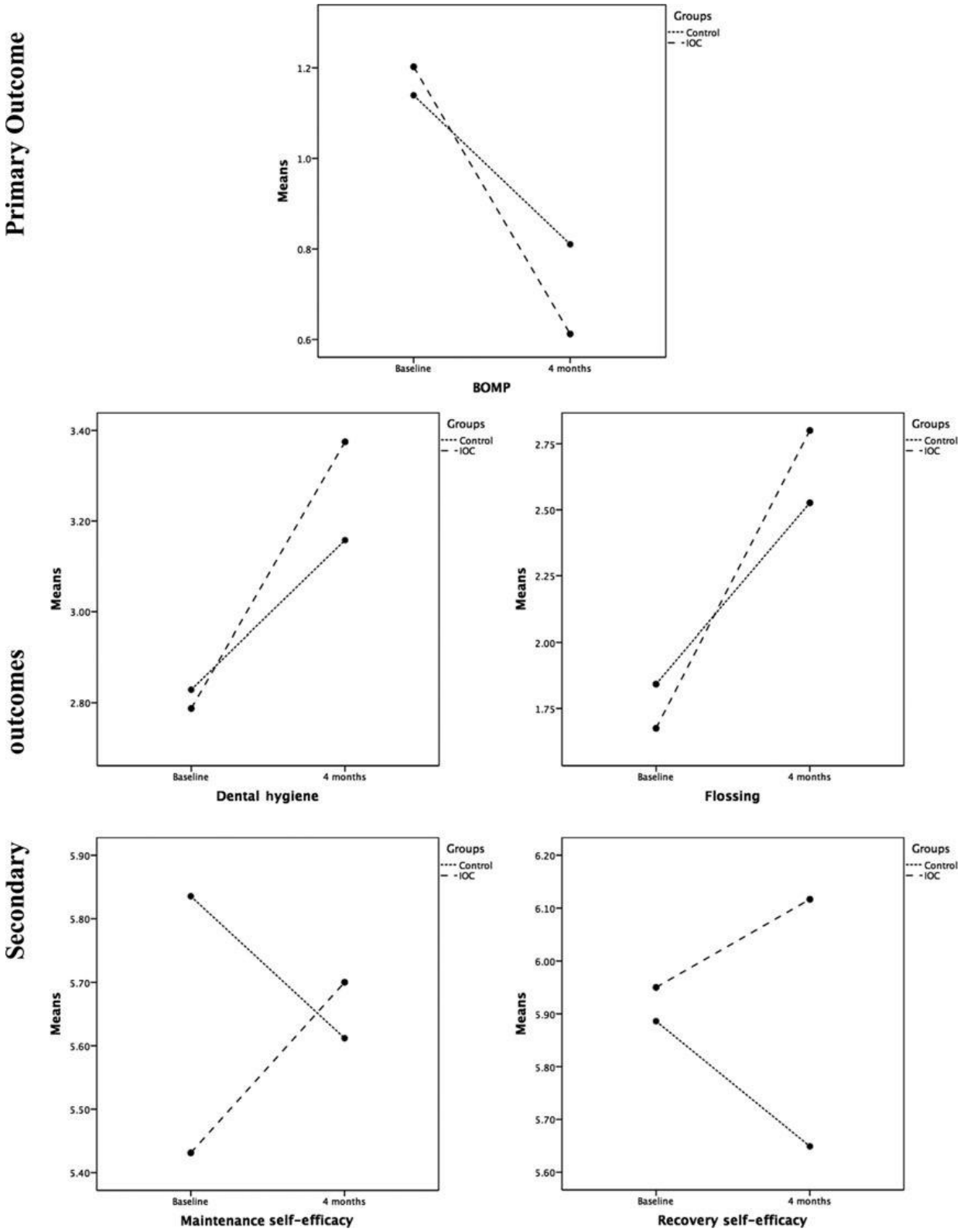

Figure 9. Levels of Bleeding on Marginal Probing (BOMP), dental hygiene, flossing, maintenance self-efficacy, and recovery self-efficacy in the two conditions at two points in time. Dental hygiene combines the frequency of toothbrushing and flossing.

4.4. DISCUSSION

This study set out to evaluate the importance of IOC use in a SPT with patients suffering from 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 (Van der Weijden et al., 1994).

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 (Willershausen et al., 1999). 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. (2015) 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 (Ahmad, 2009).

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 (Willershausen et al., 1999). 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 (Willershausen et al., 1999) 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 (Schwarzer, Antoniuk, & Gholami, 2014), have been rendered determinants of changes in oral hygiene behaviors.

However, in the present study, and in keeping with that of Schüz et al. (2007), 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 (Webb & Sheeran, 2006), 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 dental 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 (Nuzzo, 2015).

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. (2007) 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 (Lin et al., 2014). 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.

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5. EMPIRICAL STUDY 2

Using mobile text messages and a new floss holder to improve gingival health: A randomized controlled trial

This chapter is based on the paper:

Araújo, M.R., Godinho, C.A., & Alvarez, M.-J. (2020). Using mobile text messages and a new floss holder to improve gingival health: A randomized controlled trial. *Journal of Dental Hygiene*, 94, 29-38.

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ABSTRACT

Purpose: To evaluate the effects in gingival health of using mobile text messages and a floss holder on patients with gingivitis.

Methods: A total of 142 adults with gingivitis was randomized into three groups: (1) Finger Floss, (2) New Floss Holder, and (3) New Floss Holder plus Text Messages. Bleeding, self-reported dental hygiene behaviors, and psychological determinants of behavior change were evaluated before the treatment session and four months later. Repeated measures analysis of variance (ANOVA) was used to compare groups over time.

Results: At the follow-up, both groups using the new floss holder showed significantly higher levels of self-reported flossing, action self-efficacy, intention, action planning, and action control. Group 3 also showed lower levels of bleeding and higher levels of dental hygiene and recovery self-efficacy than the other groups, as well as higher levels of maintenance self-efficacy than Group 1.

Conclusions: Flossing with a new floss holder improves behavioral and psychological determinants of gingival health, but clinical parameters only reach significant improvements when used in conjunction with text messages. These strategies can help to improve flossing and contribute to the management of gingival health. This study supports the National Dental Hygiene Research Agenda priority area client level: Oral health care (new therapies and prevention modalities).

Key words: behavioral research; clinical research; e-learning technology; periodontology; technology for patient care

5.1. INTRODUCTION

Mechanical control of biofilm is the primary therapeutic strategy for preventing gingival diseases (Tonetti et al., 2015). Toothbrushing plays an important role to that end and is the most used mean of controlling plaque (Van der Weijden & Slot, 2015) but is not sufficient for efficiently reaching into interdental surfaces (Sälzer et al., 2015). Recent literature reviews have found interdental brushes (IDB) as the most effective interdental cleaning devices (Sälzer et al., 2015; Worthington et al., 2019). However, some limitations have been noted for IDB, as several shapes and sizes are required and most of the interdental spaces in the anterior teeth are not sized for their use (Sälzer et al., 2015). Additionally, some authors have drawn attention to the scarcity of well-designed studies showing the relative clinical value of flossing, arguing that it may be premature to set floss aside (Vernon et al., 2017). A more recent systematic review mentions that both floss and interdental brushes may contribute to reduce gingivitis (Worthington et al., 2019). With this in mind, many researchers advocate that it is advisable for dental professionals to change their mindset from 'flossing' to 'interdental cleaning', choosing the best interdental cleaning methods according the dimensions of the embrasure space and patients' skill levels and motivation – not only according to the comparative results of efficacy (Sälzer et al., 2015; Vernon et al., 2017; Worthington et al., 2019).

Individuals often fail to exert control over their behavior despite being motivated to do so (Sniehotta, Scholz, & Schwarzer, 2005), and control can be even more challenging when routine behaviors are involved, such as those concerning dental hygiene. Therefore, some models of health behavior change, such as the Health Action Process Approach (HAPA) (Schwarzer, 2008), take volitional[2] or self-regulatory aspects of behavior into consideration.

[2] Volition or will is the cognitive process by which an individual decides on and commits to a particular course of action.

According to the HAPA, a change in health behavior is the result of a motivational phase where individuals form an intention to act, but it also involves a volitional, post-intentional phase where the individuals plan how they will put their intentions into practice and maintain their behavioral changes (Dumitrescu, Dogaru, Duta, & Manolescu, 2014; Scheerman et al., 2016; Schwarzer, 2008; Sniehotta et al., 2005) (Figure 1 – Pag. 25). When compared to other social cognitive models, the HAPA proved to be a good predictor of oral hygiene behaviors (Dumitrescu et al., 2014; Scheerman et al., 2016).

It is also known that people thrive on novelty and challenge, seeking new experiences and stimulating activities (González-Cutre et al., 2016; Kashdan & Silvia, 2009). Under most theories of motivation, both curiosity and a personal sense of control influence readiness and motivation to initiate behavior and expend effort (Bandura, 1977), which is particularly important when approaching novel situations, such as using a new floss holder or receiving text messages about oral health issues. Floss holders have long been used, with studies showing benefits for patients lacking the dexterity to use finger flossing and in helping patients establishing a long-term flossing habit in comparison to finger flossing (Blanck et al., 2007; Kleber & Putt, 1990). New floss holders (NFH) may be a way to increase curiosity, control, and flossing frequency, thereby fostering dental hygiene efficacy.

One way of disrupting undesired habits, such as failing to control interdental spaces, is by bringing habitual behavior and its context to conscious awareness (Dumitrescu et al., 2014). Consciousness-raising for health behavior may be facilitated by mobile digital technologies, which provide the opportunity to display habit-disrupting cues (Alkiş & Findik-Coşkunçay, 2018). Mobile text messages (TM) may offer an opportunity to disrupt habitual behavior by keeping a goal salient or by bringing the goal back to working memory at an appropriate time. Moreover, according to a recent systematic review with a meta-analysis (Toniazzo et al., 2019), the use of mobile health interventions has been shown to positively influence communication

between patients and providers, facilitating relationship-centered healthcare. In the same vein, TM have been shown to foster social support mechanisms (Perri-Moore et al., 2016).

The aims for this randomized controlled trial were (1) to investigate whether the effect of using a new floss holder would improve adherence and help to develop positive health behaviors in order to promote gingival health, and (2) to investigate the possibility of boosting the sustainability and clinical efficacy of those behaviors by using mobile text messages between appointments. For the primary outcomes of this study, we sought to test whether the use of an NFH plus TM – compared to the NFH alone and to the usual finger flossing (FF) – would have a positive effect on gingival health as indexed by gingival bleeding, through an increase of self-reported flossing. For secondary outcomes we examined the effects of the intervention on relevant psychological determinants as outlined by the HAPA. We hypothesized that:

1. In comparison to finger flossing, the NFH would increase individuals' levels of motivation to use dental floss, owing to its novelty and ease of use. We therefore expected higher levels of motivational determinants (e.g., outcome expectancies, action self-efficacy), and consequently greater intention to floss among patients who used the NFH.
2. TM would serve as "cues to action" and would bring the behavioral objectives for dental hygiene to consciousness, reinforcing subjects' self-regulatory mechanisms (planning, self-efficacy, and action control) in contrast to the other two groups.
3. The NFH would contribute to increased frequency of flossing compared to FF, and the use of the NFH plus TM would contribute more than the use of the NFH alone.
4. Bleeding would be lower in the NFH group when compared to the FF group, and the use of NFH plus TM would contribute to even lower BOMP (Bleeding on Marginal Probing Index) levels than those obtained with the NFH.

Table 3. Demographic characteristics of the final sample (N = 142) by conditions

Demographic characteristics	*n* (%)		
	FF	NFH	NFH+TM
	(*n* = 43)	(*n* = 38)	(*n* = 61)
Sex			
Women	28 (65)	21 (55)	35 (57)
Men	15 (35)	17 (45)	26 (43)
Age			
18-24 years	12 (28)	4 (10)	7 (12)
25-34 years	10 (23)	9 (24)	18 (30)
35-44 years	8 (19)	11 (29)	24 (39)
45-54 years	7 (17)	8 (21)	8 (13)
55-75 years	5 (11)	5 (13)	4 (6)
> 75 years	1 (2)	1 (3)	0 (0)
Highest qualification			
Basic education	1 (12)	3 (8)	0 (0)
Secondary education	3 (7)	7 (18)	3 (5)
Higher secondary education	14 (33)	15 (39)	24 (39)
University and tertiary education	25 (48)	13 (35)	34 (56)
Occupation			
Actively working	36 (83)	29 (77)	50 (82)
Unemployed	5 (12)	7 (18)	9 (15)
Retired	2 (5)	2 (5)	2 (3)

5.2. METHODS

5.2.1. PARTICIPANTS

A total of 165 patients were initially enrolled in the study, but twenty-one patients failed to meet the inclusion criteria (Figure 10). Two others dropped out, resulting in a final longitudinal sample of 142 participants (Table 3).

5.2.2. PROCEDURE

Participants were recruited among the local urban community, through newspaper ads and advertisements in local shops. A dental hygiene consultation was delivered to participants with gingivitis by an experienced dental hygienist in two private dental clinics and a randomized controlled trial was conducted over a span of four months with two assessment points.

First, participants filled in an online informed consent and a questionnaire (T1) with measures on psychological determinants and oral health behaviors. Two weeks later, the gingival condition (BOMP - Bleeding on Marginal Probing) (Van der Weijden et al., 1994) was evaluated in the appointment. After the bleeding index values were collected, each participant was allocated by a research assistant through a computer-generated random sequence into one of three groups: Finger Floss (FF), New Floss Holder (NFH), or New Floss Holder plus Text Messages (NFH+TM). Next, a dental hygiene consultation (DHC) was performed by an experienced dental hygienist who was blind to the patients' assigned groups.

In order to treat the gingival inflammation, the DHC included a Professional Mechanical Plaque Removal session and individualized oral hygiene instructions. At the end of the consultation, patients were asked to answer to another questionnaire (T2). The same measures were collected again four months later (T3) (see Figure 10).

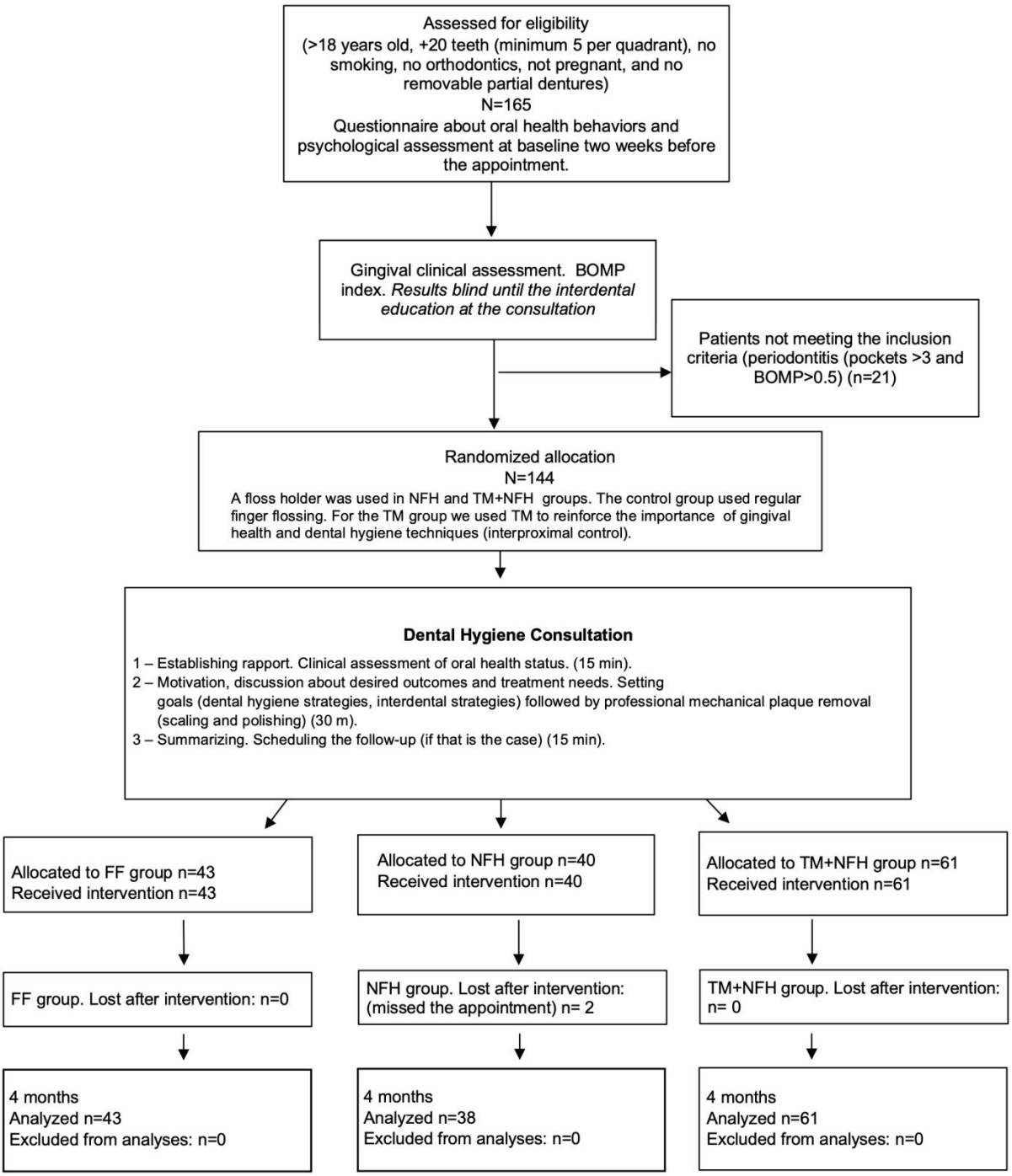

Figure 10. Flowchart depicting subject enrolment and measures.

A new floss holder, GumChucks®, was offered at the DHC to all the patients from the NFH and NFH+TM groups, who additionally rated their satisfaction with its use after 4 months. This new flossing system resembles miniature nunchucks, featuring disposable tips connected by a piece of dental floss. The two-handle system apparently increases dexterity and control, enabling the recommended "C" shape with the floss. The FF group used a waxed non-flavoured floss (GUM® ButlerWeave®).

Those assigned to the TM group were informed about how the messaging system would operate and asked to provide their mobile phone number in order to receive the TM, at the rate of one per week, over the next four months. Messages had approximately 140 characters; their content concerned oral hygiene and gingival inflammation and was designed to include characteristics described as important for improving their effectiveness, such as humour, assertiveness, comprehensibility, originality, size, and individualization (Gold et al., 2010). TM were pretested with an independent sample of 40 adults in order to evaluate their perceptions of the messages on these attributes. An example of one of the TM was: "*It is impossible to sneeze with your eyes open, BUT it is possible to take care of the gingiva between your teeth, even if it has been some time without doing so. You'll see! If you can, your gingiva will be healthy again. (Hygienist's name)*" (Appendix 2).

The dental hygiene consultations (professional mechanical plaque removal session and individualized oral hygiene sugestions), which lasted for approximately 60 minutes, were free of charge and was the same for all the groups and included specific behavior change techniques (Newton & Asimakopoulou, 2015). The individualized oral hygiene instructions required by the patients were delivered through verbal and practical demonstration (tell, show, and do) and with the help of a hand mirror, if needed. Data confidentiality and anonymity were assured and the ethics committees of the institutions involved approved the clinical trial (Ethics Committee

Doc. No. 6/14). The study was registered at the ClinicalTrials.gov database (NCT03120559). A detailed description of the consultation is given in Figure 10.

5.2.3. MEASURES

Gingival condition was assessed using the BOMP index, as described by Van der Weijden et al. (1994). In this index, bleeding is scored during 30 seconds of probing using a 3-point scale, from 0 to 2 (0 = no bleeding, 1 = pinprick bleeding and 2 = excessive bleeding). Moderate gingivitis was defined as at least 40% of the test sites showing bleeding on probing at screening (Van der Weijden et al., 1994). The BOMP healthy score was considered to be equal to or less than 0.5 — fewer than 25% of sites bleeding on marginal probing (Barendregt, Timmerman, Velden, & Weijden, 2002). Four months later, the same measure and procedure was used. At baseline and four months one-fifth of the patients were re-evaluated during the BOMP level assessment by another dental health professional – also blind to the assigned groups – in order to calculate the inter-rater agreement, a procedure that is common whenever evaluations may be subject to a certain degree of variability. High agreement was found between the two judges who evaluated bleeding level, $\kappa = .718$ (95% CI, .50; .94), $p < .001$.

In order to assess dental hygiene, two questions were answered on brushing and flossing habits, using a 5-point scale (1 - not using, 2 - barely, 3 - once a day, 4 - twice a day, 5 - more than twice a day). Scores for brushing and flossing were calculated and a composite (mean) score for dental hygiene was also computed. Satisfaction with the NFH was assessed by: “How do you rate the use of the GumChucks®?”: (1) “They are easy to use and I like them”; (2) “ I like them, but they are difficult to use”; (3) “I don’t like them”; (4) “They are a waste of time”.

Table 4. Item examples; Cronbach's alpha; and means and standard deviations for behavioral, clinical, and psychological determinants at baseline and four-months follow-up in the three conditions.

			Baseline			4 months			Group comparison					
	Item example (Number of items)	Cronbach alpha Baseline (4-months)	Floss Group n=43	NFH n=40	NFH+TM n=61	Floss Group n=43	NFH n=38	NFH+TM n=61	Group		Time		Group x Time	
									F	$\eta_p 2$	*F*	$\eta_p 2$	*F*	$\eta_p 2$
BOMP			1.15 (.32)	1.14 (.33)	1.19 (.35)	.82 (.26)$_a$	.81 (.33)$_a$	.62 (.33)$_b$	1.43	.02	262.95***	.65	11.74***	.15
Flossing	In the last two weeks/four months how often have you flossed your teeth? (1)		1.58 (.70)	1.84 (.86)	1.69 (.81)	2.28 (.63)$_a$	2.53 (.51)$_b$	2.80 (.54)$_c$	4.50*	.06	134.74***	.49	4.45*	.06
Toothbrushing	In the last two weeks/four months how often have you brushed your teeth? (1)		3.84 (.75)	3.82 (.77)	3.80 (.75)	3.91 (.75)$_{a,b}$	3.79 (.62)$_a$	4.07 (.63)$_b$	.50	.01	3.68	.03	2.70	.04
Dental Hygiene[1]			2.71 (.48)	2.83 (.58)	2.75 (.59)	3.09 (.48)$_a$	3.16 (.45)$_a$	3.43 (.37)$_b$	2.61	.04	103.07***	.43	6.69**	.09
Outcome Expectancies	Avoiding bleeding gums/Avoiding bad breath (7)	.86 (.82)	5.68 (1.23)	5.79 (.79)	5.72 (.99)	5.75 (.79)	5.79 (.59)	5.91 (.98)	.18	.00	1.12	.01	.51	.01
Action Self Efficacy	I believe I can clean interproximally and brush daily, even if I need to change routines. (3)	.86 (.87)	5.64 (1.21)	5.81(1.00)	5.67 (.82)	5.25 (.90)$_a$	5.87 (.87)$_b$	5.90 (1.12)$_b$	2.72	.04	.12	.00	4.63*	.06
Intention	In the upcoming weeks I intend to carry out interproximal cleaning and brush my teeth daily. (3)	.89 (.87)	6.26 (.66)$_{a,b}$	5.90(1.20)$_{b,c}$	5.91 (.71)$_c$	5.30 (.74)$_a$	5.92 (.88)$_b$	6.36 (.81)$_c$	3.28*	.05	4.83*	.03	32.91***	.32
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)	.83 (.86)	5.41 (1.27)$_a$	5.84(1.13)$_a$	5.31 (1.11)$_b$	5.19 (.97)$_a$	5.61(1.23)$_{a,b}$	5.61 (1.05)$_b$	1.80	.03	.33	.00	5.21**	.07
Recovery 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)	.81 (.78)	6.05 (1.12)	5.89(1.21)	5.87 (.87)	5.47 (.82)$_a$	5.65 (.98)$_a$	6.22 (.76)$_b$	2.02	.03	3.96*	.03	13.92***	.17
Action Planning	I already have plans for when I should brush my teeth and use an interproximal aid. (3)	.81 (.72)	5.14 (1.40)	5.18(1.51)	5.49 (1.20)	5.17(1.15)$_a$	5.96 (.97)$_b$	5.67 (1.14)$_b$	2.59	.04	7.18**	.05	3.13*	.05
Coping Planning	I have plans for what I should do if I have difficulties in practicing my dental hygiene. (3)	.78 (.80)	5.03 (1.34)$_{a,b}$	4.71(1.55)$_a$	5.30 (1.29)$_b$	5.10(1.28)	5.27 (1.33)	5.51 (1.04)	2.15	.03	5.10*	.04	1.21	.02
Action Control	I evaluate my behavior to see if I'm brushing my teeth twice a day and cleaning between teeth daily. (3)	.78 (.80)	5.50 (1.05)	5.32(1.31)	5.61 (.86)	5.05(1.02)$_a$	5.68 (1.04)$_b$	5.90 (.93)$_b$	3.83*	.05	.62	.00	8.03**	.10

Note. Means with different subscript represent significant differences in the pairwise comparisons. *$p < .05$; **$p < .01$; ***$p < .001$ 1 - (brush and floss)

Measures adapted to oral health from previous studies with the HAPA model were used (Araújo, Alvarez, Godinho, & Pereira, 2016) with a seven-point Likert-type scale ranging from "totally disagree" (1) to "totally agree" (7). The total number of items, item examples, and Cronbach's alphas are displayed in Table 4.

Evaluation of the TM, according to the overall interest (comprehensibility, interest, and relevance) and usefulness, was measured by adapting a 10-item scale (Araújo et al., 2016) using a five-point Likert scale. A four-point scale ranging from "Less than one message per week" (1) to "More than three messages per week" (4) was also used to determine the frequency at which participants were willing to receive more messages. To ask what participants usually did when they received the TM, a five-point scale was used, ranging from "Ignored it" (1) to "Read it immediately" (5).

The fidelity of the intervention checked by two other oral health professionals over 20% of the consultations (selected at random), in order to verify whether the consultation script was similar for all the patients and to ensure that the effects on gingival health did not depend on the consultation, using a four-item checklist (introduction and diagnosis, explanations, hygiene goals, and clinical procedures). In 80% of the checked appointments, the fidelity obtained was 100%. For the remaining 20%, the fidelity was above 90%.

5.2.4. DATA ANALYSIS

A dropout analysis and a randomization check were performed through multivariate analysis of variance (MANOVA) for the psychological determinants, behavior, and clinical gingival outcome, while ANOVA and Chi-square tests were used to compare continuous and categorical variables, respectively. Distribution normality (Shapiro-Wilk) and variance homogeneity (Levene's test) were verified for all outcome variables. To compare the three groups at the four-month follow-up, mixed between/within-subject repeated measures

ANOVA with intervention group (FF, NFH, NFH+TM) x assessment time (baseline vs. four months) were computed. Whenever differences of interest were found at baseline in outcome variables, the same analysis was repeated introducing baseline scores as a covariate.

5.3. RESULTS

5.3.1. DROPOUT ANALYSIS AND RANDOMIZATION CHECK

No significant differences between the longitudinal sample (n = 142) and those who dropped out (n = 2) were found in any baseline sociodemographic variables. However, a difference was found in intention, which was lower among those who dropped out (M = 4.00, SD = 4.24) in comparison to those who remained in the study (M = 6.00, SD = .86), p = .003.

No differences across the three groups were found at baseline in relation to sociodemographics, frequency of flossing, tooth brushing, or BOMP, nor on most of the psychological determinants (p > .10). Exceptions were found for intention, maintenance self-efficacy, and coping planning. At baseline, intention was significantly higher in the FF group than in the NFH+TM group; maintenance self-efficacy was significantly higher in the FF and NFH groups than the NFH+TM group; and coping planning was higher in the NFH+TM than the NFH group (all p < .05).

5.3.2. DESCRIPTIVE STATISTICS

Demographic descriptive data for the sample are presented in Table I. Participants' daily frequency of flossing was low at baseline; the majority never or barely used dental floss. Reference to other interdental devices to control dental plaque was low, with only 2.8% of individuals using interdental brushes. However, the majority of the sample brushed their teeth

twice a day (Table 5). The initial level of BOMP for the entire sample was relatively high, an average of 60% of points bleeding (Table 5).

The majority of the sample considered the messages useful for the treatment and rated the TM very positively overall in terms of comprehensibility, interest, and relevance (Table 5). Concerning the new floss holder, 69% liked it after four months of usage, although around a third of participants reported some difficulties in using it.

Table 5. BOMP and dental hygiene behavior descriptives for the total sample at baseline and 4-months (n =142). New Floss holder (n = 99) and text messages (n = 61) opinions.

		Baseline	**4 months**
		m (SD)	**m (SD)**
	BOMP	1.2 (.34)	0.7 (.32)
	Toothbrushing	3.8 (.75)	3.9 (.68)
	Flossing	1.7 (.79)	2.6 (.60)
		***n* (%)**	***n* (%)**
Flossing			
	Daily use	27 (19)	81 (56)
	Never use	115 (81)	61 (44)
Toothbrushing			
	Daily use	135 (95)	139 (98)
	Never or barely use	7 (5)	3 (2)
Other interdental device			
	Daily use	4 (3)	
	Never use	138 (97)	
New Floss Holder (GumChucks™)			
	I like the NFH and it's easy to use		68 (69)
	I like the NFH but it's not easy to use		25 (25)
	I don't like the NFH		6 (6)
Text Messages			
	Overall positive opinion about TM		55 (90)
	Overall negative opinion about TM		6 (10)
	The mobile TM are useful		54 (89)
	The mobile TM are not useful		7 (11)
	I am willing to receive messages less than once per week		17 (28)
	I am willing to receive one message per week		34 (57)
	I am willing to receive more than one message per week		10 (15)
	When I received a message, I read it immediately		36 (59)
	When I received the message, I read it later that day		12 (20)
	When I received the message, I didn't read it that same day		13 (21)

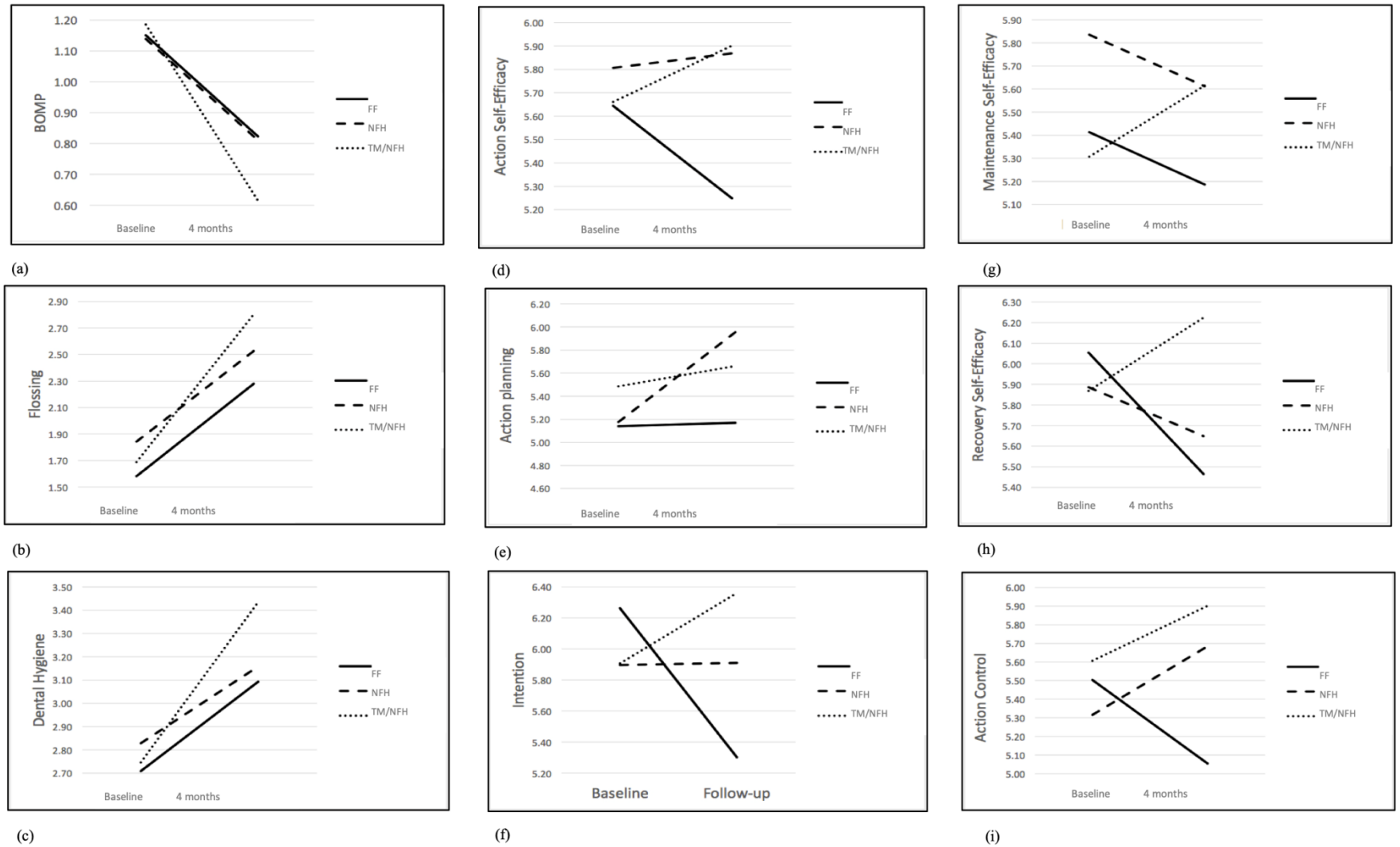

Figure 11. (a) Levels of bleeding on marginal probing (BOMP), (b) flossing, (c) dental hygiene (DH), (d) action self-efficacy, (e) action planning, (f) intention, (g) maintenance self-efficacy, (h) recovery self- efficacy and (i) action control in the two conditions at two points in time. DH combines toothbrushing and flossing frequency.

5.3.3. INTERVENTION EFFECTS ON CLINICAL AND BEHAVIORAL OUTCOMES

Values for interaction between group and time, and for the main effects of group and time at baseline and at the four-month follow-up are presented in Table II[3]. Significant interactions between intervention group and time were obtained for BOMP (F[1,139]=262.95, p<.001) (Figure 11a), for flossing (F[1,139]=134.74, p<.001) (Figure 11b), and for dental hygiene (F[1,139]=103.07, p<.001) (Figure 11c). While at baseline no differences between the groups were found for any of these three outcomes, at the four-month follow-up the NFH+TM group presented a significantly lower BOMP value (i.e., 0.6; SD=.32) and a significantly higher level of dental hygiene than the other two groups.

The average BOMP score in the NFH+TM group lowered from 1.2 (SD =.35) at baseline, to 0.6 (SD=.32) at 4 months, which corresponds to a change from 60% to 30% of sites bleeding from baseline to 4 months. Thus, the bleeding in the NFH plus TM group was lower than in the other two groups, as expected, but the NFH group results were not significantly lower than the FF group.

The NFH+TM group reported higher frequency of flossing at the four-month follow-up (67% of the individuals started using floss once a day) than the NFH group (50% started to use it once a day), which itself showed higher flossing frequency than the FF group (37% started to use it once a day).

[3] Given that baseline differences across the three groups were found for intention, maintenance self-efficacy, and coping planning, the repeated measures analyses described below were repeated using the baseline scores as covariates. However, the results were equivalent.

5.3.4. INTERVENTION EFFECTS ON PSYCHOLOGICAL DETERMINANTS OF ORAL HYGIENE

Interaction effects between intervention group *vs.* assessment time were obtained for nearly all the assessed psychological determinants. The two exceptions were for outcome expectancies, which were not affected by either time or the intervention, and for coping planning, which was significantly affected by time only, with all groups showing an increase in the planning of coping responses from baseline to four months, despite this increase only being significant in the NFH group ($M_{diff\ 4month\ -\ baseline}$ = 0.56, *SE* =0.24, *p* = .02).

While no significant differences existed between the groups at baseline in relation to action self-efficacy (Figure 11d), action planning (Figure 11e), or action control (Figure 11i), the levels for these determinants at the four-month follow-up were significantly higher in both the NFH and NFH+TM groups when compared to the FF group.

Despite the FF group showing a slightly-but-significantly higher level of intention at baseline (Figure 11f) the level of intention among participants in this group was significantly lower than those in the other two groups at the four-month follow-up; those in the NFH+TM group further showed a significantly higher level of intention than the NFH group. Participants in the NFH+TM group at the follow-up showed significantly higher levels of maintenance self-efficacy compared to FF (Figure 11g), as well as showing significantly higher levels of recovery self-efficacy than both FF and NFH groups (Figure 11h).

In summary, for the psychological determinants, the NFH+TM and the NFH groups showed a positive and significant change in action self-efficacy, action planning, and action control when compared to the FF group. Intention and recovery self-efficacy increased in the NFH+TM compared to the other two groups, and maintenance self-efficacy became higher in NFH+TM compared to FF.

5.4. DISCUSSION

This study was designed to evaluate the effects of using a new floss holder and text messages between appointments to improve gingival health. To that end, we assessed changes in adherence to interdental hygiene behaviors, clinical outcomes, and underlying psychological determinants among patients with gingivitis. Patients that received TM in addition to the NFH showed a higher frequency of flossing four months after the first appointment – on average attaining the recommended frequency of dental floss use (i.e., once a day) and, consequently, a lower level of gum bleeding – than individuals who used finger floss or only the NFH.

In the present study, the average BOMP score in the NFH+TM group fell significantly from baseline to the four-month follow-up, with only 30% of sites bleeding at this follow-up. This is a good score when compared with that described by Barendregt et al. (2002). According to these authors, fewer than 25% of sites bleeding on probing, can be considered to correspond to gingival health. However, it should be acknowledged that the values for percentage of bleeding have since been updated by Chapple et al. (2018), now defining periodontal stability as corresponding to fewer than 10% of sites with bleeding on probing.

As expected, the use of floss was also more frequent in the NFH group at 4 months than in the finger floss group, although this difference in behavior was not translated into a significant difference in the level-of-bleeding score (Worthington et al., 2019). As such, our fourth hypothesis was only partially confirmed, as it was expected that the NFH without TM would also present a significantly lower level of BOMP than the FF group, which was not the case. The same effect was found in other studies where the efficacy of floss holders was compared with finger floss (Blanck et al., 2007; Kleber & Putt, 1990).

It was also expected that TM would work as reminders or “cues to action”, thereby increasing proximity with the patient and frequency of flossing, and ultimately contributing

toward effective use. In this regard, significant results were obtained for frequency of use. The combined use of TM with the NFH contributed to better results than those found in systematic reviews which show that dental floss has a weaker effect on plaque or bleeding indices when used alone, due to patients' difficulty in accepting it and using it correctly as well as their low levels of motivation and of dexterity (Sälzer et al., 2015; Van der Weijden & Slot, 2015; Worthington et al., 2019).

In comparison to traditional finger floss, the use of NFH can only be considered a different way to get the string between the teeth. However, the satisfaction with its use reported in other studies of floss holders was lower than was found in the present study (i.e., around 70% vs. 90.1%) (Blanck et al., 2007; Kleber & Putt, 1990). This could have contributed to an increase in patients' motivation at follow-up, inferred by increases in action self-efficacy and intention, thereby confirming hypothesis one.

Levels of recovery self-efficacy were higher in the NFH+TM group, as expected, but the other self-regulation variables were shown to be as high as in the NFH group. Hence, the second hypothesis was only confirmed for recovery self-efficacy. One explanation for this may be that, as the messages functioned as reminders for oral hygiene behaviors, they reinforced the subjects' beliefs that it is possible to return to and reach the objective even after a lapse (i.e., recovery self-efficacy). However, the fact that the NFH+TM group showed improved results at the behavioral level, without any significant differences in self-regulation variables (except in recovery self-efficacy), may mean that part of the effect TM had on behavior operated via non-deliberated, automatic processes – not mediated by these deliberate self-regulatory cognitive processes(Hofmann, Friese, & Wiers, 2008).

The primary and secondary outcomes therefore point to an increase in motivation resulting from the use of a new device to facilitate flossing, but only when accompanied by the use of TM does this new floss holder ultimately help to reduce levels of gingival bleeding.

Similarly, to what is described in the literature, we found that the use of floss improved with increasing levels of intention, but that intention alone did not suffice to attain the desired outcome, and that other self-regulatory processes or cues to action must also be deployed. The TM seem to have worked as a cue to action in the NFH+TM group, causing an effect on flossing that could not be fully explained through an increase in self-regulation. Moreover, and as in some previous studies, it was not the changes in planning but rather changes in self-efficacy that helped to explain the behavioral and clinical modifications obtained (Zhou et al., 2015).

In light of patients' positive reactions to the TM, and considering the formality that traditionally characterizes the relationship between the oral health professional and the patient (Newton & Asimakopoulou, 2015), the use of a strategy such as sending TM may also have contributed to forming a closer relationship between the professional and the patient, facilitating relationship-centered healthcare (Toniazzo et al., 2019). It may also have contributed to behavior changes as it consisted of persuasive messages coming from a credible source and a source of social support, fostering patients' self-efficacy and belief in being able to handle the challenge (Newton & Asimakopoulou, 2015; Toniazzo et al., 2019).

Several study limitations should be considered in the interpretation of our findings. Although all patients used floss less frequently than recommended, they were generally motivated for oral hygiene behaviors, as can be inferred by high levels of intention at baseline. This is not surprising, considering that all patients had gingivitis and had been invited to treat it at no cost. Hence, these results can only be generalized to similarly motivated individuals with low levels of floss usage. In order to better understand the motivational contribution provided by the new floss holder, a group combining the use of finger floss with TM will be important to include in future studies. Future studies should also consider the comparison of floss holder devices vs another interdental cleaning aid such as interdental brushes, water flossers, and wood sticks.

In spite of the aforementioned limitations, this study had several strengths. The first was having included not only self-reported measures, but also objective clinical measures. Secondly, the consultation was designed to include important behavior change techniques in both groups, which represents an important addition to the usual care employed in dental consultations. Thirdly, having included a follow-up at four months; although this interval should be lengthened in future studies, it is greater than many of the follow-ups normally used (Newton & Asimakopoulou, 2015; Worthington et al., 2019).

The findings presented also have important implications for practice, especially considering that TM are inexpensive, easy to apply, and may be easily introduced into the routines of oral health professionals and integrated within a broader stepped-care approach (Toniazzo et al., 2019). The option of articulating different interventions (NFH+TM) is also innovative, seeking to create a multiaction strategy to optimize the oral health behaviors addressed in the consultation. Simply telling our patients to brush and floss is just not working (Wilder, 2013). However, flossing can work if people become motivated do it frequently and correctly (Vernon et al., 2017; Worthington et al., 2019).

Finding positive results not only in motivation, but especially in self-regulation processes underlying behavioral change, is an unusually good result. Even when interventions are effective in fostering motivation for change, the translation of this intention into self-regulation for behavior change is more difficult to achieve (Araújo et al., 2016; Solberget al., 2000). The coaction of the NFH and the TM contributed to behavioral changes four months after the first consultation, with resulting clinical improvements. This research stresses the utility of text messaging used in conjunction with a floss holder to improve oral health behavior.

5.5. CONCLUSION

Flossing with a new floss holder contributed to improving behavioral and psychological determinants of gingival health, but clinical parameters only reached significant improvements when used in conjunction with text messages. By fostering patients' motivation and by serving as an alternative way to create cues to action and form alternative routines and strategies, mobile text messages and alternative flossing devices can help to reach therapeutic objectives and make the management of pathologies such as gingivitis more effective.

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6. EMPIRICAL STUDY 3

An eight-month randomized controlled trial on the use of intra-oral cameras and text messages for gingivitis control among adults

This chapter is based on the paper:

Araújo, M.R., Alvarez, M.-J., Godinho, C.A., & Roberto, M.S. (2020). An eight-month randomized controlled trial on the use of intra-oral cameras and text messages for gingivitis control among adults. *International Journal of Dental Hygiene, 17*, 202-213. doi:10.1111/idh.12391.

ABSTRACT

Objective: To investigate the effects of using an intra-oral camera (IOC) during a dental hygiene consultation and mobile text messages (TM) between appointments on clinical, behavioural and psychological parameters of patients with gingivitis.

Materials and methods: Patients were randomly assigned into four conditions: IOC, TM, IOC + TM and control, and examined at three assessment points over eight months (N = 142). Bleeding on marginal probing (BOMP), dental hygiene (brushing and flossing) and social cognitive determinants of behaviour change (outcome expectancies, action and volitional self-efficacy, intention, planning and action control) were evaluated in an examiner-blind controlled study. Mixed-effects modelling was employed to examine changes in study outcomes. Mediations by the psychological determinants were inspected for the effect on treatment groups in clinical parameters and behaviour.

Results: Compared to the control group, all treatment conditions improved dental hygiene and revealed a significant decrease in BOMP from baseline to 4 months, maintained at 8 months; this was clinically relevant in the IOC + TM group, where individuals had more positive outcome expectancies as well as higher levels of action self-efficacy and intention from baseline to four months, maintained at eight months. Volitional self-efficacy was reinforced in all treatments. The psychological determinants did not prove to be the mechanisms responsible for these effects.

Conclusions: A multiple-strategy benefit from using the IOC in consultation and TM between appointments improves clinical, behavioural and psychological parameters of periodontal health four months after treatment, maintained at eight months' follow-up. Insights are provided for the efficacy of the images and text messages for oral hygiene changes.

Keywords: gingivitis, health behaviour, intra-oral photography, oral hygiene, self-regulation

6.1. INTRODUCTION

It is known that effective control of dental plaque is a pillar of gingival health (Tonetti et al., 2015). Tooth brushing and interproximal plaque control are the most appropriate ways to prevent and treat gingivitis (Berchier, Slot, Haps, & Van der Weijden, 2008). However, use of these methods does not always reach the level necessary to be effective in plaque reduction, especially in interproximal areas (Berchier et al., 2008; Jepsen et al., 2017; Sambunjak et al., 2011).

Interventions for the promotion of oral hygiene behaviours usually consist only on the transmission of information to patients in the absence of a theoretical rationale about behavioural change (Ramseier & Suvan, 2010; Wilder, 2013). However, other behavior changes techniques have proven to be more successful than information provision for the promotion of health behaviours (Newton & Asimakopoulou, 2015), and interventions tend to be more effective when they are grounded on behavior change theories and supported by additional communication methods, such as the use of intra-oral cameras (IOC) and text messages (TM) (Araújo et al., 2016; Webb, Joseph, Yardley, & Michie, 2010).

It is essential that patients clearly understand the oral hygiene behaviours suggested by the oral health professional and that these are adopted in the long term to be effective in controlling gingivitis. This has stimulated the use of strategies that can enhance these effects and thereby make the dental hygiene consultation more effective.

Little research is available on the effects of the IOC on the oral hygiene behavior of patients, but when used as a coadjuvant of verbal communication it has shown important effects on patients' motivation and on levels of bleeding and plaque (Willershausen et al., 1999). More recent results have shown that this can also act at the level of self-regulation, more specifically on psychological variables that contribute to the maintenance of behavior, such as the

perception of self-efficacy in the various phases of the process of change, with results for oral hygiene habits and gingival health improvement (Araújo et al., 2016).

Although not high in number, there have been more studies done on the use of TM in the service of oral hygiene. These have shown that TM are a useful tool as reminders of review consultations (Perry, 2011), in the acquisition of knowledge, in the motivation to change oral health behaviours (Sharma, Hebbal, Ankola, & Murugabupahty, 2011), and as reminders for these behaviours (Bellucci, Dharmesena, Nguyen, & Calache, 2017).

According to Scheerman et al. (2016), framework models such as the HAPA (Health Action Process Approach) (Schwarzer, 2008) can improve the understanding of oral hygiene behaviours as well as provide better strategies for behavioural change, as motivational interventions seeking preventive self-care behavior must be augmented by interventions that enable behavioural intentions to be successfully translated. This model takes volitional (i.e., self-regulatory) processes into consideration, which have been put forward as psychological mechanisms that help to transform intentions into effective actions.

The present study aimed to test the effects of using an IOC and TM, together and separately, in a dental hygiene consultation where behavior change techniques were used, in order to boost the frequency of oral hygiene behaviours and to maintain a decrease in patients' BOMP (primary outcomes). As secondary outcomes we aimed to evaluate the effects of these technologies on the psychological determinants described by the HAPA, and to examine the mediating role of these determinants in flossing behavior and clinical parameters, in order to understand how these interventions, bring about their effects.

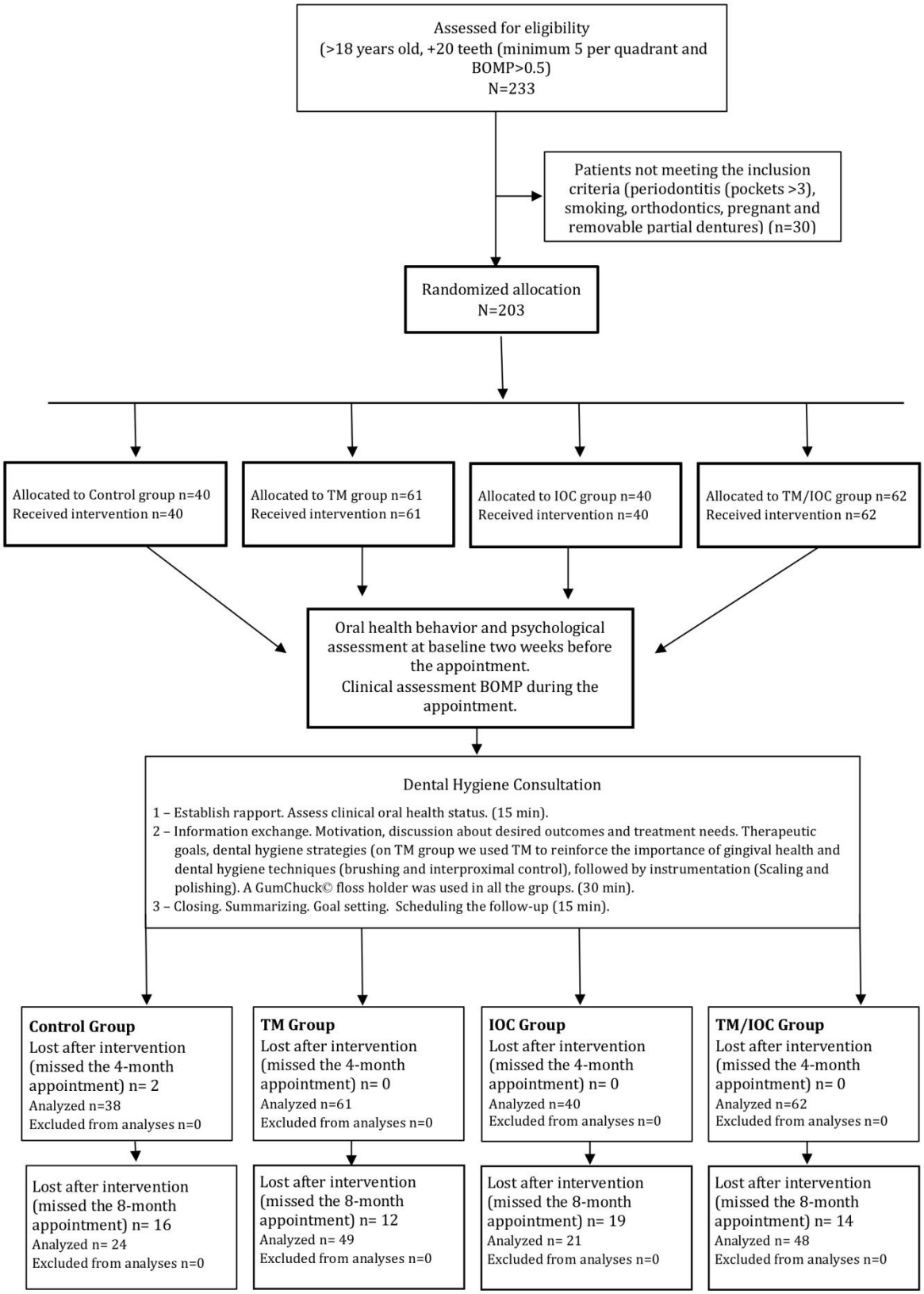

Figure 12. Study flow chart

6.2. STUDY POPULATION AND METHODOLOGY

Four groups were created to study the effect of two technological devices, an intra-oral camera (IOC) and text messages (TM) to increase communication with patients and/or to keep in touch with them, using images provided by the IOC, and the use of TM between consultations. The intervention was reinforced with evidence-based strategies for the change and maintenance of oral hygiene behaviours.

6.2.1. PARTICIPANTS

A total of 233 patients, aged 18 years or more, with more than 20 teeth (with a minimum of 5 per quadrant), and a level inflammation over 0.5 (measured by the bleeding on marginal probing index - BOMP), completed the baseline questionnaire. Thirty were not included in the final sample due to the exclusion criteria, such as being smokers or the presence of periodontitis (pockets ≥ 5 mm), orthodontic appliances, and removable partial dentures (see Figure 12). The final sample was composed of 142 patients, aged 18-70 years (Mean (*M*) = 38.4; Standard Deviation (*SD*) = 12.49) of which 84 (59%) were women (Table 6).

Table 6. Demographic characteristics of the final longitudinal sample for the total sample and by groups.

	Total sample (N = 142)	Groups			
		Control (n = 24)	IOC (n = 21)	TM (n = 49)	IOC + TM (n = 48)
Age (M [SD])	38.40 (12.49)	40.92 (12.31)	36.86 (11.01)	37.45 (11.72)	38.79 (14.03)
Range	18-70	18-69	20-57	18-70	18-63
Gender n (% women)	84 (59%)	14 (58%)	13 (62%)	31 (63%)	26 (54%)
Highest qualification n (%)					
Basic education	07 (5.0%)	3 (12.5%)	2 (9.5%)	1 (2.0%)	1 (2.0%)
Secondary education	12 (8.5%)	3 (12.5%)	2 (9.5%)	1 (2.0%)	6 (12.5%)
Higher secondary education	50 (35.0%)	7 (29.0%)	4 (19%)	21 (43.0%)	18 (37.5%)
University and tertiary education	73 (51.5%)	11 (46.0%)	13 (62%)	26 (53.0%)	23 (48.0%)

A randomized controlled trial was run for eight months, delivered by an experienced (more than 25 years of experience) certified bachelor dental hygienist, in two private dental clinics. Individuals were recruited by advertisements in local newspapers, dental clinics, and local business. Two weeks before the dental consultation (DC), participants read, acknowledged and accepted the conditions of a digital informed-consent form and filled out an online questionnaire with measures on psychological determinants and oral health behaviors. Clinical data were collected in the DC, after which participants were allocated by the researcher's assistant using a computer-generated random sequence (Randone: Randomizer©) into one of the four groups: Control, IOC, TM, and IOC+TM. Their levels of gingival bleeding were noted using the BOMP index (Van der Weijden et al., 1994), and this was repeated for the second and third consultations. The BOMP was done in such a way that each patient's group was unknown to the oral health professional. This index was validated through reassessment of a random 20% of the patients by an oral health professional (dentist with more than 20 years of experience) trained and calibrated for this purpose. This reassessment was performed at baseline, at four, and at eight months, 30 minutes after the initial evaluation.

The consultation was free of charge, lasted one hour of duration, and was organized in accordance with the features of each patient, such as their gingival condition, gingivitis perception, habits, and expectations concerning the treatment (Suvan et al., 2010). It also included specific behavior change techniques, such as goal-setting, feedback, and reinforcement (behavior change techniques number 1.1, 2.1, 2.7, and 10.4 as described by Michie et al. (2013).

A description of the consultation is provided in Figure 12**.** This sequence, specified in a guide that was developed for this study, was followed in all the groups. Two oral health professionals trained for this purpose ensured fidelity using a four-item checklist (introduction

and diagnosis, explanations, therapeutic goals, and clinical procedures) in a random 15% of the interventions, controlling the communication strategy in the key phases of the consultation.

In the IOC group, an ACTEON Soprocare® intra-oral camera was used in the examination and diagnosis phase as well as during the explanation of oral hygiene strategies. It was used to capture photographs of areas of inflammation (gingivitis) and dental plaque that were later shown and discussed with the patient. In the TM group, weekly text messages with an average of 170 characters were sent during the first four months, a total of 16 messages received by each patient (Appendix 2). The purpose and timing of the messages were explained to patients at the first consultation. They were created for the purpose of changing oral hygiene behaviours in patients with gingivitis by cementing strategies for inflammation control. In composing message content, characteristics such as humour, assertiveness, comprehensibility, originality, size, and individualization were considered for the importance they have in making an impact with the receptor (Gold et al., 2010). The messages were also aimed at the determinants of behavior change present in the HAPA: outcome expectancies, intention, planning, self-efficacy, and action control. Both technologies were used in the IOC+TM group. The consultation procedures used in the other groups were also followed in the control group, treating it as an active control including specific behavior change techniques as described in Figure 12. At four and eight months the same consultation was repeated. Additionally, all patients received a GumChuck® floss holder at the first appointment to use for flossing at home.

The study was approved by the ethics committee (Ethics Committee Doc. No. 6/14) and all participants signed an informed consent form at the outset. This study has been registered at the ClinicalTrials.gov database (NCT03439969) and was conducted in accordance with the CONSORT guidelines. The flow chart of the study is presented in Figure 12.

6.3. MEASURES

The gingival condition was assessed using the BOMP index, described by Van der Weijden et al. (1994). In this index, bleeding is scored during 30 seconds of probing using a three-point scale, from 0 to 2 (0 = no bleeding, 1 = pinprick bleeding, 2 = excessive bleeding).

For assessing dental hygiene, two questions on brushing and flossing habits were asked, and a five-point scale (1 = not brushing or flossing, 2 = barely, 3 = once a day, 4 = twice a day, and 5 = more than twice a day) was used. Individual scores were calculated for brushing and for flossing, and a composite score for dental hygiene was also computed based on both.

Measures of psychological determinants were adapted to oral health from previous studies with the HAPA model (Godinho et al., 2014). All the HAPA constructs were evaluated using a seven-point Likert scale, ranging from "totally disagree" (1) to "totally agree" (7), unless otherwise stated. See Table 8 for internal consistency and item examples.

Intra-oral camera opinion was measured by adapting a nine-item scale (Shaw, 2012) considering satisfaction and usefulness, and a five-point Likert scale, ranging from "totally disagree" (1) to "totally agree" (5), was used.

6.3.1. ANALYTIC STRATEGY

A multivariate analysis of variance (MANOVA), several analyses of variance (ANOVA) and Chi-square tests were performed to test group equivalence at baseline. Distribution normality (Shapiro-Wilk) and variance homogeneity (Levene's test) were verified for all outcome variables.

Mixed-effect modelling (Rasbash & Goldstein, 1994) was employed to verify if change occurred in study outcomes (from baseline to four-month and eight-month assessments between treatments [control, IOC, TM, and IOC+TM] groups. Two-level mixed models were

tested in which intra-individual repeated measures (level-1) were nested within individuals (level-2). This statistical approach was selected to account for the hierarchical structure of the data and its non-independence. Models included time, treatment group, and treatment-by-time interaction as predictors of flossing and dental hygiene behaviours, BOMP, and the psychological determinants. In terms of sample size, literature on multilevel techniques revealed that little to no bias was exhibited in the estimates of fixed parameters and level-1 variance when small sample sizes are used; for fewer than 30 clusters only level-2 variance exhibited an increased bias (e.g., Bell, Ferron, & Kromrey, 2008; Clarke, Wheaton, & Clarke, 2007; Maas & Hox, 2005; McNeish & Stapleton, 2016). Although the sample size in the present study has more than 30 level-2 units (n =198 with all available units for each time point being used), due to the underlying complexity of multilevel modelling only random-intercept models were estimated, using REML, a robust estimation of variance components.

An additional analysis was performed to test the hypothesis of mediation, examining whether the effect of treatment groups on dental hygiene and BOMP was mediated by the psychological determinants. Results obtained from mixed models were used as criteria for the selection of the psychological determinants for the mediation equation model, according to their statistical significance set at 0.05. The independent variable was recoded into a binary categorical variable, allowing comparisons between a general treatment group (comprising IOC, TM, and IOC+TM) and control. The significance of indirect effects was examined and information for 95% bias-corrected confidence intervals was retrieved after the estimation of 1,000 bootstrap samples.

SPSS (v. 23, IBM Corp.) was used to conduct descriptive statistics, while mixed-model analyses were performed using packages designed for R environment (R Core Team, 2015): lme4 package (Bates, Maechler, Bolker, & Walker, 2015) and lmerTest (Kuznetsova, Brockhoff & Christensen, 2016). Mediation tests were executed using Lavaan (Rosseel, 2012).

6.4. RESULTS

6.4.1. RANDOMIZATION CHECK

Analysis revealed no differences across the four groups at baseline in sociodemographic, psychological, behavioural, and clinical variables (p's > 0.11), except for the educational level, $\chi 2(12) = 21.37$, $p = 0.045$, with more participants having only basic education in control and IOC groups.

6.4.2. DROPOUT ANALYSIS

Analysis comparing both samples at baseline allowed the conclusion that the longitudinal sample (n = 142) was representative of those who dropped out at four (n = 2) and eight months (n = 59), as no differences were found in any sociodemographic, psychological, behavioural, or clinical variables (p's > 0.11).

A difference was revealed at the eight-month follow-up among conditions $\chi 2(3) = 12.45$, $p < 0.006$, with the IOC group having fewer follow-up responses. Participants' characteristics were not associated with the dropout rate, and the lesser maintenance in the IOC group was not due to different opinions about the IOC between those who continued or discontinued the participation in the study $F(1, 39) = .49$, $p = 0.49$.

6.4.3. DESCRIPTIVE STATISTICS

Table 1 shows participants' characteristics in the total longitudinal sample and separately by the randomization groups. Means and standard deviations for clinical, behavioural, and psychological determinants at baseline, four months, and eight months are presented in Table 7. A total of 97% of the participants brushed their teeth at least once a day and a majority (74.4%) brushed twice or more per day. Participants reported a low level of dental flossing

frequency, with 80.8% never or hardly ever using dental floss and the level of BOMP was high at baseline 1.2 (*SD* = 0.31).

Table 7. Examples and number of items, Cronbach's alpha, mean, and standard deviation for behavioral, clinical, and psychological determinants at baseline and at 4 and 8-month follow-ups for the total sample and for separate groups.

		Total sample *M* (*SD*)			Control *M* (*SD*)			IOC *M* (*SD*)			TM *M* (*SD*)			IOC + TM *M* (*SD*)		
	Item example (number of items and Cronbach's alpha at baseline)	Baseline *N*= 203	4 months *n*= 201	8 months *n*= 142	Baseline (*n*= 40)	4 months (*n*= 38)	8 months (*n*= 24)	Baseline (*n*= 40)	4 months (*n*= 40)	8 months (*n*= 21)	Baseline (*n*= 61)	4 months (*n*= 61)	8 months (*n*= 49)	Baseline (*n*= 62)	4 months (*n*= 62)	8 months (*n*= 48)
BOMP		1.19 (.31)	.59 (.32)	.55 (.28)	1.12 (.33)	.81 (.33)	.77 (.28)	1.20 (.29)	.61 (.28)	.59 (.25)	1.19 (.35)	.62 (.33)	.59 (.27)	1.23 (.28)	.42 (.23)	.39 (.21)
Brushing	How often have you brushed your teeth in the last two weeks/four months? (1)	3.91 (.73)	4.00 (.60)	4.00 (.51)	3.83 (.78)	3.79 (.62)	3.75 (.53)	3.90 (.63)	3.95 (.50)	3.90 (.54)	3.80 (.75)	4.07 (.63)	4.00 (.46)	4.08 (.73)	4.11 (.60)	4.17 (.48)
Flossing	How often have you flossed your teeth in the last two weeks/four months? (1)	1.72 (.80)	2.81 (.59)	2.65 (.54)	1.85 (.83)	2.53 (.51)	2.33 (.48)	1.68 (.76)	2.80 (.65)	2.62 (.59)	1.69 (.81)	2.80 (.54)	2.57 (.54)	1.71 (.82)	3.00 (.57)	2.90 (.43)
DH (Brush and Floss)	Flossing and brushing together.	2.82 (.58)	3.40 (.44)	3.29 (.40)	2.84 (.58)	3.16 (.45)	3.08 (.35)	2.79 (50)	3.37 (.43)	3.28 (.41)	2.75 (.59)	3.40 (.35)	3.28 (.38)	2.89 (.62)	3.56 (.48)	3.41 ((.39)
Outcome Expectancies	Avoiding bleeding gums/Avoiding bad breath. (7; α= .84)	5.78 (.90)	6.00 (.81)	5.99 (.71)	5.7 (.83)	5.79 (.59)	5.78 (.54)	5.89 (.95)	5.84 (.80)	5.85 (.68)	5.72 (.99)	5.91 (.98)	5.90 (.81)	5.80 (.82)	6.31 (.66)	6.24 (.63)
Action Self-Efficacy	I believe I can clean interproximally and brush daily, even if it is difficult for me. (3; α= .84)	5.75 (.94)	6.08 (.94)	6.00 (.70)	5.84 (.99)	5.87 (.87)	5.68 (.56)	5.64 (1.03)	5.98 (.82)	5.86 (.55)	5.66 (.82)	5.90 (1.12)	5.90 (.62)	5.84 (.93)	6.44 (.74)	6.33 (.78)
Intention	In the oncoming weeks I intend to carry out interproximal cleaning and brush my teeth. daily (3; α= .93)	5.93 (1.02)	6.32 (.80)	6.06 (.87)	5.78 (1.41)	5.91 (.88)	5.82 (.65)	6.12 (.98)	6.21 (.68)	5.95 (.66)	5.91 (.71)	6.36 (.81)	5.90 (1.11)	5.95 (.99)	6.60 (.71)	6.38 (.68)
Maintenance Self-Efficacy	I believe I can maintain my daily interproximal control and tooth brushing habits even if I feel lazy about doing it. (4; α= .86)	5.50 (1.14)	5.67 (1.08)	5.60 (.94)	5.84 (1.13)	5.61 (1.23)	5.34 (1.08)	5.43 (1.26)	5.70 (.95)	5.60 (.92)	5.31 (1.11)	5.61 (1.05)	5.52 (.92)	5.52 (1.06)	5.73 (1.12)	5.81 (.90)
Recovery Self-Efficacy	If I've failed to control interproximal areas or brush my teeth on a daily basis, I believe I could start again (3; α= .82)	5.89 (1.06)	6.17 (.89)	6.02 (.92)	5.94 (1.21)	5.65 (.98)	5.53 (.98)	5.95 (1.26)	6.12 (.96)	6.16 (.78)	5.87 (.87)	6.22 (.76)	5.88 (.94)	5.83 (1.03)	6.46 (.78)	6.36 (.81)
Action Planning	I already have plans on how to brush my teeth and use an interproximal aid. (3; α= .82)	5.25 (1.36)	5.80 (1.09)	5.34 (1.24)	5.11 (1.56)	5.96 (.97)	5.56 (.98)	5.05 (1.46)	5.91 (1.13)	5.14 (1.36)	5.48 (1.20)	5.66 (1.14)	5.04 (1.40)	5.23 (1.31)	5.78 (1.09)	5.63 (1.02)
Coping Planning	I have plans for what I should do if I have difficulties in practicing my dental hygiene. (3; α= .81)	5.15 (1.41)	5.64 (1.12)	5.33 (1.15)	4.68 (1.59)	5.27 (1.33)	5.00 (1.30)	5.14 (1.39)	5.76 (.96)	5.46 (.72)	5.30 (1.29)	5.51 (1.04)	5.20 (1.20)	5.32 (1.38)	5.92 (1.09)	5.58 (1.16)
Action Control	I strive to act according to my intention to brush my teeth and use an interproximal aid daily. (3; α= .84)	5.47 (1.10)	5.86 (.94)	5.77 (.98)	5.28 (1.31)	5.68 (1.31)	5.61 (1.09)	5.42 (1.13)	5.79 (.89)	5.68 (1.00)	5.61 (.86)	5.90 (.93)	5.64 (1.13)	5.51 (1.15)	5.96 (.92)	6.03 (.69)

Table 8. Generalized linear mixed model of dental hygiene, BOMP, and HAPA constructs (n level-2 = 198; n level-1= 546).

Fixed Effects	Dental Hygiene	BOMP	Outcome Expectancies	Action Self-Efficacy	Intention	Maintenance Self-Efficacy	Recovery Self-Efficacy	Action Planning	Coping Plan	Action Control
	B(SE)	B(SE)	B(SE)	B(SE)	B(SE)	B(SE)	B(SE)	B(SE)	B(SE)	B(SE)
Intercept	3.16(.08)***	.80(.05)***	5.77(.13)***	5.88(.14)***	5.88(.14)***	5.61(.17)***	5.67(.15)***	5.93(.20)***	5.26(.20)***	5.67(.16)***
Group										
IOC	.20(.11)	-.21(.06)**	.08(.18)	.08(.20)	.31(.20)	-.01(.24)	.33(.21)	-.05(.28)	.45(.28)	.10(.23)
TM	.27(.10)**	-.18(.06)**	.15(.17)	.02(.18)	.484(.18)**	-.01(.22)	.55(.20)**	-.27(.26)	.26(.25)	.23(.21)
IOC+TM	.39(.10)***	-.38(.06)***	.53(.17)**	.57(.18)**	.72(.18)***	.15(.22)	.85(.19)***	-.14(.25)	.69(.25)**	.31(.21)
Time										
T1	-.32(.09)***	.32(.05)	-.04(.05)	-.04(.16)	-1.04(.17)	.22(.16)	.27(.16)	-.82(.22)***	-.58(.22)**	-.40(.19)*
T3	-.08(.10)	-.02(.05)***	-.01(.18)	-.18(.19)	-.15(.20)	-.23(.20)	-.09(.19)	-.40(.26)	-.27(.26)	-.08(.22)
Group*Time										
IOC*T1	**-.26(.12)***	**.27(.06)*****	.09(.21)	-.30(.23)	.01(.24)	**-.49(.23)***	-.43(.22)	-.03(.31)	-.03(.31)	-.02(.26)
TM *T1	**-.36(.11)*****	**.25(.05)*****	-.15(.19)	-.20(.21)	-.35(.22)	**-.53(.21)***	**-.62(.20)****	**.65(.29)***	.37(.29)	-.10(.24)
IOC+TM*T1	**-.34(.11)****	**.49(.05)*****	**-.47(.19)***	**-.55(.21)****	**-.55(.22)***	**-.44(.21)***	**-.90(.20)*****	.27(.29)	-.02(.28)	-.06(.24)
IOC*T3	.03(.15)	-.01(.07)	.02(.26)	.01(.28)	-.02(.30)	.20(.28)	.21(.27)	-.24(.38)	.06(.38)	.04(.32)
TM*T3	-.09(.12)	-.01(.06)	.00(.22)	.17(.24)	-.31(.25)	.17(.24)	-.26(.23)	-.22(.33)	-.08(.33)	-.29(.27)
IOC+TM*T3	-.09(.12)	.19(.06)	-.06(.22)	.10(.24)	-.06(.25)	.31(.21)	.21(.27)	.24(.33)	-.05(.33)	.16(.27)

Note. Results show the control group and T2 as references for comparison. *** < .001; ** <.01; * <.05

Table 9. Unstandardized estimates, standard errors and indirect effects for mediation models

	Study Outcomes	
	Dental Hygiene	BOMP
Step 1 (X -> Y)		
Intervention vs. Control Groups	0.31(0.08)***	-0.27(0.05)***
Step 2 (X -> M)		
Outcome Expectations	0.25(0.11)**	0.25(0.11)**
Action Self-Efficacy	0.26(0.16)	0.26(0.16)
Intention	0.52(0.15)**	0.52(0.15)**
Maintenance Self-Efficacy	0.07(0.21)	0.07(0.21)
Recovery Self-Efficacy	0.64(0.18)***	0.64(0.18)***
Action Planning	-0.19(0.18)	-0.19(0.18)
Step 3 (X and M -> Y)		
Intervention vs Control Groups	0.24(0.08)**	-0.24(0.05)***
Outcome Expectations	0.01(0.03)	-0.01(0.03)
Action Self-Efficacy	0.05(0.03)	-0.04(0.02)
Intention	0.05(0.03)	-0.03(0.02)
Maintenance Self-Efficacy	0.01(0.03)	0.02(0.02)
Recovery Self-Efficacy	0.08(0.03)*	0.00(0.03)
Action Planning	0.05(0.03)	-0.02(0.02)
Bootstrapped indirect effects		
Outcome Expectations	0.00(0.01)	-0.00(0.01)
Action Self-Efficacy	0.01(0.02)	-0.01(0.01)
Intention	0.01(0.03)	0.01(0.01)
Maintenance Self-Efficacy	0.00(0.01)	0.00(0.01)
Recovery Self-Efficacy	0.05(0.03)	-0.03(0.02)
Action Planning	-0.01(0.01)	0.01(0.01)

Note: *** $p < .001$, ** $p < .01$, * $p < .05$; unstandardized estimates with standard errors in parenthesis. Step 1 dependent variable (Y) predicted by independent variable (X); Step 2 mediators (M) predicted by independent variable (X); Step 3 dependent variable (Y) predicted by independent variable (X) and mediators (M).

6.4.4. TIME AND TREATMENT EFFECTS

Mixed-model results indicated that there were significant interaction effects for each outcome (dental hygiene, BOMP, and psychological determinants). As shown in Table 8, all treatment groups improved dental hygiene behaviours and revealed a significant decrease in BOMP from baseline to four months, in comparison to the control group. Changes in dental hygiene behaviours revealed to be due to changes in flossing, instead of tooth brushing, as modifications were observed in flossing for all groups and only in TM group for tooth brushing (Table 9).

Hierarchical linear regressions also showed that individuals in the IOC+TM group had more positive outcome expectancies, revealed higher levels of action self-efficacy, and presented a significant improvement in their intention from baseline to four months when compared to the control group. All treatment groups reinforced their maintenance and recovery self-efficacies when compared to the control group from baseline to four months. For action planning, results indicated participants in the TM group lowered their levels of this determinant from baseline to four months. No significant interactions were found for action control or coping planning, even though a main effect for the group was detected for the latter, indicating that individuals in the IOC+TM group had higher levels of coping planning than the control group. No differences or a slight, non-significant decrease of the overall values were detected between the four-month and eight-month follow-ups for almost all the variables. Table 10 provides additional information.

6.4.5. MEDIATION ANALYSIS

Due to the absence of differences or a slight decrease in the study outcomes between four and eight months post-intervention, with the largest impact arising at four months in the mixed-model results, this time range was chosen for mediation analysis. Results obtained from mixed models led to the selection of outcome expectancies, action planning, action self-efficacy,

maintenance self-efficacy, recovery self-efficacy, and intention as mediators. Mediation models were tested to evaluate the indirect effect of condition on each outcome through our hypothesized mediators; results did not reveal significant indirect effects through the tested psychological determinants (Figure 13) (Table 10).

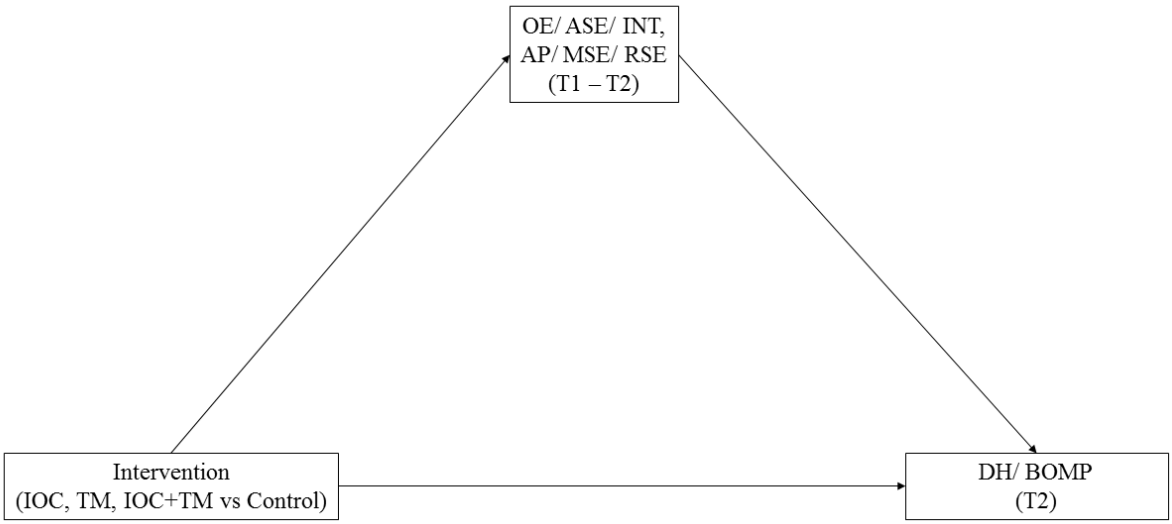

Figure 13. Mediation models of the effects of treatment via mediators on dental hygiene (DH) and bleeding on marginal probing (BOMP). *Note*: AP, action planning; ASE, action self-efficacy; INT, intention; IOC, intra-oral camera; Mediators: OE, outcome expectancies; MSE, maintenance self-efficacy; RSE, recovery self-efficacy; TM, text messages

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Table 10. Supplementary statistics for generalized linear mixed model of toothbrushing, flossing, dental hygiene, BOMP, and the HAPA (n level-2 = 198; n level 1= 546)

Fixed Effects	Toothbrushing			Flossing			Dental Hygiene			BOMP			Outcome Expectancies		
	df	*t*	*p*	df	*t*	*p*	df	*t*	*p*	df	*t*	*p*	df	*t*	*p*
Intercept	322.8	37.400	<.001	467.4	23.934	<.001	417.8	40.255	<.001	373.4	17.104	<.001	450.8	44.068	<.001
Group															
IOC	354.1	1.118	.264	475.7	1.715	.086	432.8	1.869	.062	395.5	-3.213	.001	461.3	0.450	.653
TM	317.1	2.071	.039	462.8	2.055	.040	411.8	2.731	.006	367.1	-3.070	.002	445.7	0.872	.383
IOC+TM	334.9	2.469	.014	468.5	3.440	.000	342.5	3.901	<.001	380.7	-6.366	.000	452.7	3.188	.001
Time															
T1	341.6	0.337	.734	350.9	-5.460	<.001	342.5	-3.796	<.001	342.7	6.885	<.001	348.3	-0286	.775
T3	352.3	-0.751	.453	378.6	-1.199	.231	364.1	-0.777	.437	358.7	-0.388	.698	373.7	-0.078	.938
Group*Time															
IOC*T1	339.1	-0.644	.520	347.6	-2.560	.001	339.3	-2.205	.028	339.7	4.131	<.001	345.0	0.408	.683
TM *T1	339.6	-2.587	.010	348.3	-2.745	.006	340.0	-3.345	<.001	340.4	4.203	<.001	345.7	-0.766	.444
IOC+TM*T1	339.7	-0.551	.581	348.3	-3.862	.000	340.0	-3.105	.002	340.4	8.333	<.001	345.7	-2.453	.014
IOC*T3	354.9	0.442	.659	384.1	0.176	.860	368.5	0.181	.856	362.2	-0.126	.899	378.8	0.097	.922
TM*T3	349.5	-0.101	.919	372.4	-0.318	.750	359.0	-0.730	.466	354.7	-0.207	.835	368.0	0.019	.985
IOC+TM*T3	349.9	0.688	.492	373.2	0.424	.671	359.7	-0.683	.495	355.3	0.281	.778	368.7	-0.82	.777

Supplementary_file_S2 (cont.)

Fixed Effects	Action Self-Efficacy			Intention			Maintenance Self-Efficacy			Recovery Self-Efficacy		
	df	*t*	*p*	df	*t*	*p*	df	*t*	*p*	df	*t*	*p*
Intercept	458.3	41.783	<.001	469.6	41.085	<.001	348.1	32.158	.000	394.6	37.059	<.001
Group												
IOC	467.7	0.409	.682	479.0	1.569	.117	374.3	-0.055	.956	413.2	1.571	.117
TM	453.3	0.113	.910	466.3	2.638	.008	341.9	-0.025	.979	388.4	2.824	.004
IOC+TM	459.7	3.169	.001	471.6	3.939	<.001	357.4	0.680	.497	400.1	4.383	<.001
Time												
T1	338.7	-0.227	.820	323.3	-0.597	.550	338.8	1.364	.173	343.5	1.680	.093
T3	366.9	-0.909	.364	361.7	-0.748	.455	352.6	-1.181	.238	361.9	-0.470	.638
Group*Time												
IOC*T1	335.3	-1.317	.188	321.5	0.049	.960	336.0	-2.139	.033	340.4	-1.948	.052
TM *T1	336.0	-0.965	.335	321.9	-1.571	.117	336.6	-2.530	.011	341.1	-3.066	.002
IOC+TM*T1	336.1	-2.614	.009	321.9	-2.487	.013	336.6	-2.091	.037	341.1	-4.430	<.001
IOC*T3	372.5	0.322	.747	367.1	-0.071	.943	355.7	0.712	.476	365.8	0.759	.448
TM*T3	360.6	0.705	.481	353.7	-1.214	.225	349.1	0.702	.483	357.5	-1.121	.263
IOC+TM*T3	361.4	0.437	.662	354.6	-0.249	.803	349.6	1.274	.203	365.8	0.759	.448

Supplementary_file_S2 (cont.)

Fixed Effects	Action Planning			Coping Planning			Action Control		
	df	*t*	*p*	df	*t*	*p*	df	*t*	*p*
Intercept	434.7	29.644	<.001	434.4	26.355	.000	448.7	34.563	<.001
Group									
IOC	447.3	-0.187	.851	447.1	1.622	.105	459.4	0.432	.666
TM	429.0	-1.070	.285	428.8	1.008	.314	443.4	1.099	.272
IOC+TM	437.4	-0.556	.578	437.2	2.741	.006	450.7	1.482	.139
Time									
T1	340.6	-3.666	<.001	342.4	-2.614	.009	344.1	-2.104	.036
T3	364.8	-1.491	.136	366.3	-1.036	.301	369.9	-0.377	.706
Group*Time									
IOC*T1	337.3	-0.111	.911	339.1	-0.105	.916	340.8	0.078	.938
TM *T1	338.0	2.260	.024	339.8	1.299	.194	341.5	0.418	.676
IOC+TM*T1	338.0	0.942	.346	339.9	-0.083	.933	341.5	-0.234	.814
IOC*T3	369.7	-0.629	.529	371.1	0.170	.865	375.0	0.119	.905
TM*T3	359.3	-0.686	.493	360.8	-0.252	.801	364.0	-0.716	.474
IOC+TM*T3	360.0	0.720	.471	361.5	-0.149	.881	364.8	0.572	.567

Note. Significant changes over time (T1 vs. T2) for the control group were only found for BOMP (B = .32, SE = .04, t(60.4) = 7.763, p <.001), Flossing (B = -.68, SE = .13, t(61.2) = -5.157, p <.001), Dental Hygiene (B = -.32, SE = .08, t(58.8) = -3.843, p <.001), Action Control (B = -.32, SE = .16, t(60.4) = -2.439, p = .018), Coping Planning (B = -.57, SE = .20, t(60.1) = -2.818, p = .007) and Action Planning (B = -.83, SE = .23, t(56.2) = -3.538, p <.001).

6.5. DISCUSSION

Sending mobile text messages to patients and using an intra-oral camera during appointments are two ways of using technology in support of oral health behaviours that are frequently available in dental clinics and yet underused. In the present study we aimed to investigate whether using these two technologies, separately and in coaction, would improve clinical, behavioural, and psychological parameters of oral health in patients with gingivitis over an eight-month period.

Compared to control, interproximal control (through the use of floss, in our study) increased and tooth brushing habits were maintained at a good level, when the IOC and TM were used, both separately and together, with a corresponding decrease in bleeding measured through BOMP. However, behavioural and clinical parameters revealed higher improvements with the coaction of both devices, and a closer examination shows that the behavioural increase and the decrease in BOMP needed to attain gingivitis control were only reached in the combined condition as, in order to have healthy gums, interproximal control has to be practiced at least once a day (Marchesan et al., 2018) and bleeding should be equal to or less than 0.5 in BOMP, i.e., less than 25% of sites bleeding on marginal probing (Barendregt et al., 2002). Those numbers are now updated by Chapple et al. (2018) where periodontal stability is based on successful treatment resulting in under 10% of sites with bleeding on probing. In the present study we did not reach this value but achieved an average score of .39 at 8 months in the IOC+TM group which corresponds to 19% of sites bleeding, a 70% reduction on BOMP compared to baseline.

It is well-known that the simple fact of having individuals participate in a study may appear to produce positive results, especially when participants have free access to the treatment under consideration. This has been observed in this study however the gains did not

increase after four months. It is therefore important to determine whether effects with clear clinical expression may be detected and sustained over time. Despite the relative lack of research, previous studies have already shown the effect of the IOC on patients' motivation, self-efficacy in relation to dental hygiene, and levels of bleeding and plaque (Araújo et al., 2016; Willershausen et al., 1999) and the effect of TM on the motivation to change oral health behaviours (Sharma et al., 2011), but to our knowledge no study has been conducted on these devices in conjunction. In the present study, only when paired did these devices have behavioural and consequently clinical effects in reducing gingivitis after four months (although a reduction in the effects was detected between four and eight months, it was not significant), and improvements were sustained and did not return to baseline levels.

There are several studies in lifestyle behavioural change that show the beneficial effects of treatment with multiple strategies (McCambridge, Wittonb, & Elbournec, 2014; Solberg et al., 2000), but fewer studies are available on the role of orchestrated interventions in oral hygiene. In the present study it is possible to draw conclusions about the beneficial role of using an IOC and TM together to increase dental flossing and decrease bleeding. Notwithstanding, it is legitimate to wonder whether these gains were found mainly among young people as technology use in Portugal reflects a generational gap (Lilleyet al., 2017). Our study did not show significant age differences over time for the TM intervention (data not presented), which may be due to cohorts not being homogenous groups in terms of technology use. Additionally, as these devices were used in a theory - and evidence-based intervention, it was also possible to investigate the determinants responsible for the change that occurred and its underlying mechanisms.

Theory-based psychological parameters were inspected as secondary outcomes in order to find plausible determinants should dental hygiene changes occur. The combined use of the IOC and TM was the only condition to show an imbalance favouring pro against cons of

flossing and toothbrushing behaviour, and where increases in the belief in one's own personal ability to initiate such oral health behaviours and in intentions to floss and brush were detected in comparison to the control group. Therefore, the combined condition optimized motivational changes conducive to an increase in behavioural intentions to floss and brush. Contrary to what is found in the literature neither the IOC nor the TM alone increased patients' motivation to dental hygiene behaviours in comparison to the control condition, and it was only the use of both that helped to maintain high levels of motivation four months after the appointment. When accompanied by weekly TM over the four months, the IOC apparently helped to boost the in-chair relationship with patients, the perception of flossing as entailing several benefits, and the self-efficacy needed for its resolution as found in earlier studies on the positive effects of self-efficacy on levels of bleeding and plaque (Araújo et al., 2016; Willershausen et al., 1999). In contrast, volitional self-efficacy improved in all conditions in comparison to the control group. This is an unexpected result as self-regulatory processes are more difficult to change than motivational ones (Vieira, 2018), and both the combined condition and the devices separately affected beliefs in the ability to maintain a recently adopted behavior and deal with unexpected obstacles, i.e. maintenance self-efficacy, and to overcome periods of inefficacy and recover from them, i.e. recovery self-efficacy. In the group receiving only TM, one possible explanation is that this may have worked as an important source of (social) support that contributed to strengthening the belief in individual resources to maintain or resume flossing and tooth brushing behaviours.

When the IOC alone was used to demonstrate the benefits and ease of dental hygiene it also contributed to boost volitional self-efficacy beliefs, despite its having been expected to primarily affect motivational processes. The effect of the IOC in strengthening these beliefs, namely that behavior may be changed even if sustained flossing and toothbrushing is hampered and that it can still be resumed after a lapse, has already been found previously (Araújo et al.,

2016). We wonder if the increase in action self-efficacy could have boosted volitional self-efficacy, as found in other studies (Webb & Sheeran, 2006; Luszczynska & Schwarzer, 2003). Making specific plans on when, where, and how to perform the behavior (i.e. action planning), and the development of strategies to be used should barriers or difficulties arise (i.e. coping planning), as well as action control, an ongoing regulatory process that partially occurs during behavioural enactment, were not different among the conditions in comparison to control, except in the TM condition where action planning decreased.

Considering the effect of text messages as triggers in self-management of chronic conditions (Pinidiyapathirage, Jayasuriya, Cheung, & Schwarzer, 2018), this decrease may have occurred as individuals who regularly received text messages may have started to rely on them to act on their goals in relation to dental hygiene and not so much on forming a plan regarding when, where, and how to perform the behavior. Although the three conditions led to an increase in planning efforts between baseline and four months (except in the TM condition), this increase did not manifest behaviourally in the same way; only in the combined condition did dental hygiene through the use of floss reach the frequency necessary to positively affect gingivitis.

Also, despite the effects of the various treatment conditions on gingival bleeding and the behavioural indicators under consideration (i.e., toothbrushing and flossing), the psychological determinants under study did not prove to be the mechanisms responsible for these effects. One possibility might be that TM served as reminders or cues for action that operate at the level of automatic processes, not mediated by factors related to conscious and deliberate behavior change such as intention, planning, self-efficacy, or outcome-related beliefs (Thakkar et al., 2016).

Several limitations to the present study should be acknowledged. First, we used a snowball sampling method, and since individuals were recruited through advertisements, many

of them already had a considerably high level of motivation at the beginning of the study. This may have contributed to the observed ceiling effect and hence greater difficulty in detecting treatment effects. Another aspect worth noting in this regard is that the control condition was also an "active control", and although this made it possible to disentangle the specific effects of using the IOC and TM from the behaviour change techniques used in the appointment, those behaviour change techniques – which have been shown to have an impact on behaviour change - and its determinants may have also contributed toward making the detection of effects more challenging (Hamilton et al., 2017; Newton & Asimakopoulou, 2015). Also, even though multilevel models are particularly robust in their estimates when at least 35 level-2 units are used, inferential cautions should be made in terms of group comparison for the control and the IOC groups at T3. For these groups, only at these specific time point sample sizes decrease to 20 and 21, respectively which may increase Type I error and lead to a power threshold below .80, compromising comparisons for these groups at this specific time point, but not for other time points where level-2 units were all higher than 35 clusters (O'Malley et al., 2016). Finally, the use of behavioural self-reported measures, although common practice, is not ideal, as people have difficulties in accurately recalling what they have done, especially when considering behaviours that belong to their daily routine, as is the case with dental hygiene (Smiley, 2015). In this regard, it is reassuring to note that the clinical objective measures that were also included revealed the same pattern of results.

Despite these limitations, several strengths of the present study can be stressed, namely the fact that clinical objective measures have been used in addition to the self-reported ones and that a longer follow-up was used in comparison to the follow-ups used in most studies (Greene, 2015). Also, the fact that the intervention was theory-based and guided by the knowledge on effective behavior change techniques is worth emphasizing, as is the attempt to investigate the mechanisms responsible for the observed intervention effects.

Overall, the current study adds to the literature on interventions to promote dental hygiene and showed that combining TM, an inexpensive and easy-to-implement intervention, with the IOC, which is already available in most clinics but underused, can have substantive and clinically significant effect on an important gingival health indicator. Moreover, the effects were maintained over time, which is indicative of the sustained behavior change vital for making the management of pathologies such as gingivitis more effective and contributing to the envisioned results for oral health.

6.5.1. CLINICAL RELEVANCE

Rationale for the study: Dental hygiene behaviours are of paramount importance for controlling gingival health. There is evidence on the use of IOC and of text messages in boosting motivation, sustainability and clinical efficacy of dental hygiene behaviours. Orchestrating these two technologies is expected to create a coaction effect which could improve behavior change interventions, but the effectiveness of such strategy needs to be inspected.

General findings: Used in coaction, the IOC and the text messages improve clinical, behavioural and psychological parameters of periodontal health.

Practical Implications: The use of multiple technological devices may be an important support element to increase the efficacy of oral health caregivers in sustained gingival health over an 8-month period.

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7. EMPIRICAL STUDY 4

Self-regulation in oral hygiene behaviours in adults with gingivitis: The mediating role of coping planning and action control

This chapter is based on the paper:

Araújo, M.R., Alvarez, M.-J., Godinho, C.A., Almeida, T., & Pereira, C.R. (2020). Self-regulation in oral hygiene behaviours in adults with gingivitis: The mediating role of coping planning and action control. *International Journal of Dental Hygiene, 18,* 192-200. doi:10.1111/idh.12430

ABSTRACT

Aim: This study investigates the joint role of volitional predictors of oral hygiene behaviors of flossing and brushing in adults with gingivitis, framed by the Health Action Process Approach model (HAPA).

Materials and Methods: In a longitudinal online survey, 201 participants aged 18-75, of which 56.7% were women, completed assessments at baseline(T1), 2 weeks(T2), and 4 months(T3). Oral hygiene behaviors (OH) (brushing and flossing) and social cognitive determinants of behavior in the HAPA: action and maintenance self-efficacy (ASE & MSE), intention (INT), coping planning (CP), and action control (AC) were evaluated. Structural equation modelling was used to test a series of three nested models. In Model 1, action self-efficacy would determine MSE and INT, and INT would determine OH; in Model 2, INT would determine both CP and AC and the two OH behaviors; and in Model 3 CP and AC would be sequential mediators between INT and OH.

Results: Model 3, predicting a mediating process from intention to behavior via coping planning and action control, showed the best fit according to the fit indices and explained more of the variance in dental hygiene. The mediating role of coping planning and action control between intention and oral hygiene behaviors was thus confirmed. Importantly, coping planning did not mediate between intention and oral hygiene behaviors, which means that oral hygiene intention influences action control through coping planning, and both sequentially mediate this influence on behavior.

Conclusions : For individuals who are not yet following the recommendations for specific oral hygiene behaviors, coping planning and action control represent psychological mechanisms by which intentions are put into practice.

Keywords: behavioral science; oral hygiene; gingival health; self-regulation; psychosocial determinants of oral health.

7.1. INTRODUCTION

Consistent evidence affirms that the main aetiology of periodontal diseases is the formation and persistence of bacterial biofilms on dental surfaces (Sanz et al., 2015) Collaboration on the part of the patient in the daily disruption of this biofilm and managing gingivitis are critical factors in attaining long-term success with periodontal treatment (Chapple et al., 2015; Gurenlian, 2015; Sanz et al., 2015). It is therefore of utmost importance that effective interventions are designed to improve patients' adherence to a type of oral hygiene control capable of promoting gingival health (Duane, 2017; Newton & Asimakopoulou, 2015), such as brushing habits and interproximal control (Berchier et al., 2008; Sanz et al., 2015). However, it is a well-known fact that most patients in the long run fail to correctly use means of controlling interdental biofilm and fail to turn up for control appointments (Chapple et al., 2015).

Gingival health is therefore dependent to a large extent on the individual's oral health behavior and is not merely a consequence of a clinical intervention in a consultation context (Renz et al., 2007; Tonetti et al., 2015). Although professionals are generally aware of this issue, their actions towards changing the oral hygiene behavior of their patients (e.g., feedback on oral hygiene, explaining the correct use of a toothbrush and interdental cleaning) seem to be restricted primarily to a verbal transmission of information during the consultation (Gobat et al., 2010; Newton & Asimakopoulou, 2015). However, oral hygiene behavior change requires not only basic oral health knowledge, but has also been shown to depend on psychological processes (Duane, 2017; Gobat et al., 2010; Newton & Asimakopoulou, 2015). Hence, theory-based research is sorely needed in order to deepen our understanding of the psychological mechanisms involved in behaviors that impact on gingival health, with a view to developing evidence-based interventions (Duane, 2017; Newton & Asimakopoulou, 2015;

Scheerman et al., 2016). The aim of the present study was to investigate the joint role of self-regulatory processes in daily oral hygiene behaviors of adults with gingivitis.

According to the HAPA model, health behavior is the result of a motivational phase, where individuals form an intention to act, and a volitional, post-intentional phase, where the individuals plan to translate their intentions into action and plan how to maintain their behavioral changes (Schwarzer, 2008; Schwarzer et al., 2007) The behavioral intentions are characterized by explicit decisions to act and concentrate on a person's motivation for a certain goal. Although considered a good predictor of behavior change (Armitage & Christian, 2003), intentions are not sufficient by themselves, with other processes being necessary to improve behavior implementation (Godinho et al., 2014).

The HAPA model highlights four constructs involved in behavioral enactment: self-efficacy, intention, planning, and action control (Fig 1 – Pag 25). Action self-efficacy predicts a wide range of health behaviors, including those of oral health; when patients present higher levels of self-efficacy in the use of floss, they also show higher levels of actual usage (Scheerman et al., 2017; Zhou et al., 2015). While action self-efficacy is fundamental to the establishment of intention, maintenance self-efficacy is essential for attaining the self-regulation needed to initiate and maintain the behavior. There is evidence that maintenance self-efficacy has a predictor role in planning or in the relationship between planning and behavior (Affendi et al., 2018; Sniehotta et al., 2005), meaning that harbouring optimistic self-beliefs increases the value of planning the actions. The same was also found for oral self-care in a study intervention, where participants with higher levels of self-efficacy reported higher levels of planning at follow-up (Zhou et al., 2015). Planning facilitates the translation of intentions into actions, namely through anticipatory strategies to deal with adversities (Schwarzer et al., 2007). Such plans to prevent possible lapses, coping planning, have been shown to be an important psychological determinant in the implementation of behavioral

intentions (Craciun et al., 2011), including in oral hygiene (Schwarzer et al., 2007). However, planning alone is not always sufficient for behavioral initiation (Affendi et al., 2018; Godinho et al., 2014; Reys-Fernandez, 2016; Suresh et al., 2012), with action control, a self-monitoring of behavior, being an essential element for putting those plans into practice (Schwarzer et al., 2007). Planning is believed to function as a more distal volitional predictor, while action control is one that is more proximal to the behavior (Godinho et al., 2014). It can be understood as a feedback control that aims to compare one's efforts to one's objectives, seeking to reduce the differences between them (Sniehotta et al., 2005). In an intervention to stimulate action control, through the use of a diary to record floss usage, an increase of dental floss was observed (Reyes-Fernández et al., 2016). Some studies, not concerning oral hygiene, have gone farther, finding a relation between coping planning and action control sequentially mediating between intention and behavior (Chapple et al., 2018; Godinho et al., 2014).

Considering the as-yet limited amount of evidence for the co-action of coping planning and action control in the explanation of oral hygiene behaviors, we aimed to test the mediating role these constructs play between intention and oral hygiene behavior within the HAPA model, using three measurement points in time, among a sample of adult patients with gingivitis. The interest in these volitional processes resulted from most of the patients attending dental appointments being "intenders", but those intentions often being led astray. The difficulty in implementing intentions regarding oral hygiene behaviors lead us to seek a deeper understanding of these post-intentional mechanisms.

According to the HAPA model (Schwarzer, 2008), it was hypothesized that:

1. Action self-efficacy would be a determinant of maintenance self-efficacy and oral hygiene behavioral intention. Intention would only indirectly predict oral hygiene behaviors 4 months later;

2. Intention would be a determinant of maintenance self-efficacy, action control, and coping planning, with the latter also predicted by maintenance self-efficacy;
3. Coping planning and action control would sequentially mediate the relation between intentions and oral hygiene behaviors.

7.2. STUDY POPULATION AND METHODOLOGY

7.2.1 PARTICIPANTS

A total of 233 individuals participated in the study. There were several inclusion criteria: participants must have been over 18 years old, with 20 or more teeth (minimum 5 per quadrant) and the presence of gingivitis (Chapple et al., 2018). Thirty were not integrated in the final sample due to the exclusion criteria, assessed by the dental hygienist: periodontal pockets >3, smokers, those under orthodontic treatment, pregnant, or using removable partial dentures. The final longitudinal sample was composed of 201 individuals with gingivitis, as two participants failed to complete the questionnaire four months later.

We did not calculate the desired power prior to data collection, but conducted a sensitive power analysis by using the procedures proposed by Schoemann, Boulton & Short (2017) to determine power for simple and sequential mediation models. Using the observed correlation matrix as input (see Table 11) and setting confidence intervals at 95%, our sample size (N = 201) gives an 88% chance of detecting a sequential indirect effect and one of at least 95% for finding a simple mediation effect.

Table 11. Descriptive statistics and correlations of the latent variables.

	1	2	3	4	5	6	7	Mean	SD
1. Action Self-Efficacy (T1)	-							5.74	.94
2. Intention (T1)	.42**	-						5.95	.96
3. Coping Planning (T2)	.36**	.34**	-					5.57	1.19
4. Maintenance Self-Efficacy (T2)	.47**	.33**	.52**	-				5.72	1.00
5. Action Control (T2)	.30**	.36**	.51**	.43*	-			5.82	.98
6. Oral Hygiene (T1)	.23**	.13	.21**	.23**	.27**	-		2.82	.58
7. Oral Hygiene (T3)	.19**	.15*	.18**	.11	.29**	.51**	-	3.40	.45

*p< .05 **p < .01.

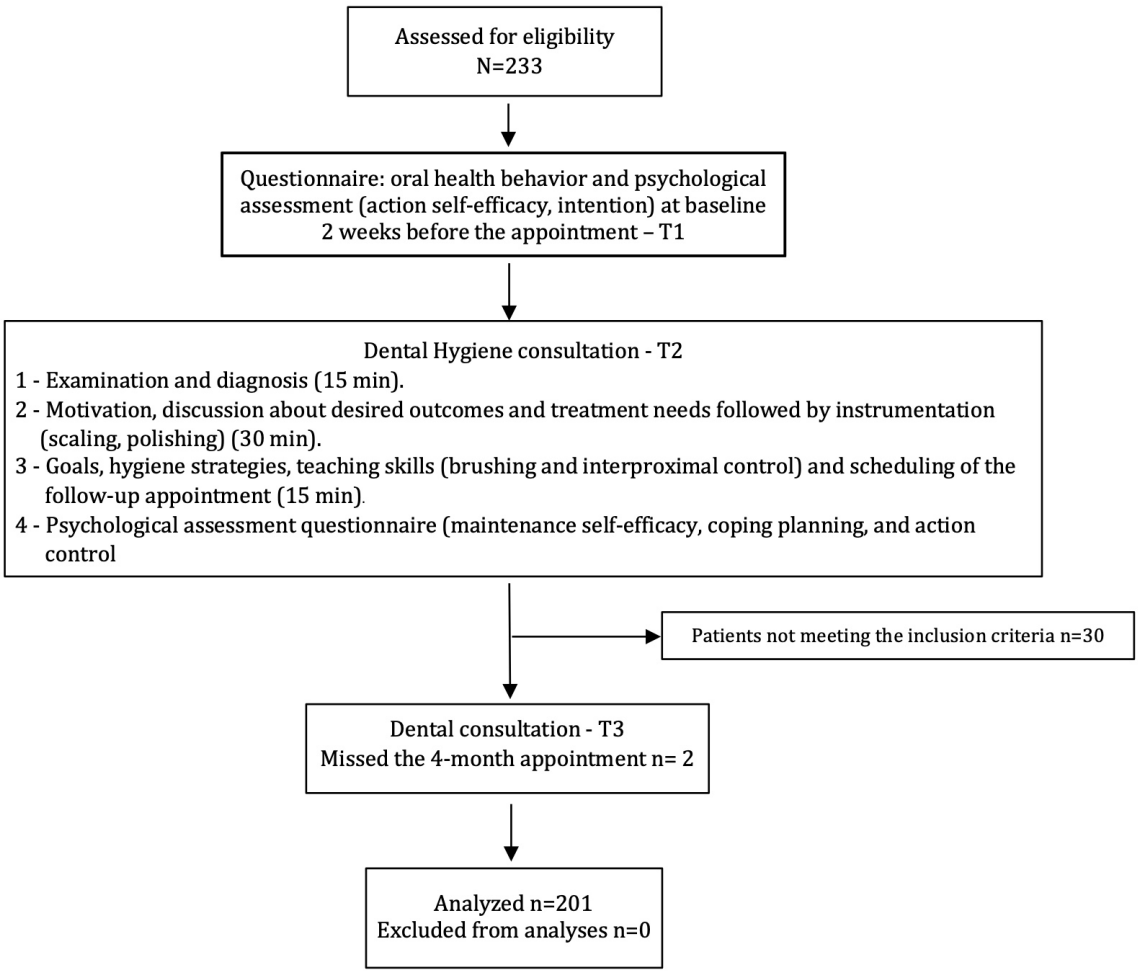

Figure 14. Study flow chart.

7.3. STUDY DESIGN AND PROCEDURE

Individuals were recruited via advertisements in local newspapers, dental clinics, and local shops. The study took place in two private dental clinics and was conducted over a span of four months with three assessment points.

Participants received an email explaining the study two weeks prior to the first dental hygiene appointment, and they were directed to read and sign a digital informed-consent form and answer an online questionnaire (Qualtris, Inc., Provo, UT, USA) with measures for action self-efficacy, intention, and dental hygiene behavior (T1). Two weeks later (T2), at the end of the first appointment, data on maintenance self-efficacy, coping planning, and action control was collected. Dental hygiene behavior was evaluated again four months later (T3), in the second appointment (details in Figure 14). The questionnaires were in Portuguese and the participants had to answer to all the questions. All the excluded participants had access to the first dental hygiene consultation, but their data was not used, and they did not participate in the second appointment. The appointments attended by the participants – carried out by the first author, a dental hygienist – were provided free of charge. The study was approved by the ethics committees of the institutions involved (Ethics Committee Doc. No. 6/14).

7.4. MEASURES

The measures used were adapted to oral health from previous studies with the HAPA model[11,14]. All the HAPA variables were evaluated using a seven-point Likert-type scale, ranging from “totally disagree” (1) to “totally agree” (7), unless otherwise stated.

To assess action self-efficacy, three items were used. The first item was “I believe I will be able to brush and clean between my teeth on a daily basis, even if I have to change my

routines." For the other two items, this stem was followed by barriers such as "even if it is difficult" or "even if I need to do some planning" (T1 Cronbach's α=.84).

To measure intention, the question: "For the next two weeks, what is your intention for brushing your teeth twice a day and cleaning between your teeth daily?" was followed by three items used to answer it: "I intend to do it from now on"; "From now on, I intend to do it daily"; and "I intend to do it every day" (T_1 Cronbach's α =.93).

To assess maintenance self-efficacy four items were used. The first item was "I believe I can keep in the habit of brushing my teeth and cleaning between my teeth daily even if… I'm lazy" and for the remaining three items, the stem was followed by barriers such as "I have to start again several times", "I am concerned about other aspects of my life", or "my family (or those who live with me) do not have these oral hygiene habits" (T_2 Cronbach's α =.86).

Coping planning was assessed through three items: "I already have concrete plans for when I need to be especially careful to brush and clean between my teeth daily"; "I already have concrete plans on what to do in difficult situations to brush and clean between my teeth daily" and "I already have concrete plans about how I should act if I stop brushing and cleaning between my teeth daily" (T_2, Cronbach's α =. 82).

Action control was measured using three items, each of which addressed a different component of action control: "I am currently evaluating my behavior to see if I am brushing and cleaning between my teeth on a daily basis", for self-monitoring; "I always have in mind the intention of brushing and cleaning between my teeth on a daily basis", for awareness of standards; and "I strive to act according to my intentions to brush and clean between my teeth on a daily basis" for self-regulatory effort (T_2, Cronbach's α = .83).

In order to assess oral hygiene behaviors, one question about brushing and another about flossing habits were both asked at Time 1 and Time 3: "In the last two weeks/four months how often have you brushed/flossed your teeth? (1 = never; 2 = less than once a day; 3= once

a day; 4 = more than once a day). Individual scores for brushing and flossing were calculated and a composite score (a mean) was also computed for both, referred to as oral hygiene (r_{T1} = .14, p = .04; r_{T3} = .16, p = .03).

7.4.1. ANALYTIC STRATEGY

First, to evaluate the fit of the proposed measurement model to the factorial structure of the observed variables, a confirmatory factor analysis was performed. Six factors were specified – action self-efficacy, intention, maintenance self-efficacy, coping planning, action control, and oral hygiene (brushing and flossing) – at baseline, Time 2, and/or Time 3, and they were allowed to freely intercorrelate with no correlation between measurement error. Statistical identification of the models was assured by constraining all factors' variances to 1.00. All parameters were calculated using maximum likelihood estimation, and confidence intervals for mediating effects were obtained with bootstrapping procedures with 1,000 resamples. Each indicator only loaded on its respective factor.

Structural equation modelling (SEM) with AMOS v. 24 was performed on the variance–covariance matrix of the indicators using the maximum likelihood estimation of the parameters. Confidence intervals for the mediating parameters were subsequently estimated using bootstrapping procedures with 1,000 resamples, a nonparametric procedure recommended for mediation analyses since it does not require normality in the distribution of the sample's indirect effects (Hayes, 2009).

To test the hypotheses of the volitional factors as sequential mediating mechanisms between behavioral intentions and oral hygiene behavior at Time 3, three nested models were estimated – i.e., all variables were included in each model. The first one specified the motivational variable (action self-efficacy), measured at Time 1, as a predictor of intention also measured at Time 1 and of maintenance self-efficacy measured at Time 2. Intention at Time 1

was specified as a predictor of maintenance self-efficacy, coping planning, and of action control at Time 2, as well as of oral hygiene behavior at Time 3. In the second model, coping planning and action control (both measured at Time 2) were specified as predictors of oral hygiene at Time 3, and maintenance self-efficacy, measured at Time 2, was added as a predictor of coping planning. Moreover, to test the hypothesized sequential mediation, an additional path from coping planning to action control was specified in Model 3. Past behavior (i.e., baseline oral hygiene) was included in all models as a direct predictor of oral hygiene at Time 3. All the predictors were specified as latent variables. Action self-efficacy and past behavior were allowed to correlate.

The sequence of estimated models ranged from a more parsimonious model, where only intention predicted behavior (Model 1), to a less parsimonious model, where the volitional predictors were tested as multiple mediators between intention and behavior (Model 2), to the full proposed model, where the two volitional predictors were specified as sequential mediators between intention and behavior (Model 3). Paths not used in Models 1 and 2 were constrained to 0. Parameters representing the hypothesized paths were freely estimated. The fit of the different models was assessed by examining the χ^2, χ^2/df, comparative fit index (CFI), the Tucker-Lewis Index (TLI), and the root mean square error of approximation (RMSEA). A satisfactory model fit is indicated by χ^2/df (<2), CFI and TLI (>.90) (Bentler, 1990) and RMSEA (<.08) (Hu & Bentler, 1998). The comparison of models also considered the Akaike Information Criteria (AIC), with lower values suggesting a more parsimonious solution (Akaike, 1974; Kass & Raftery, 1995), and a chi-square difference test (Bollen, 1989). Significance testing was performed at the $\alpha = .05$ level.

7.5. RESULTS

7.5.1. CONFIRMATORY FACTOR ANALYSIS

The final measurement model showed a good fit to the data, χ^2 (149) = 260.69, χ^2/df = 1.75, CFI = .95, TLI = .93, RMSEA=.06, 90% CI (.048; .073), which indicated that the items measured the proposed six constructs (Figure 15).

7.5.2. DESCRIPTIVE STATISTICS

The final sample was composed of 201 patients, aged 18-75 years (*M* = 38.6; *SD* = 12.49) of which 114 (56.7%) were women. The average level of education was a university degree (50.2%) and the majority of the individuals were actively working (78.1%). At baseline, more than 97% of the participants brushed their teeth at least once a day and the majority (74.4%) brushed twice or more. Despite the fact that all admitted to knowing the importance of controlling interproximal area participants reported a low level of control of those areas at baseline, with 80.8% never or barely ever controlling them. Means, standard deviations, and correlations for behavioral and psychological determinants at baseline, two weeks, and four months are presented (Table 11). All correlations were positive and ranged from .11 to .52.

Only two of them were not significant: oral hygiene at baseline and intention and oral hygiene at four months and maintenance self-efficacy.

7.5.3. MEASUREMENT MODEL

The final measurement model presented a good fit: $\chi2(149) = 260.69$, $p < .001$; $\chi2/df = 1.75$; CFI = .95; TLI = .93; RMSEA = .061, 90% CI (.048; .073), indicating that the items measured the six proposed constructs. All factor loadings were higher than .50, except for the items of flossing in oral hygiene behavior at Time 1 and Time 3 (.19).

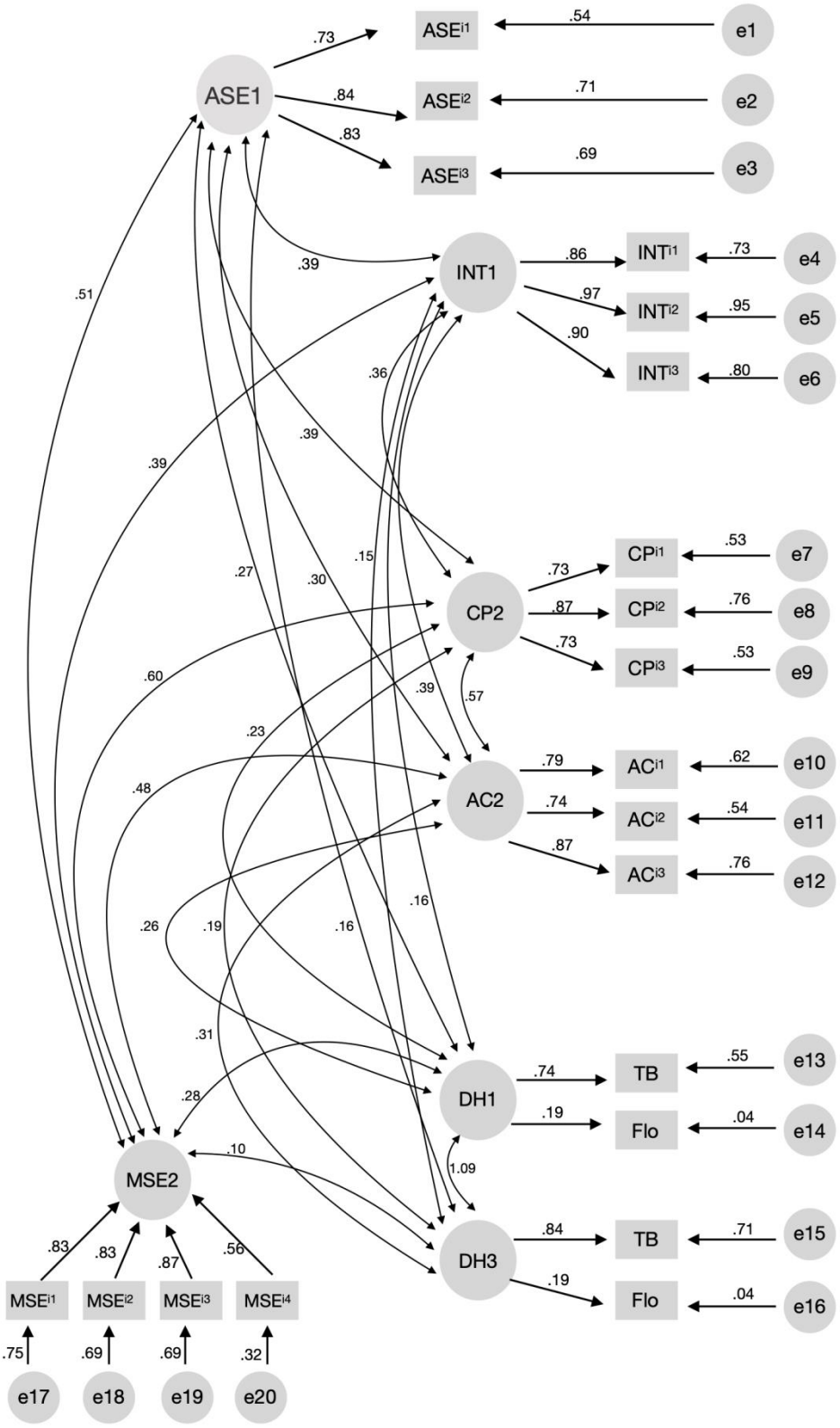

Figure 15. Confirmatory Factor Analysis of the six constructs of the measurement model ($\chi 2$ [149] = 260.69, $\chi 2/df$ = 1.75, CFI = .95, TLI = .93, RMSEA=.06, 90% CI [.048; .073]).

ASE: Action Self-efficacy; INT: Intention; CP: Coping Planning; MSE: Maintenance Self-efficacy; AC: Action Control; DH: Dental Hygiene; TB: Toothbrushing; Flo: Flossing

7.5.4. MODEL 1: INTENTION AS A PREDICTOR OF ORAL HYGIENE BEHAVIOR

Model 1 had action self-efficacy as a predictor of maintenance self-efficacy and intention, and intention as the only predictor of oral hygiene behavior at Time 3, besides the level of oral hygiene at Time 1 (i.e., past behavior). The model fit was good: $\chi^2(162) = 366.78$, $p < .001$, $\chi^2/df = 2.26$, CFI = .90, TLI = .89, RMSEA = .08, 90% CI (0.068; 0.09), p (RMSEA) < .001, AIC = 462.78.

In support of the first hypothesis, action self-efficacy measured at baseline was positively and significantly associated with intention also measured at Time 1, β = .40, p < .001, accounting for 16% of the variance in intention, and with maintenance self-efficacy measured at Time 2, β = .43, p <.001. Moreover, as stated in the first hypothesis, intention alone was not significantly related to oral hygiene at Time 3, β = .04, p = .46. Only the baseline behavior significantly predicted oral hygiene level at Time 3, β = .74, p = .03, accounting for 56% of the variance in the behavior (Figure 16).

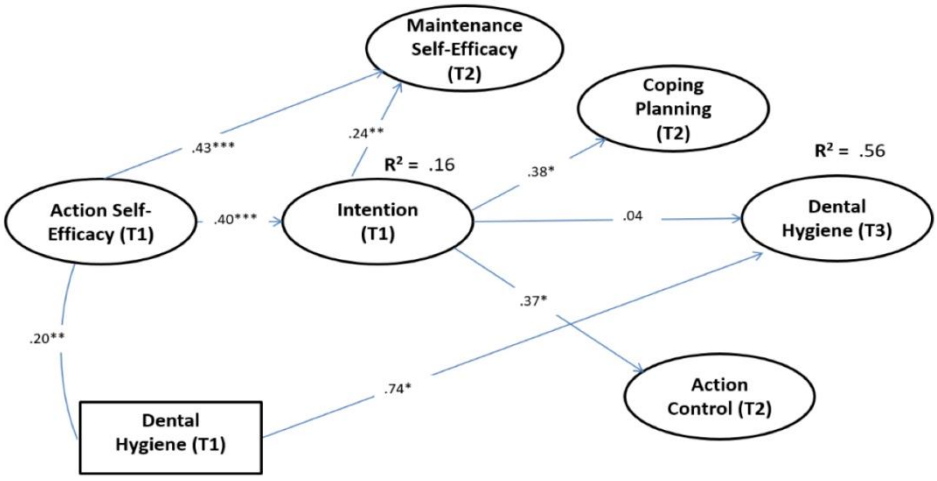

Figure 16. Model 1 had action self-efficacy as a predictor of maintenance self-efficacy and intention, and intention as the only predictor of oral hygiene behavior at Time 3, besides the level of oral hygiene at Time 1 (i.e., past behavior). All depicted coefficient estimates are standardized and represents direct effects. *Note*: *p < .05; **p < .01; ***p < .001.

7.5.5. MODEL 2: COPING PLANNING AND ACTION CONTROL AS MEDIATORS OF THE RELATIONSHIP BETWEEN INTENTION AND ORAL HYGIENE BEHAVIOR.

In Model 2, the paths between coping planning and behavior and between action control and behavior were freely estimated, as was the path between maintenance self-efficacy and coping planning. The fit of the model proved to be good: $\chi^2(159) = 314.77$, $p < .001$, $\chi^2/df = 1.98$, CFI = .93, TLI = .91, RMSEA = .07, 90% CI (0.058; 0.081), p (RMSEA) < .001, AIC = 416.77. Intention was a significant predictor of both coping planning, β= .15, p = .04, and of action control, β= .37, p < .001, and coping planning was also significantly predicted by maintenance self-efficacy, β= .55, p < .001. The second hypothesis was fully confirmed. However, coping planning failed to directly predict oral hygiene at Time 3, β= -.04, p = .53, but action control proved to be a significant predictor of this behavior, β= .16, p = .01 (Figure 17), which is a precondition for the sequential mediation tested in Model 3.

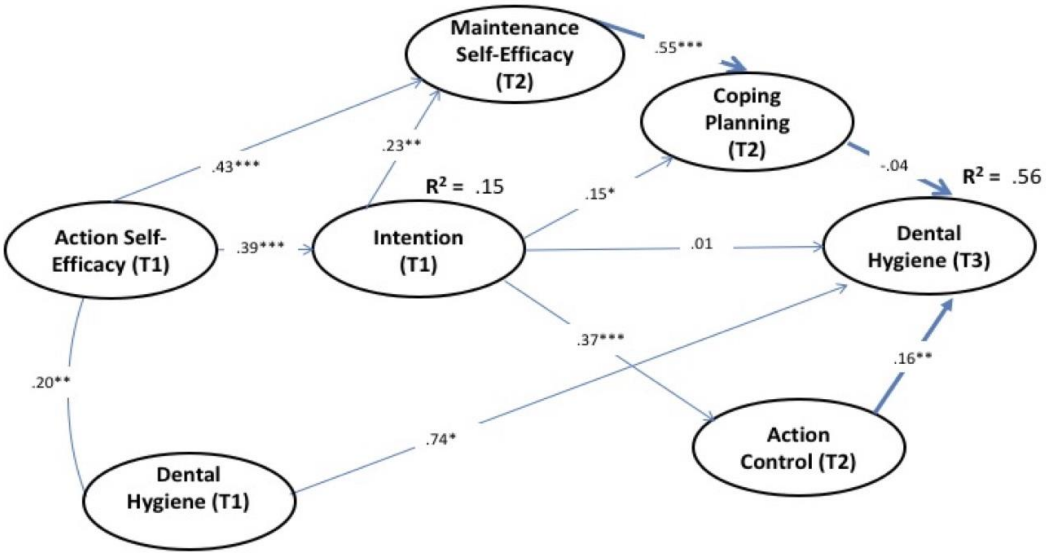

Figure 17. In Model 2, the paths between coping planning and behavior and between action control and behavior were freely estimated, as was the path between maintenance self-efficacy and coping planning. All depicted coefficient estimates are standardized and represents direct effects. Paths in bold denote the added pathways compared to model 1. *Note:* *p < .05; **p < .01; ***p < .001.

7.5.6. MODEL 3: COPING PLANNING AND ACTION CONTROL AS SEQUENTIAL MEDIATORS OF THE RELATIONSHIP BETWEEN INTENTION AND ORAL HYGIENE BEHAVIOR.

In Model 3, the path from coping planning to action control to behavior was freely estimated. This model presented a good fit to the data: $\chi^2(158) = 275.49$, $p < .001$, $\chi^2/df = 1.74$, CFI = .94, TLI = .93, RMSEA = .06, 90% CI (0.049; 0.072), p (RMSEA) = .017, AIC = 379.49. Intention remained a predictor of coping planning, β=.14, p =.05, and of action control, β=.20, p =.007. Coping planning also predicted action control, β=.51, $p < .001$, while action control directly predicted oral hygiene at Time 3, β= .20, p =.015, and, together with intention, accounted for 31% of the variance in oral hygiene. Overall, when considering the effect of oral hygiene behavior at baseline, the model was able to explain 56% of the total variance in the oral hygiene behavior (Figure18).

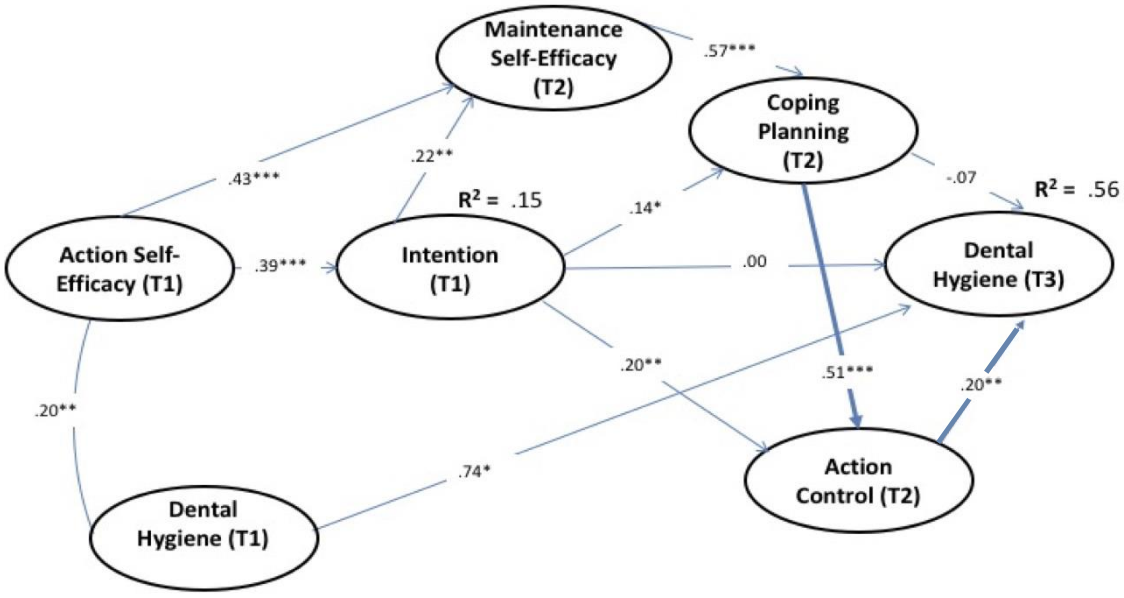

Figure 18. Model 3, with coping planning and action control as sequential mediators between intention and oral hygiene behaviors. All depicted coefficient estimates are standardized and represents direct effects. Indirect effects are presented in Table II. Paths in bold represent the added pathways compared to model 2. *Note:* *p < .05; **p < .01; ***p < .001.

Table 12 breaks down the indirect effects estimated in Model 3. As proposed, the sequential mediation was reliable, with the impact of intention at Time 1 on oral hygiene at Time 3 passing in a chain through coping planning and action control. This chain indicates a set of simple mediations that are also significant: coping planning mediates between intention and action control, while action control mediates between coping planning and oral hygiene as well as between intention and oral hygiene behavior. However, coping planning did not mediate between intention and oral hygiene behavior, which means that the effect of intention on this behavior was exerted through action control.

Table 12. Unstandardized indirect effects of model 3, representing the mediating processes from intention at Time 1 to oral hygiene behavior at Time 3 through coping planning and action control.

	Estimated	95% CI
Simple Mediations	Indirect Effect	
BI --> CP --> AC	.14	.067-.26
BI --> CP --> OHB	.01	-.009-.025
BI --> AC --> OHB	.03	.005-.076
CP --> AC --> OHB	.06	.01-.15
Sequential Mediation		
BI --> CP --> AC --> OHB	.03	.000-.071

BI = Behavioral Intention; CP = Coping Planning; AC = Action Control; OHB = Oral Hygiene Behavior

Model 3 showed the lowest AIC, which is indicative of a better fit. Moreover, when contrasting the third model with the first one, there was a significant increase in the model fit, $\Delta\chi^2$ (4) = 83.29, $p < .001$; the same occurred when comparing Model 3 with Model 2, $\Delta\chi^2$ (1) = 37.28, *p*

< .001, and the latter showed a better fit compared to Model 1, $\Delta\chi^2$ (3) = 46.01, p < .001. Thus, Model 3, where the sequential mediation was considered, was the best among the tested models.

7.6. DISCUSSION

This study investigated the psychological mechanisms underlying the oral hygiene behaviors of brushing and flossing. Specifically, we aimed to test the sequential mediating role of coping planning and action control between intention and oral hygiene behavior within the HAPA model, among a sample of adults with gingivitis.

As predicted, our findings revealed that intentions are not synonymous with change; they need the support of self-regulatory processes – such as self-efficacy, planning, and action control – to have an effect on the behaviors. Hypothesis 1 was thereby corroborated; intention alone was not sufficient to predict oral hygiene behaviors, as reported in other studies (Judah, Gardner, & Aunger, 2013; Zhou et al., 2015). However, also as predicted, intention proved to be a predictor of coping planning and action control. Intentions impel people to exert control over their behavior by mobilizing planning and executing actions, which corroborates hypothesis 2.

In this study, when the volitional processes of coping planning and action control were studied sequentially they proved to be mediators between intention and oral hygiene, with intention acting on the planning of how to handle and overcome obstacles, which in turn had an effect on oral hygiene behaviors through awareness of standards, self-monitoring, and effort (i.e., sequential mediation) – thereby corroborating hypothesis 3. This sequential mediation shows that even when patients make good plans and anticipate difficulties, this in itself is not enough to guarantee the behavior.

Both planning and action control have been shown to have an effect on altering and maintaining self-care in oral hygiene, improving the efficacy of these behaviors (Zhou et al., 2015). However, the sequential relationship between these constructs has, to the best of our knowledge, never been explored before in the domain of oral hygiene, despite the mediation through planning and action control having already been investigated and found for other behaviors. For example, Sniehotta et al. (2005) demonstrated the mediating role of action control between action planning and physical exercise, and later Godinho et al. (2014), concerned with fruit and vegetable consumption, showed that coping planning should be followed by strategies of action control in order to affect behavior through this sequential mediation. This mediation was also found in another study, where coping planning and action control sequentially mediated the effect of an intervention for hand washing (Reyes-Fernández et al., 2016).

Similarly, to the studies mentioned, and despite the measurement points in time being different, the results found in the present study suggest the validity of what was hypothesized, with coping planning being a more distal predictor of action and action control being a more proximal predictor of such change in oral hygiene habits. The need to consolidate the planned changes through more constant monitoring therefore appears to be important for achieving therapeutic results.

This study has some limitations, such as that coping planning was evaluated at the same time as action control. Not doing so would have entailed four measurement points in time, a design that would have been very demanding to apply in practice. However, we have followed the recommendation of having different measurement points in time between the independent and the dependent variables (Cole & Maxwell, 2003). Another limitation is the use of a convenience sample, which might therefore not be indicative of the whole target population. Since participation was voluntary and involved only individuals with gingivitis, participants

may have been particularly motivated for the treatment, thus introducing some bias. Given the large body of related research supporting the urgent need to find effective strategies to control gingival diseases, which afflict a significant percentage of individuals (Jepsen et al., 2017), future research would benefit from exploring other mediators, finding additional self-regulatory contributors that could improve oral hygiene behaviors (e.g., action planning, social norms).

The present study adds support to a general consensus that has been reached regarding the importance of behavior management in the prevention and control of periodontal diseases (Chapple et al., 2015). However, despite this consensus, periodontal treatments continue to focus on treating the sequelae of acute episodes, rather than on chronic disease management strategies, where behavioral change and maintenance are fundamental pillars (Gobat et al., 2010). Meta analyses and systematic reviews (Jepsen et al., 2017; Newton & Asimakopoulou, 2015; Webb & Sheeran, 2006), as well as other studies (Gobat et al., 2010), are clear in stating that we continue to treat patients as if they were information containers and not actors capable of understanding and managing their behaviors.

It is of fundamental importance that professionals come to understand and manage their clinical interventions through a more relational, psychological, and communicational perspective, with increased understanding of how behavioral relationships help to reveal possible individual solutions. Understanding the behavior of patients is an integral part of the therapeutic process, and this must be brought into focus in order to be more effective in controlling periodontal diseases. This helping relationship, providing patients with not only motivational but also self-regulatory strategies, will not only make them more active agents in their own process of change, but will also enable them to achieve and maintain their desired therapeutic outcomes.

7.6.1. CLINICAL RELEVANCE

This theory-based study provides additional evidence on the psychological mechanisms of oral hygiene behaviors. Behavior change strategies based on these mechanisms can help individuals be more active in self-regulation, improving their periodontal health.

Scientific rationale for the study: Evidence supports the understanding that oral hygiene behaviors require self-regulatory effort. Psychological factors have proven to be important determinants for these behaviors, but there is a need to understand the specific mechanisms that enable an intention to perform oral hygiene behaviors more regularly to be put into practice.

Principal findings: The sequential mediating role of coping planning and action control between intention and oral hygiene behaviors was confirmed.

Practical Implications: Behavioral change interventions aiming to improve gingival health should seek to foster self-regulation processes such as coping planning (anticipation of obstacles and ways to overcome them) and action control (awareness of standards, self-monitoring, and effort).

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8. GENERAL DISCUSSION

8.1. OVERVIEW

The thesis defended in this work is that activating patients' motivation and, above all, self-regulation, is essential if patients are to change their behaviors toward their oral hygiene. We investigated the effect of an individual intervention, adapted to the patient, with the use of an intraoral camera (IOC) and text messages (TM) as optimizers of motivational and self-regulatory processes and as optimizers of gingival status in patients with gingivitis. We specifically examined behavior around brushing and flossing.

Our objectives were: 1) check for changes in self-regulatory processes and gingival health status resulting from the use of the intraoral camera and/or text messages in the service of brushing and flossing, through a randomized and controlled clinical trial; 2) understand the psychological mechanisms involved in behavioral change and explore their role in the effectiveness of the interventions under study; 3) verify the applicability of the HAPA model for oral hygiene behavior in a sample of adult patients with gingivitis.

To achieve these objectives, three experimental and longitudinal studies (presented in chapters 4, 5, and 6) and a quantitative longitudinal study (presented in chapter 7) were carried out. The four studies took place in two private dental clinics over a period of 24 months, involving 185 participants who completed all the evaluation moments (out of 246 who started some of the studies). Participants were adult patients between 18 and 70 years old (M = 38.1, SD = 13.18), the majority has a college degree (53%) or secondary education (35%).

Next, we shall briefly summarize the main results obtained in the set of studies.

8.2. SUMMARY OF FINDINGS

The objective of the first study was to determine whether the use of an intraoral camera would make it possible to increase the clinical effectiveness and sustainability of behaviors known to promote oral hygiene and gingival health. The results showed that, in addition to the intraoral camera being very positively accepted on the part of the patients, its use promoted a significant reduction in levels of bleeding, by promoting an increase in flossing, in comparison with the control group. Concerning psychological variables, there was an increase in the perception of self-efficacy, an important result for the process of self-regulation involved in the use of dental floss.

In the second study, we set out to identify the role of text messages in increasing the sustainability and effectiveness of oral hygiene behavior in patients with gingivitis. The results showed that receiving text messages promoted the use of dental floss, a behavior accompanied by higher levels of self-efficacy, intention, planning, and action control compared to the control group. Text messages helped to increase patients' motivation and provided an alternative way to create cues for action with effects on oral hygiene routines, so they should be considered as aiding in the management of pathologies such as gingivitis.

In the third study we set out to investigate the effect of using the intraoral camera and text messages together, seeking to identify whether this combined action would increase the frequency of oral hygiene behavior and decrease levels of gingival bleeding. We also evaluated the effects of these technologies on the psychological determinants described by the HAPA over a period of eight months. The results showed that, used together, the intraoral camera plus text messages improved the psychological parameters and clinical conditions of periodontal health. The joint use of these technologies is a useful element for supporting oral hygiene strategies in patients with gingivitis for a period of eight months.

The fourth study aimed to investigate coping planning and action control – two psychological predictors proposed by the HAPA model, yet little-studied in the context of oral health – for their effects on oral hygiene behavior, specifically brushing and flossing. The results showed the presence of a sequential mediation composed of these two predictors between intention and behavior. Coping planning did not prove to be a direct mediator of behavior, but it did exert its influence on action control, which in turn was shown to have an important effect on oral hygiene behavior.

8.3. DISCUSSION OF RESULTS AND PRIMARY IMPLICATIONS

The treatment of periodontal diseases depends largely on specific behaviors on the part of the individual patient; it is not merely a consequence of the professional's intervention in the context of the dental appointment (Renz et al., 2007; Tonetti et al., 2015). Although there is general consensus on the importance of biofilm control in the prevention and control of periodontal diseases (Tonetti et al., 2015), periodontal treatments continue to focus on the sequelae of acute episodes rather than employing behavior change strategies as fundamental pillars for treatment and management of the chronicity of these diseases (Costa et al., 2019). As mentioned in the framework, we continue to treat our patients as if they were mere recipients of information, not actors capable of understanding and managing their behaviors (Newton & Asimakopoulou, 2015; Ramseier & Suvan, 2010; Renzet al., 2007; Webb & Sheeran, 2006).

Health care is increasingly oriented towards the long-term management of chronic situations, being therefore directly concerned with behaviors that have an impact on health. With this in mind, it is no longer possible to consider oral health interventions and the role of oral health professionals without including patients' behavior change strategies as a fundamental contribution to the prevention, treatment, and maintenance of health (Rollnick et al., 2008). Behavioral change requires not only basic knowledge of oral health, but is also

dependent on motivational processes that promote the formation of intentions and post-intentional or volitional processes that, in turn, trigger behavioral initiation and maintenance (Hamilton et al., 2017; Scheerman et al., 2016; Schwarzer, 2008). We join several authors who advocated intraoral camera are interventions based on behavioral theories. We must be able to develop these behavioral interventions based on the best existing evidence, not just on common sense (Järvinen et al., 2018; Newton & Asimakopoulou, 2015; Scheerman et al., 2016).

Based on these assumptions and in accordance with the first objective of the thesis (to verify the existence of changes in motivational and self-regulatory processes and in the state of gingival health resulting from the use of different technologies to promote brushing and flossing), we tried strategies using an intraoral camera (IOC) and/or text messages, strategies based on current communication trends: use of images (from the intraoral camera) and mobile communication technologies. The HAPA model (Schwarzer, 2008) was used as a theoretical basis in the studies developed. Included in the oral health care appointment developed for this investigation were specific behavioral change techniques, namely reinforcement, goal setting, and feedback, which are considered the most effective for supporting new preventive and therapeutic behaviors in oral health (Newton & Asimakopoulou, 2015).

8.3.1. THE ROLE OF INTRAORAL CAMERA IN VOLITIONAL SELF-EFFICACY

In Study 1 we found that the use of images via the intraoral camera, plus the specific behavioral change techniques mentioned above, contributed to the increase of gingival health by improving oral hygiene behaviors, in particular of dental floss. In terms of psychological processes, we saw an increase in self-efficacy, which is fundamental in the mobilization and maintenance of self-regulation processes that drive the transformation of behavioral intention into action.

In the present study, self-efficacy was the main process associated with the change in oral hygiene, as previously found by other authors (Hamilton et al., 2017; Schüz et al., 2007). This result contrasts with other previous studies in which outcome expectations – beliefs about the pros and cons of behavior and planning – proved to be the main determinants of changing oral hygiene behaviors (Schwarzer et al., 2014; Zhou et al., 2015).

The importance of the self-regulatory mechanisms detected in the results of this study suggests that the use of the intraoral camera is an effective strategy in oral health appointments, as a way both to promote self-regulation of behaviors for biofilm control and to maintain these behaviors, at least in the medium term. This is all the more noteworthy, as it is usually easier to induce changes at the level of motivation (which lead to the formation of an intention to change) than at the level of self-regulatory processes involved in effective behavioral change and maintenance (Sheeran & Webb, 2016; Webb & Sheeran, 2006).

In line with other studies, the positive results obtained with the use of the intraoral camera appear to enable patients to better assimilate information in the context of the dental appointment (Willershausen et al., 1999). One of the main implications of the present study stems from the fact that the observed changes are relevant to the effective control of gingivitis. We found that some psychological constructs of the HAPA model seem to have been influenced by the use of images in particular, and, as mentioned, by self-regulatory mechanisms related to volitional self-efficacy.

The changes observed in maintenance and recovery self-efficacy point to the value of the intraoral camera in strengthening behaviors that, if their effectiveness is maintained over time, are fundamental for gingival health. Volitional self-efficacy emphasizes confidence in dealing with difficulties when preparing, executing, maintaining, or returning to an action after discontinuing it. The use of the intraoral camera may have increased patients' ability to use dental floss through feedback mechanisms leading them to become interested in the effects

obtained and to choose alternatives when the strategy failed. Volitional self-efficacy thus appears to activate the self-regulation necessary to change habitual behavior, since overcoming habits may be influenced by situational cues from the feedback mechanisms offered by the intraoral camera (e.g., areas where biofilm control has improved, where inflammatory signs are no longer visible) (Sutton, 1994).

In summary, the results obtained point to the importance of the intraoral camera in strengthening the idea that it is possible to improve the efficacy of using dental floss, sustaining it over time, and that the behavior can be resumed even after a period of relapse. These results in terms of self-efficacy assume real importance in the use of dental floss, since the need for prolonged use is fundamental for the control of gingivitis and setbacks are very frequent, tending to result in behavioral interruption (Kotsakis et al., 2018; Sälzer et al., 2015; Sambunjak et al., 2011; Schüz, Wiedemann, & Mallach, 2009; Vernon et al., 2017).

The main implication of Study 1 adds to the growing evidence that technologies such as the intraoral camera can play an important role in behavioral change interventions for oral health. Murrell et al. (2019) have recently highlighted the fact that intraoral cameras are well-accepted by students, teachers, and patients when used in a university environment, facilitating the learning of certain treatments in the area of oral health, as well as facilitating communication between teachers and students. Their study also found that the treatments performed by the group of students who used the intraoral camera to communicate with patients were more effective when compared to the group that did not use the intraoral camera. In the same vein as our study, Pentapati & Siddiq (2019) report that the intraoral camera can increase patient compliance with dental treatments, increase understanding of the diagnosis, help in setting goals and in planning and maintaining treatments and good habits. The use of images and the individualized relational communication strategy used in our investigation can thus

contribute to the difference between success and failure in the medium-term control of periodontal pathologies.

8.3.2. THE ROLE OF TEXT MESSAGES ON THE REINFORCEMENT OF BEHAVIORAL CHANGES

In Study 2 we investigated the effect of using text messages (TM) to reinforce behavioral changes. We knew that behavioral interventions based on novelty, the surprise effect, and curiosity could potentiate and stimulate cognitive processes associated with changing habits (Kashdan & Silvia, 2009). Stimulating curiosity can influence the commitment, motivation, and effort required for new behaviors, which is particularly important when creating new alternative strategies for patients.

As previously mentioned, text messages have been used with the aim of changing health behaviors (Cole-Lewis & Christian, 2003; Fedele et al., 2017; Fjeldsoe et al., 2009; Hall, et al., 2015). While the results of these studies are promising, evidence on the use of text messages in interventions aimed at changing behaviors in oral health is still scarce (Toniazzo et al., 2019).

We hoped that the use of text messages would have a supportive effect in maintaining oral hygiene behaviors, especially for interproximal control, by functioning as reminders or "cues for action" to increase the proximity between the professional and the patient, thus contributing toward behavior change. In this regard, Study 2 found significant results for the frequency of flossing, which resulted in a reduction in bleeding levels in the group that received messages.

As expected, we found an increase in the use of dental floss with the presence of increasing levels of intention, but intention alone was not sufficient to achieve the desired result. As in other studies, including Study 1, it was not changes in planning, but in terms of self-efficacy that best helped explain the behavioral and clinical changes obtained (Zhou et al., 2015).

Our proposal to use text messages as a complement to the consultation received very positive reactions from patients, as did the process in which those messages were received. Taking into account the traditional formality that often characterizes the relationship between oral health professionals and patients (Ramseier & Suvan, 2010), the innovative use of text messages in the context of oral health, as a therapeutic complement and not just as "reminders" of the consultation, may have contributed to the formation of a closer relationship between the professional and the patients, thereby focusing attention on the relationship (Qudah & Luetsch, 2019).

The use of text messages by oral health professionals is not something regular in clinical practice and is consequently not yet widely studied as an accessory to the communication process in the consultation. In fact, a recent meta-analysis and systematic review concluded that text messages have found use mostly in confirming dental appointments (Mohammed, Rizk, Wafaie, Ulhaq, & Almuzian, 2019). Even so, this role is relevant because patients contacted through texting are more likely to attend planned consultations. Regarding the use of text messages as a consultation strategy and an integral part of treatment, studies have mainly been in the area of orthodontics, where the motivation for oral hygiene measures is aided by their use (Kumar et al., 2018; Li et al., 2016; Ross et al., 2019). Health education is another area where the use of text messages shows positive results, namely in relation to the acquisition of oral health knowledge (Jadhav et al., 2016). And finally, the few existing studies also show the effectiveness of TM in supporting oral hygiene measures, specifically in the use of dental floss (Hashemian, Kritz-Silverstein, & Baker, 2015).

As mentioned, the use of text messages can also promote social support mechanisms, facilitating the development of a context of proximity between the patient and the health professional (Noar & Harrington, 2012; Perri-Moore et al., 2016). This fact may have contributed to the behavioral changes detected in Study 2, since we used a persuasive message

from a trusted source of social support (the health professional) for four months, promoting patients' self-efficacy and their belief in being able to handle the challenge (Newton & Asimakopoulou, 2015).

Reading the results in the light of the HAPA model helps us to understand the intricacy of the actions inherent in the way patients change their behaviors. Coping planning – developing strategies to be used if barriers or difficulties arise – and action control – a continuous regulatory process that occurs partly during the implementation of the behaviors themselves – were not different when compared to the control group. The exception occurred for action planning – making specific plans about when, where, and how to execute the behavior – which declined. Considering the effect of text messages as initiators of behavioral management processes in chronic situations (Thakkar et al., 2016), the decrease in action planning may have resulted from individuals who received text messages regularly coming to rely on them rather than forming plans about when, where, and how to carry out the behavior. However, this is a possibility that needs confirmation in later studies.

8.3.3. THE COACTION EFFECTS OF THE INTRAORAL CAMERA AND TEXT MESSAGES

In Study 3 we maintained the conditions of IOC, TM, and control, but also went further by combining the two technologies in the interventions – IOC + TM – creating an integrated strategy to optimize the oral health behaviors addressed in the consultation. For Dombrowski et al. (2016), strategies based on communicational interventions supported by evidence and used simultaneously, as well as the specific way in which the professional operationalizes the strategy, are decisive characteristics for obtaining the desired behavioral outcome. In fact, in Study 3, the shared action of both devices showed superior results for the behavioral and clinical parameters. Interventions with shared strategies, carried out synergistically, reinforced the motivational processes and so led to better results.

Study 3 offers us a set of information about the importance of using different behavioral strategies with the patient, which, when introduced in the consultation, seem to increase the probability of more sustainable behavior changes (Järvinen et al., 2018; Newton & Asimakopoulou, 2015). We are unaware of the existence of any studies in the field of oral health that have used and compared the intraoral camera and text messages together. While we knew that they worked independently, we did not expect that, together, their results would be so strong and interesting. When used together, these devices had behavioral effects (significantly increased use of dental floss) and clinical effects (reduced bleeding) after four months. In addition, the improvements were sustained over eight months, not returning to the initial levels and maintaining the improvements detected at four months, thus confirming the first objective of the thesis: to verify the existence of changes in the motivational and self-regulatory processes and in the state of gingival health from the use of the intraoral camera plus text messages.

There are several studies on behavioral changes in lifestyle that show the beneficial effects of treatment with multiple strategies (Lilley et al., 2017; Solberg et al., 2000), but there are no publications available on interventions for changing oral hygiene behaviors. This supports the innovation of the present investigation and motivates us to find explanations for the results obtained in using the strategies together. For Spaling (1994), "Cumulative effects refer to the accumulation of changes over time and across space in an additive or interactive manner" (p. 232). We wondered whether the beneficial effects of using these two strategies resulted from an additive effect (in which the camera brings its effect, then the messages bring their effect) or an interactive one (in which the two technologies mutually potentiate). This will be a point that needs further investigation.

It is right to ask whether these gains were found mainly among the young, since the use of technology in Portugal reflects a generational gap (Vieira, 2018). However, no significant

differences were found in terms of age in the intervention with text messages and, considering that this technology is widely adopted (reaching the majority of the population, even the elderly) (Kuerbis, Mulliken, Muench, Moore, & Gardner, 2017), we believe that age is not a factor that would impede the success of this type of intervention.

When the use of the intraoral camera in the consultation was accompanied by the use of weekly text messages for a period of four months, the intraoral camera helped to increase patient satisfaction, perception of the benefits of using dental floss, and effectiveness of flossing technique. This is in line with what has been described in previous studies on the positive effects of intraoral cameras on the use of floss and the consequent decrease in levels of gingival bleeding and dental plaque (Willershausen et al., 1999). Volitional self-efficacy (maintenance and recovery self-efficacy) improved in all conditions when compared to the control group. However, it is important to highlight that clinical effects were found only in the joint IOC + TM condition, possibly because it was only in this case that the use of floss reached the minimum levels necessary to reduce bleeding.

Action planning and coping planning, as well as action control, were not different between groups when compared to control, except in the TM group, where action planning decreased. Zhang, Zhang, Schwarzer, & Hagger (2018) propose the idea that individuals may not need to form conscious plans to promote their behavior – sometimes intention by itself is sufficient for motivation. Considering the effect of text messages as catalysts in the management of chronic situations (in gingivitis for example [Thakkar et al., 2016]), this decrease may have occurred because the messages functioned as a support for continuing the behavior. Although the IOC group and the TM group showed an increase in planning values between baseline and the four months, this increase did not carry over to behaviors; only in the combined group (IOC + TM) did oral hygiene behavior reach the frequency necessary to positively affect gingival health.

Despite the effects that different interventions had on gingival bleeding and oral hygiene behaviors (toothbrushing and flossing), the psychological determinants under study did not prove to be the mechanisms responsible for these results. One possibility is that text messages may have functioned as reminders or cues to action. That is, they may have operated at the level of automatic processes, not mediated by factors related to changes in conscious and deliberate behavior, such as planning and self-efficacy, a hypothesis already put forward by other authors (Hamilton et al., 2017).

Therefore, the combined strategy seems to have optimized the motivational changes leading to an increase in behavioral intentions, with consequences for oral hygiene habits. Similar to the results of Studies 1 and 2, the changes detected in the self-regulatory variables (volitional self-efficacy) are an important result – noteworthy because medium-to-strong impacts in the motivational phase often only translate into medium-to-weak impacts on self-regulatory processes.

If these behaviors change strategies become an integral part of the therapeutic process, we will be more effective in controlling periodontal diseases (Chapple et al., 2018). This focus on technology and communication will open the way not only to motivational strategies, but also to more effective self-regulatory strategies. This will help to make patients more active agents in their process of change and also to achieve and maintain the desired therapeutic results.

Historically, professionals have assumed a role in the oral health scenario often characterized as “haughty”, “authoritarian”, and “expert”, with patients having a more “passive” role (Ramseier & Suvan, 2010). The environment of the dental office is traditional; the patients assume a position of near-submission before the professional who treats them. Tending to be focused on technical knowledge, oral health professionals mostly resort to their common sense in the communication strategies they use, often considering them to be a

secondary factor for a successful treatment (Newton & Asimakopoulou, 2015; Ramseier & Suvan, 2010). This urgently requires a change in perspective, in which professionals' attitudes towards therapies are collaborative and in line with patients' expectations (Kelly & Barker, 2016). As one example, the intraoral camera is an effective tool for personalizing the intervention and providing individualized feedback. We now have evidence that this type of strategy should be further explored by professionals. In this idea of an increasingly collaborative and individual intervention, the actors should be more varied and multidisciplinary: dentists, dental hygienists, doctors, patients, psychologists, etc. Personalization must respect the characteristics of the disease and it will be up to the therapeutic decision makers to negotiate the operationalization of these technologies for each patient, depending on their behavioral states (Cafiero, 2014).

8.3.4. THE HEALTH ACTION PROCESS APPROACH ON THE PREDICTION OF ORAL HYGIENE

In Study 4 we tested the HAPA model as a whole for explaining oral hygiene behavior, highlighting the sequential mediation of coping planning and action control between oral hygiene intention and behavior. This observation originated in previous studies carried out by the team Godinho et al. (2014), which indicated the importance of these self-regulatory processes used in a certain order to change behavior.

The results revealed that intentions are not the proximal antecedent of change, as predicted and as found in previous studies (Hamilton et al., 2017; Judah et al., 2013); to have an effect on behaviors, intentions need to translate into self-regulatory processes such as self-efficacy, planning, and action control.

Both action self-efficacy and maintenance self-efficacy have been shown to make up part of the model used in Study 4, the former in the motivational phase and in the latter in the

volitional phase, which is in line with our previous studies where self-efficacy stood out as being important in increasing the use of floss.

Also, as expected, intention proved to be a predictor of *coping planning* and *action control*. Finally, when these volitional processes were studied sequentially, they showed themselves to be mediators between intention and oral hygiene, with intention having an effect on coping planning, which in turn had an effect on oral hygiene behaviors through awareness of standards, self-monitoring, and effort invested (sequential mediation). We believe that even if patients create excellent action plans and anticipate some difficulties, this alone will not be enough to change behavior. Planning is therefore a more distal factor in relation to behavior, and for it to have an effect it must act on *action control*, which occurs during the very implementation of behavior, involving the mobilization of self-regulatory skills that have already been shown to be fundamental for changing various behaviors, including oral hygiene (Hamilton et al., 2017; Sniehotta, Soares, & Dombrowski, 2007).

Few studies exist in the field of oral health on the use of these two volitional processes – coping planning and action control – together. Planning, used in isolation, has been shown to have an effect on the use of dental floss (Schüz et al., 2009), and the inclusion of planning in interventions has also shown more effective results in terms of behavioral change, when compared with interventions in oral hygiene based only on the provision of information (Hamilton et al., 2017).

Action control was also found to have a mediating role between action planning and behavior in the context of physical exercise (Sniehotta et al., 2005). Subsequently, Godinho et al. (2014) showed its mediating role in the area of fruit and vegetable consumption. However, one of the most important conclusions of that study was based on the fact that coping planning must be followed by action control strategies, in sequential mediation, in order to be able to affect behavior. This mediation was also found in another study, in which coping planning and

action control sequentially mediated the effect of an intervention for hand washing (Reyes-Fernández et al., 2016). Finally, both action planning and action control have been shown to have an effect on altering and maintaining oral hygiene self-care, improving the effectiveness of these behaviors (Zhou et al., 2015), but they have not been studied in conjunction.

The results found in Study 4 confirmed our hypothesis: that coping planning and action control sequentially mediated the relationship between intention and oral hygiene behaviors. Thus, coping planning proved to be a more distal predictor of action, while action control was a more proximal predictor of changes in oral hygiene behaviors. The need to consolidate planned changes, through more constant monitoring, seems to be the most important factor in achieving the desired therapeutic results. For individuals who are not yet following the recommendations for specific oral hygiene behaviors, coping planning and action control represent psychological mechanisms by which intentions are put into practice.

8.4. LIMITATIONS, STRONG POINTS AND FUTURE STUDIES

As in any research, certain limitations to these studies should be recognized and taken into account. First, a convenience sample was used, which is thus not representative of the target population. Another aspect that requires some care in reading the results is the fact that the patients in the sample are motivated for oral hygiene appointments, which is not surprising, considering that everyone had gingivitis and were invited to treat it at zero cost. Thus, the results found can only be generalized to individuals with similar motivation and low levels of effectiveness in controlling interproximal plaque. The use of dental floss as a control strategy is another possible limitation. All patients mentioned floss as their main means of removing interproximal plaque. However, the majority flossed less frequently than recommended and practically none used another means of interproximal removal. We thus opted to use dental floss as the strategy of interproximal control, although several meta-analyses have shown only

small reductions in plaque with the use of dental floss as a brushing aid (Berchier et al., 2008; Poklepovic et al., 2013; Sambunjak et al., 2011). However, the existing evidence for not using dental floss to the detriment of other ways of controlling interproximal plaque (interdental brushes, oral irrigators, wooden or silicone toothpicks) is not yet sufficiently robust from the point of view of research design (Vernon et al., 2017). The role of oral health professionals should include helping to select which type of floss or other means of interproximal removal is right for the patient's oral health preferences and needs (Vernon et al., 2017). Caution should also be taken in interpreting some results due to the fact that some variables in Study 4 were evaluated at the same time: intention with coping planning; action control with oral health behavior. Finally, the personal characteristics of the dental hygienist may have been relevant for the reported effects. As this possibility cannot be ruled out, it will be important in the future to carry out similar studies using different professionals. However, considering that the dental hygienist was the same in all the experimental conditions, the differences observed between the groups cannot be attributed to this factor. In addition, a blind analysis of the data was carried out in order to strengthen the impartiality of the results presented.

Despite these limitations, this thesis makes an important, innovative contribution in its use of clinical studies, included in behavioral research. The use of clinical parameters and of sufficiently wide time intervals to measure effective behavior changes are characteristics that lend value to the studies. The inclusion of clinical parameters is important for understanding the real health gains brought about by the interventions, as clinical data represents the most important resource for healthcare progress (Arrow et al., 2009). And although Renz et al. (2007) has proposed years rather than months as the gold standard, the intervals of four or eight months in our studies are longer than those found in most of the studies included in their systematic review.

On the other hand, the oral hygiene appointment that we developed and put into practice was made to be able to standardize the intervention and to enable consistency in communication, so that the main aspects of the relationship and behavioral intervention with the patient were uniform in all the appointments. The consultation was also designed to include important behavioral change techniques. In this sense, ours was distinguished from the usual oral hygiene consultation in which it is common to follow a sequence of "*diagnosis, teaching, scaling, polishing, and fluoride application*", which often falls short of the real and specific needs of patients. The conceptual plan for the appointment was the same for all groups, and included specific behavior change techniques, such as reinforcement, goal setting, and feedback, as described by Michie et al. (2013), which are considered fundamental for the creation of long-term behavioral changes. In this sense, the control group was actually an "active control" group. This strategy allowed us to separate the specific effects of using the intraoral camera and text messages from the behavior change techniques used in our oral health appointment, which are known to have a positive impact on behaviors (Hamilton et al., 2017; Newton & Asimakopoulou, 2015). This fact may have made it more challenging to detect effects caused by the technologies, which were nevertheless detected in the studies we conducted.

Given the urgent need to find effective strategies to control the periodontal diseases that affect a significant percentage of individuals, future research would benefit from the exploration of other technologies (apps, intraoral digital scanners, digital radiographs, etc.) to find more ways of interacting with other types of patients and periodontal situations.

Considering the self-regulatory importance that the components of planning and continuous monitoring have in promoting several changes in health behaviors and the ample evidence about their importance as mediators between intention and behavior (Guillaumie et al., 2012; Kreausukon, Gellert, Lippke, & Schwarzer, 2012; Lange et al., 2013), future

investigations should explore other variables with a mediating role (e.g., self-efficacy, social norms) and the circumstances in which moderating effects can be identified.

Finally, it is important to study other ways of interacting with patients (e.g., other ways to use motivational interviewing techniques or other approaches and techniques to behaviour change) (Michie et al., 2013; Rollnick et al., 2008) in hopes of broadening the range of evidence-based behavioral interventions and uncovering any additional contributions of motivation and self-regulation that could improve periodontal health.

The use of new technologies in the context of an oral health appointment is an area with important paths to be explored. Technologies will continue to bring new possibilities in the future. With the use of increasingly intuitive and individualized applications, telemedicine structures make sharing with professionals increasingly effective; with the advent of the use of intraoral 3D digital scanners, we will be in a position to be closer partners with our patients, creating increasingly collaborative and effective environments with regard to periodontal health (Ahad, Kobashi, & Tavares, 2018; Hotwani et al., 2019; Nayyar, Ojcius, & Dugoni, 2020). Thus, with regard to mobile imaging and communication technologies, further studies will be needed to ascertain the value brought by different alternatives, to better understand the mechanisms underlying behavior change, and to establish how the use of these technologies can be improved in supporting other treatments such as dental implants, prosthodontics, periodontology, and orthodontic treatments, among others.

8.5. CONCLUDING REMARKS

Changing behavior is a long and winding process that is not always promoted in the best way by oral health care professionals.

Although it is difficult to change long-term behaviors and to introduce specific techniques for this purpose to our oral health appointments, there seem to be strategies that can

be incorporated without creating entropy on the consultation, bringing benefits for patients and oral health professionals. We must believe that each patient has the ability to adopt new behaviors when faced with the situation in which they find themselves. Presupposing that they are not capable of change would be a strategy destined for failure.

We know that the incidence of oral diseases, especially periodontal diseases, is not controlled at the global level (Tonetti et al., 2017). Considering also that oral hygiene habits, namely with regard to interproximal control, are globally low and ineffective (Tonetti at al., 2015) and knowing the importance that a whole set of psychological and behavioral tools have for health oral (Newton & Asimakopoulou, 2015), the results presented in this thesis are a contribution to the discussion of the importance that certain behavioral change techniques have for clinical practice in oral health, as well as of the promotion of their use in a regular and effective manner.

It was interesting to note that intraoral cameras, seldom used regularly in dental practices, do not simply help to positively alter clinical results – the decrease in the rate of gingival bleeding – but help to promote self-regulatory mechanisms for behavior change. Our study thus contributes to the growing evidence that these technologies can play an important role in behavioral changes in oral health (Houts et al., 2006; Willershausen et al., 1999). While at the beginning of this work we could only find the 1999 study by Willershausen et al. on the advantages of using the intraoral camera and its relationship with oral hygiene behaviors, at least two new studies on the intraoral camera have since been published (e.g. Murrell et al., 2019; Pentapati & Siddiq, 2019).

In parallel, we used text messages as an adjunct to behavior change strategies. Easy to use, widely adopted, economical, and simple to integrate, text messages can be easily introduced into the practices of oral health professionals for an organized care approach (Armanasco et al., 2017; Fjeldsoe et al., 2009; Jadhav et al., 2016). In the course of our

investigation, we confirmed that sending text messages promoted patients' self-regulation, creating clues for action and providing social support, which is vital for the establishment of alternative routines. These factors helped to achieve therapeutic goals and to make the management of pathologies such as gingivitis more effective. Additionally, sending a set of messages was in itself an innovative factor in the consultation. The choice to send text messages was understood by patients as a unique, different proposal, and their reactions – gratitude, trust, and understanding – were very positive. The messages helped strengthen patients' belief in their individual abilities to initiate, maintain, or resume oral hygiene behaviors.

People feel good when expectations are surpassed, and they weren't expecting this approach. "*You want to text me?"* they asked us when we explained the process to them. "*What a funny idea! Of course, I don't mind!*" was the sort of comment we heard several times. Although it was not part of the consultation protocol, we had a considerable number of patients who contacted us to give feedback on the messages received: "*Today's was a lot of fun!*", "*I will miss these messages!*", and "☺".

The option of articulating different interventions for behavior and studying them is not new in the field of health overall, but it is new in the field of oral health. Creating an integrated strategy using the intraoral camera and text messages to optimize the oral health behaviors addressed in the consultation and finding positive results not only in motivation, but especially in the self-regulation of behaviors, was a result that brought great satisfaction because of its impact on self-regulation. The strategy we developed involving the intraoral camera, text messages, and behavioral change techniques, with its impact on increasing the use of dental floss and reducing gingival bleeding, is one relevant contribution of this dissertation.

These strategies increase the effectiveness of health interventions. Although they require some change in the routine of health professionals, five minutes at least, which may

seem like a waste of time, can provide an increase in something that is not easily measurable – greater ability to interact with the patient, thus increasing the number of patients who are satisfied and invested in the treatments (Feuerstein, 2004).

When using these technologies to support communication with patients, one must keep in mind the basic principles of interpersonal relationships in health: more than technology per se, it is the way we use it that will make the difference. It is not the photographs themselves – it is the way we present these personal images to patients and what we do with them that will help make the process effective (Blaxter, 2009).

The success of our intervention in patients with gingival pathologies is the result of a multifaceted relationship between individuals, professionals, and treatments. The adoption of communication technologies in clinical practice is a constantly evolving process that will depend on the skills of modern oral health professionals if an appropriate balance is to be achieved between these multiple facets.

Another innovative aspect of this thesis was to apply the HAPA model (Schwarzer, 2008) in a study of adults with symptoms of gingivitis. It proved to be explanatory of oral health behavior, both in the study of oral hygiene mediators and to support the use of new technologies. The model thereby contributed to a better understanding of the impact of motivational and volitional variables in controlling this pathology.

Regarding the psychological determinants related to oral hygiene behaviors and influenced by the technologies used in this thesis, it was clear that post-intentional factors were influenced more predominantly. It is important to repeat and reflect on the results of Study 4, where we emphasize that the need to consolidate planned changes through more constant monitoring seems to be important for achieving therapeutic results. The use of strategies such as text messages and the intraoral camera can contribute to improving the monitoring necessary for improving gingival health.

The present investigation thus contributes to what has been written in recent decades about the importance of managing behavior change in oral health. What it adds to the literature is a set of results on interventions to promote oral hygiene behaviors, showing that the use of technologies can help to improve the way we intervene, without necessarily altering or radically changing the way we work (Feuerstein, 2004). However, despite the results presented and the general consensus on the importance of changing health behaviors, based on evidence and specific strategies (Michie et al., 2013; Newton & Asimakopoulou, 2015), most periodontal treatments continue to resort to common sense and focus on the treatment of sequelae of acute episodes. Various authors (e.g., Darby, 2003; Gobat et al., 2010; Newton & Asimakopoulou, 2015; Ramseier & Suvan, 2010; Renz et al., 2007; Webb & Sheeran, 2006) are clear in saying that we cannot continue to treat our patients as if they were recipients of information and not actors capable of understanding and generating their behaviors.

Bearing this in mind, learning communication strategies should be an essential element in the training of oral health professionals. Faculties of dental medicine and oral hygiene should ensure that their graduates are properly trained in these skills. However, this does not happen at present. From a careful reading of the available evidence, it can be seen that teaching in these areas is mostly poor: relegated to curricular units related to the social sciences, such as communication and psychology, where the instruction is quite theoretical, with minimal application to the practical training of future oral health professionals (Carey et al., 2010;Field et al., 2020; Neville & Waylen, 2019; Pine & McGoldrick, 2000; Soderlund et al., 2011). In our view, schools and those responsible for curriculum revisions must include this theme in a more comprehensive way, exposing students to social, educational, and psychological themes throughout their training, and behavior change techniques should be explored in clinical training, in a transversal and integrated way (Field et al., 2020; Mann et al., 2009; Murrell et al., 2019; Soderlund et al., 2011).

A dental office offers us a unique environment to intervene in oral health, as well as in health more globally. Regular visits to the dental office are widespread in the western world, and this frequency allows oral health professionals to acquire reasonable knowledge about the patient, a privileged situation from which to form a long and supportive relationship in the management of patients' health care. Considering the clear evidence that most periodontal diseases are caused by biofilm, and even those that are not induced by it are aggravated by ineffective control (Chapple et al., 2018), it is unthinkable to have a therapy that includes scaling, root planning, periodontal surgeries, bone replacement, and even implants, without including behavioral management strategies at the same level of importance. However, as already mentioned, these strategies are often underused or often ignored when professionals assume the more conventional role of dental hygienist or dentist (Ramseier & Suvan, 2010).

This investigation showed the role of the intraoral camera and text messages in the use of dental floss and in gingival health. In view of these results, we hope further studies will explore alternative information communications technology. We also hope that these results will inspire reflection on how to act in support of behavior change on the part of patients, where it is essential to highlight the use of evidence-based knowledge. We also hope to be helpful in creating new attitudes toward communication with patients by dental hygienists and dentists, in order to promote periodontal health and improvements in the therapeutic relationship. Future professionals deserve it; patients and health deserve it, too.

In truth, we're only as far away as a short message or the clicking of a camera….

8.6. REFERENCES

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9. APPENDICES

9.1. APPENDIX 1 - QUESTIONNAIRE

INFORMED CONSENT FORM

This online study is part of a research project by Mário Rui Araújo with the supervision of Professor Maria João Alvarez and Professor Cristina Godinho of the Faculty of Psychology at the University of Lisbon.

It is a project approved by the Deontology Commission of the Faculty of Psychology of the University of Lisbon.

Study presentation sheet

The aim of this project is to increase the understanding of how our oral health behaviors work.

To participate it is necessary:

1) speak Portuguese as a native language;
2) being 18 or older;
3) not having clinical condition of periodontitis.

Please read this information before agreeing to participate.

It is essential that you participate in all free dental appointments associated with this study.

The questionnaire must be individual and fully completed.

What will be requested?

If you agree to participate in this study, you will be asked to answer the questionnaire anonymously, through a web platform. You will be entitled to 3 free dental appointments where you will receive: diagnoses, gum treatments, and health education. Oral hygiene materials (GumChucks) will be offered.

In order for us to associate patient information with each dental appointment, a code will be created. This code is unique and exclusive.

It will take about 15 minutes to complete the questionnaire.

Responses will be kept confidential.

Participants in need of dental treatment will be advised to undergo treatment, however, those consultations will not be part of the study and they will be not included in the free consultations.

Consent

By selecting the option: "Yes, I have read the informed consent, I intend to continue and participate in the study" you declare that you are of legal age, have read this consent form, consider that you have been provided with the necessary information about the nature and objectives of this study and you intend to participate in it.

☐ Yes, I read the informed consent. I intend to continue and participate in the study
☐ I do not intend to participate in the study

In order for us to anonymously and confidentially study the association of data between the different questions, we will ask you to create a unique and exclusive code.

WHENEVER REPEATING THIS QUESTIONNAIRE YOU MUST USE THE SAME CODE.

The code has 6 characters: 2 letters followed by 4 digits.

To create the code, you must use:

1. the first letter of your first name;
2. the first letter of the last name;
3. the first four digits of the ID or citizen card (CC).

Please see below for an example on how to generate a code, we have underlined the letters and figures that should be used to create the anonymous code.

Example:

Name - Mário Rui Gabriel Araújo
ID/CC - 12345678
Your code will be:MA1234

Please write the code:

First letter of your first name: _____

First letter of the last name: _____

First four digits of the ID or citizen card (CC: _____

PLEASE ANSWER ALL QUESTIONS UNLESS OTHERWISE INSTRUCTED

1 - Specify the number of dental visits you have already made for this study: ☐

2 - Sex

☐ Male. (1)
☐ Female. (2)

3 - Age: _____

4 - Education Level:

☐ Basic education. (1)
☐ Secondary school (2)
☐ High School. (3)
☐ University level. (4)

5 - Which of the following categories best describes the industry you primarily work in (regardless of your actual position):

☐ Retired (1)
☐ Unemployed (2).
☐ Agriculture (3)
☐ Forestry (4)
☐ Fishing and Hunting (5)
☐ Utilities (6)
☐ Construction (7)
☐ Computer and Electronics Manufacturing (8)
☐ Other Manufacturing (9)
☐ Wholesale (10)
☐ Retail (11)
☐ Transportation and Warehousing (12)
☐ Publishing (13)
☐ Software (14)
☐ Telecommunications (15)
☐ Broadcasting (16)
☐ Information Services and Data Processing (17)

☐ Other Information Industry (18)
☐ Finance and Insurance (19)
☐ Real Estate (20)
☐ Rental and Leasing (21)
☐ College, University, and Adult Education (22)
☐ Primary/Secondary (K-12) Education (23)
☐ Other Education Industry (24)
☐ Health Care and Social Assistance (25)
☐ Arts, Entertainment, and Recreation (26)
☐ Hotel and Food Services (27)
☐ Government and Public Administration (28)
☐ Legal Services (29)
☐ Scientific or Technical Services (30)
☐ Homemaker (31)
☐ Military (32)
☐ Religious (33)
☐ Other Industry (34)

6 - In the past two weeks, how many times a day have you brushed your teeth?

☐ Did not brush (1)
☐ Barely (2)
☐ Once a day (3)
☐ Twice a day (4)
☐ More than twice a day (5).

7 - What kind of brush do you use? (*You may choose more than one option*)

☐ Manual (1)
☐ Power, oscillating rotating (round head). (2)
☐Power, sonic. (3)
☐ Other: _____ (4)

8 - Does your toothpaste contain fluoride?

☐ Yes. (1)
☐ No. (2)
☐ I don’t know (9)

9 - Besides toothpaste and toothbrush, do you use any other products for your dental hygiene? (You can choose more than one option)

☐ Dental floss (1)
☐ Interproximal brush (2)
☐ Toothpick (3)
☐ Floss holder (4)
☐ Oral irrigator (5)
☐ Rinse (6)
☐ Other products:_____ (7)
☐ Nothing (8)
☐ Don't remember (9)

10 - In the past two weeks how many times a day have you used these products:

One answer per product

	Dental Floss (finger floss)	Floss holder (GumChucks)	Toothpick	Interproximal brush
Did not use				
Barely				
Once a day				
Twice a day				
More than twice a day				

11 - You never floss or use dental floss less than once a day, because:

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	I fully agree
I don't have food between my teeth					
I do not know how to use it					
I've tried, but it's very complicated to use dental floss					
Lack of time					
The dental floss hurts my gums and they start to bleed					
I have many dental treatments and it's almost impossible to floss (bridges, prostheses on implants, etc.)					
My teeth are too tight					
Dental floss always shreds and the remnants get stuck to the teeth					

12 - In your opinion, how do you evaluate your teeth condition?

☐ Very good
☐ Good.
☐ So - so
☐ Bad
☐ Very bad

13 - In your opinion, how do you evaluate your gingiva's condition?

☐ Very good
☐ Good
☐ So - so
☐ Bad
☐ Very bad

14 - Gingivitis is an inflammation of the gums caused by the accumulation of dental plaque and dental calculus.
In your opinion, how serious is this disease? **(Circle the chosen result)**

1 *Nothing serious*
2
3
4 *Moderately severe (like a cold)*
5
6
7 *Extremely serious (life threatening)*

15 - If you do not change your dental hygiene habits, what do you consider the likelihood that you will one day have gingivitis?

☐ Well below average
☐ Below average
☐ Slightly below average
☐ Average
☐ Slightly above average
☐ Above average
☐ Well above average

16 - Good dental hygiene results in the effective removal of food debris (especially after meals), and, at the same time, prevents growth of bacteria on teeth and gingiva.

What are the consequences of a poor dental hygiene?

17 - Some people would like to improve oral hygiene habits and brush their teeth twice a day and clean between their teeth.
And you?

	Strongly disagree	Disagree	Slightly disagree	Neither agree nor disagree	I agree a little	Agree	I fully agree
I already have concrete plans about when to start brushing my teeth twice a day and clean between my teeth daily (e.g., after lunch and before going to bed).							
I already have concrete plans about where to brush my teeth twice a day and clean between teeth daily (e.g., at home and at work).							
I already have concrete plans on how to brush my teeth twice and clean between teeth daily (e.g., having a brush in the workplace and at home and a box of dental floss with me).							

18 - Various situations may hinder oral hygiene habits. Some people will make plans to deal with these situations and others don't.
And you?

	Strongly disagree	Disagree	Slightly disagree	Neither agree nor disagree	I agree a little	Agree	I fully agree
I already have concrete plans about when I will have to pay particular attention to be able to brush my teeth twice a day and clean between my teeth daily.							
I already have concrete plans about what to do in difficult situations in order to be able to fulfil my intention to brush my teeth twice a day and clean between my teeth daily.							
I already have concrete plans on how I should act and return to the same routine, if I stop brushing my teeth twice a day and clean between my teeth daily.							

19 - In your opinion, what would be the consequences of changing your oral hygiene habits and starting brushing your teeth twice a day and clean between your teeth daily?
And you?

	Strongly disagree	Disagree	Slightly disagree	Neither agree nor disagree	I agree a little	Agree	I fully agree
Avoid having toothaches							
Improving the ability to chew food.							
Preventing bleeding gums							
Feeling more beautiful.							
Avoiding having to go to the dentist more often.							
Improving my oral health.							
Improving my breath, making it fresh and more pleasant.							

20 Some people find it difficult to brush their teeth twice a day and clean between their teeth daily.
And you?

	Strongly disagree	Disagree	Slightly disagree	Neither agree nor disagree	I agree a little	Agree	I fully agree
I believe I can keep doing this behavior every day, even if you have to change my routines a bit.							
I believe I can keep doing this behavior every day even if it is difficult for me							
I think I can adjust my life to keep doing this behavior every day, even if it involves some planning.							

21 - I believe I can maintain the habit of brushing my teeth twice a day and cleaning between my teeth daily…

	Strongly disagree	Disagree	Slightly disagree	Neither agree nor disagree	I agree a little	Agree	I fully agree
Even if I'm very lazy							
Even if I have to start over several times until I get it.							
Even if I am concerned about other aspects of my life.							
Even if my family (or anyone who lives with me) does not have these oral hygiene habits.							

22 - Suppose that after you changed your oral hygiene habits and started brushing your teeth twice a day and cleaning between your teeth daily, you stop doing it for a while.

Do you think you could start brushing your teeth twice a day and cleaning between your teeth daily again?

	Strongly disagree	Disagree	Slightly disagree	Neither agree nor disagree	I agree a little	Agree	I fully agree
I believe I could, even if I had spent a few days without doing so.							
I believe I could, even if I had spent some days without doing so.							
I believe I could, even if I had spent several weeks without doing so.							

23 - For the next two weeks, what will be your intention to brush your teeth twice a day and clean between your teeth daily?

	Strongly disagree	Disagree	Slightly disagree	Neither agree nor disagree	I agree a little	Agree	I fully agree
I intend to do it from now on.							
From now on I intend to do it daily.							
I intend to do it daily.							

24 - Some people manage to control their behavior in order to realize their intentions to brush their teeth twice a day and clean between their teeth daily, while others don't.
And you?

	Strongly disagree	Disagree	Slightly disagree	Neither agree nor disagree	I agree a little	Agree	I fully agree
Currently I evaluate my behavior to see if I'm brushing my teeth two times a day and clean between teeth daily.							
I always have the intention of brushing my teeth two times a day and cleaning between teeth daily present in my mind.							
I strive to act according to my intentions to brush my teeth two times a day and to clean between my teeth daily.							

25 - Give your opinion about the Intra Oral Camera:

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	I fully agree
I enjoyed seeing images of my mouth.					
It was a nice experience to see the images during the appointment.					
I think the pictures are a good way to see the condition of my mouth.					
The images gave me information that helped me to improve my oral hygiene.					
The images were disturbing.					
I think the number of pictures was excessive.					
The contents of the images were disgusting.					
The images were useful for the appointment.					
Overall, I enjoyed seeing the pictures of my mouth.					

		YES, I thought they were worst	YES, I thought they were better	NO, I knew they were like that	I can't say
Looking in detail at your mouth with the IOC, has it changed the perception about your teeth?					
Looking in detail at your mouth with the IOC, has it changed the perception about your gums?					

26 - Give your opinion about the Text Messages you received during the last 4 months:

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	I fully agree
I enjoyed receiving the messages.					
It was nice to receive messages.					
The messages are a good way to get spot information.					
The messages had information that helped to improve my oral hygiene.					
The messages were annoying.					
The number of messages was exaggerated.					
The message content was not interesting.					
The messages helped in my oral hygiene.					
I trust the content of the messages.					
Overall, I liked the messages					
		Less than 1 message per week.	One message per week	Two messages per week	More than 3 messages per week
I am willing to receive messages that help me control my oral health.					
	I ignore it completely	Sometimes I read it	I did not read it at the moment. I let accumulate several.	I read the message when I had time	Read it immediately
What usually do you do when receiving the message about oral health?					
Tell us your opinion about the use of TM: _____					

27 - Gum Chucks

	I did not receive them	I really enjoyed and they are easy to use	I really enjoyed them but they are not so easy to use	I did not enjoy them, but maybe they can help	I did not enjoy them
What usually do you do when receiving the message about oral health?					

9.2. APPENDIX 2 - TEXT MESSAGES, HAPA CONSTRUCTS, AND THEIR HEALTH TOPICS

Text Messages	HAPA Constructs	Health Topic
This week gifts from Santa shall appear. If you brush your back molars and close to your tongue, all the inflammation we have talked about will disappear. MRA	OE	Brushing
Protect your mouth and Christmas from inflammations. Remember to remove plaque between your teeth daily. If you do it, your gingiva will be healthy. A Christmas without inflammations is a wonderful gift. Merry Christmas! 🎄MRA	OE	Flossing
Today, we have deposit 365 days of good luck, joy, and healthy gums into your account. That's all you get in a year. Use them well. Beat the game against laziness and brush your teeth twice a day. The health of your mouth will win! Happy new year! 🍾 MRA	ASE	Brushing
And the best advice for 20** is: control the plaque daily in the spaces between your teeth – that way this zone will be clean and you will always have fresh breath! MRA	AP	Flossing
No one can lick their own elbow – it's impossible to touch it with their own tongue ... Now that you've wasted your time trying to lick your elbow, start planning flossing before it is too late :) Protect your mouth and be healthy. MRA	RSE	Flossing
(Name), failure is not an option ... Although it is easy to use the GumChucks, some discipline is needed to gain the habit. You can do it! Start planning your flossing time. Thanks. MRA	AP	Flossing
Life has no remote control. We have to get up and move! Think about the obstacles to using GumChucks, find at least one way to get past them, and it	RSE	Flossing

will be easier to get into the habit of using them daily. Your gingiva will say thanks. 🙏 MRA		
Going to bed early and getting up early makes you healthy and makes bacteria grow! Strive to brush your teeth in the morning. If not after breakfast, let it be before. MRA	CP	Brushing
It is impossible to sneeze with your eyes open, BUT it is possible to take care of the gingiva between your teeth, even if it has been some time without doing so. You'll see! If you can, your gingiva will be healthy again. MRA	RSE	Flossing
Tell me about your dental hygiene and I'll tell you about your gingiva! Maintain the habits we talked about, and it will be easy to have healthy gums. Regards, MRA.	MSE	Dental hygiene
(Name), using GumChucks every day will improve the health of your gums! Have a nice week... MRA	OE	Flossing
In life, there are things that pass and leave nothing, there are others that pass and leave a lot, and there are others that do not pass – they stay forever. Floss your teeth effectively and your mouth will have healthy, fresh breath! You can do it! MRA	ASE	Flossing
(Name), it is easy to brush your teeth daily for 2 minutes. If you do, the likelihood of your gingiva staying healthy will increase ...	ASE	Brushing
Halitosis: difficult to say, easy to control. Before you go to bed, you will see that you are able to control the plaque between your teeth! It’s easy and your health will thank you. MRA	ASE	Flossing
Do you know what a werewolf does after being persuaded to use the floss? He eats the Dental Hygienist! 😂 It is fun to use the floss! MRA	ASE	Flossing
(Name) 16 weeks went by, congratulations. I know your dental hygiene is great and that's more than just hygiene. It contributes to maintaining your beautiful teeth, saving money and keeping your “health” fresh. 😉 See you at the appointment... MRA	MSE	Dental hygiene

Note. OE: Outcome Expectancies; ASE: Action Self-Efficacy; AP: Action Planning; CP: Coping Planning; MSE: Maintenance Self-Efficacy; RSE: Recovery Self-Efficacy.

9.3. APPENDIX 3 - DENTAL APPOINTMENT SCRIPT AND CHECK LIST

This script is the basis for the appointment, it is not supposed to be memorized, only the general structure must be maintained. Time and organization of the dental appointment based on Newman, Takei, Klokkevold & Carranza, 2015 (p. 716).

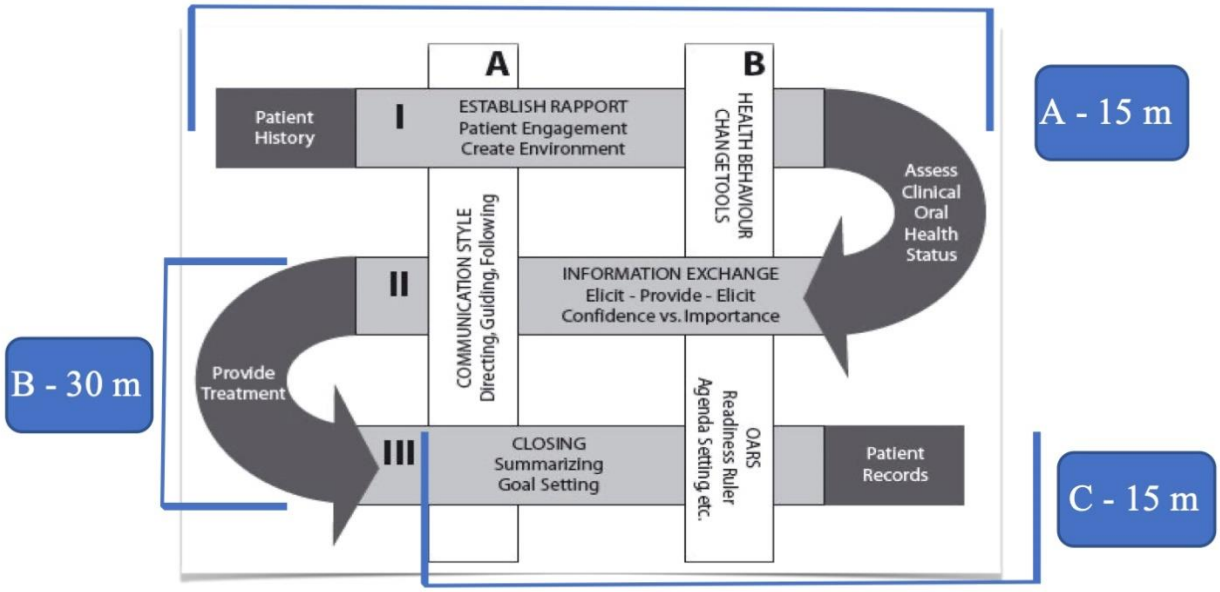

Figure 19. The structure of the appointment was based on the patient activation fabric for the dental visit (implementation model). (Ramseier & Suvan, 2010)

First Dental Appointment

1. Patient History/Assess Clinical Oral Health Status

(Call the patient in, ask them to sit in the chair but don't yet lower the back):

□ **Establish rapport** (patient engagement, creating the environment):

□ **Objectives**:

Thank you very much for having agreed to come to this appointment. This is a normal dental appointment, in fact, but as we are collecting data for a study, you had to complete the questionnaire that was sent to you. Did you have any difficulties?

Okay, so if you don't mind, let's start our observation. You don't get nervous in these places, do you?

The whole process is very easy: I will first observe the state of your gums, then explain what I found and, if necessary, we will make a small intervention to remove any tartar or plaque that may be causing some inflammation. Then we'll talk about the treatment that has to be done at home.

□ **Have a question, anything you want to ask?**

Okay, now I'm going to lower the chair.

(Lowering the chair and patient with protective goggles.)

□ **Patient perception/ Patient rapport**

So, tell me if you have any complaints in your gums.

Do your gingiva bleeds when you brush your teeth?

And when you clean between teeth?

Do you experience any bad breath or a bad taste in your mouth?

Any of these complaints bother you or worry you?

Control and TM Groups

□ **Gingival/dental exam:**

After looking at your gums and following what we found in our previous exam, I could see that your gums are…

□ **Report without judgment.**

□ **No hygiene words:**

Explains the situation. Enlighten the patient.

Let's see, the main cause of this situation has to do with the accumulation of certain deposits in certain areas of the gum. Were you aware of this situation?

Ask about the daily habits, what kind of mouth daily care he/she has.

My suggestion is, in addition to removing these deposits from your teeth, at the end of this action we will talk a little bit about how we can treat the inflammation. Do you agree?

□ **Any questions?**

Intraoral Camera group

☐ **Ask for permission:**

I am going to use a camera to help me with the oral diagnosis. Is that ok? You don't need to see if you don't want to.

☐ **Gingival/dental exam:**

After looking at your gums and according with a previous exam, I could see that your gums are…

☐ **Report without judgment**

No hygiene words:

Explains the situation. Enlighten the patient.

Let's see, the main cause of this situation has to do with the accumulation of deposits in certain areas near the gum line.

Ask about the daily habits, what kind of mouth daily care he/she has.

My suggestion is, in addition to removing these deposits from your teeth, at the end of this action we will talk a little bit about how we can treat the inflammation. Do you agree?

☐ **Ask for permission:**

Would you mind looking at your pictures?

☐ **Show pictures:**

Let's see, the main cause of this situation has to do with the accumulation of certain deposits in your mouth.

As we talked about before, I took some pictures when I was doing this little gingival exam, let's discuss them. Were you aware of this situation?

My suggestion is that, in addition to removing these deposits from your teeth, we will talk a little bit about how we can treat this inflammation so that we can stop the bleeding.

☐ **Any questions?**

2. Provide treatment: Biofilm removal advices. Behavioral modification treatment

Clinical treatment: Ex: calculus removal, stain removal, biofilme removal, polishing.

Behavioral modification treatment

Control Group

How do you feel? Was it difficult?

Well now, let's try to understand what we can do to treat and avoid this situation in the future, in fact, removing calculus is not enough to heal the gums. It helps, but the real treatment will have to be continued. Today's removal of calculus is important for you, but it's not enough.

☐ **Can you show me how do you use the TB?**

(Give a toothbrush to the patient)

☐ **Listen, and explain, without judgement***:*

The most inflamed areas need to be more controlled, maybe the toothbrush can play that role.

☐ **Positive feedback:**

Do you mind if I suggest something?

(See what the patient needs in terms of toothbrushing and make suggestions.)

☐ **Explain, demonstrate, and ask the patient to do the toothbrushing in the most inflamed areas.**

☐ **Awareness of standards:**

There will be normal bleeding, but if the treatment goes well, after approximately 3 days the bleeding will disappear.

☐ **Reaffirm:**

I see that you are trying and your oral hygiene is not bad, but brushing alone cannot help the inflammation. We will have to think about how we can change this situation. Do you think all this makes sense to you?

For the same reason the bacteria that accumulate between your teeth are causing problems in those areas. Also, here the toothbrush is doing great work on your teeth, but it's not helping the gingiva.

Remind me, what is your relation with the (interproximal device)?

☐ **Suggest**:

Okay, so let's take that situation into account and try to see if we ca help each other in this. We need to control this gingivitis (Do you know what it is?)

☐ **Goal setting**

☐ **Interproximal control suggestions:**

I suggest that, due to the existing inflammation, we should try this dental floss with special characteristics (Demonstrate how to use GumChucks). Let's try?

TM group

How do you feel? Was it difficult?

Now let's try to understand what we can do to avoid this situation in the future. In fact, removing calculus is not enough to heal the gums. It helps, but the real treatment will have to be continued. Today's removal of calculus is important for you, but it's not enough.

☐ **Explain, without judgement***:*

The most inflamed areas need to be more controlled, maybe the toothbrush can play that role.

☐ **Can you show me how do you use the TB?**

(Give a toothbrush to the patient)

☐ **Positive feedback:**

Do you mind if I suggest something?

(See what the patient needs in terms of toothbrush and make suggestions.)

☐ **Make connections with the images**

☐ **Explain, demonstrate, and ask the patient to do the toothbrushing in the most inflamed areas.**

☐ **Awareness of standards:**

There will be normal bleeding, but if the treatment goes well, after approximately 3 days the bleeding will disappear.

☐ **Reaffirm:**

I see that you are trying and your oral hygiene is not bad, but brushing alone cannot help the inflammation. We will have to think about how we can change this situation. Do you think all this makes sense to you?

The bacteria that accumulate between your teeth are causing problems in those areas. Also, here the toothbrush is doing great work on your teeth, but it's not helping the gingiva.

Remind me, what is your relation with the (interproximal device)?

☐ **Suggest**:

Okay, so let's take that situation into account and try to see if we ca help each other in this. We need to control these gingivitis (Do you know what it is?)

☐ **Goal setting**

☐ **Interproximal control suggestions:**

I suggest that, due to the existing inflammation, we should try this dental floss with special characteristics (Demonstrate how to use GumChucks). Let's try?

☐ **Suggest TM:**

I have still another proposal to make. What do you think of receiving TM from us, once a week for 4 months?

The idea is to try to help you help your gums: if you don't mind we will remind you every week about these techniques that we've agreed are important for you, but which don't always get done. It's not a critique – it's a suggestion to help you… You just receive the TM, just read it, no need to answer or anything. Just some extra support.

What do you think about this idea?

Shall we try it?

Okay, so let's take this situation into account and try to comply with this treatment strategy to see how the gums react and how the situation evolves. I will send you the messages soon.

TM/IOC group

How do you feel? Was it difficult?

Now let's try to understand what we can do to avoid this situation in the future. In fact, removing calculus is not enough to heal the gums. It helps, but the real treatment will have to be continued. Today's removal of calculus is important for you, but it's not enough

☐ **Use the camera to show details of the oral hygiene education:**

- Angulation
- Areas for flossing / back molars/Lingual zones
- Difficult areas or inflamed zones

☐ **Explain, no judgement***:*

The most inflamed areas need to be more controlled – maybe the toothbrush can play that role.

☐ **Can you show me how do you use the TB?**

(Give a toothbrush to the patient)

☐ **Positive feedback:**

Do you mind if I suggest something?

(See what the patient needs in terms of toothbrush and make suggestions.)

☐ **Tell show and do the tooth brushing in the most inflamed areas**

☐ **Make connections with the images**.

Example: Show that toothbrushing is not helping interproximal.

☐ **Interproximal control suggestions:**

I will suggest that, due to the existing inflammation, and because is not possible to those areas with the brush, maybe we need use this dental floss with special characteristics (Show and teach how to use GumChucks). Let's, try?

☐ **Awareness of standards:**

There will be normal bleeding, but if the treatment goes well, after approximately 3 days the bleeding will disappear.

☐ **Reaffirm:**

I see that you are trying and your oral hygiene is not bad, but brushing alone cannot help the inflammation. We will have to think about how we can change this situation. Do you think all this makes sense to you?

The bacteria that accumulate between your teeth are causing problems in those areas. Also, here the toothbrush is doing great work on your teeth, but it's not helping the gingiva.

Remind me, what is your relation with the (interproximal device)?

☐ **Suggest**:

Okay, so let's take that situation into account and try to see if we can help each other with this. We need to control this gingivitis (do you know what it is?).

☐ **Suggest TM:**

I have still another proposal to make. What do you think of receiving TM from us, once a week for 4 months?

The idea is to try to help you help your gums: if you don't mind we will remind you every week about these techniques that we've agreed are important for you, but which don't always get done. It's not a critique – it's a suggestion to help you… You just receive the TM, just read it, no need to answer or anything. Just some extra support. What do you think about this idea?

☐ **Goal setting**

Intraoral Camera

How do you feel? Was it difficult?

Now let's try to understand what we can do to avoid this situation in the future. In fact, removing calculus is not enough to heal the gums. It helps, but the real treatment will have to be continued. Calculus removal is important for you, but it's not enough.

☐ **Use the camera to show details of the oral hygiene education:**

- Angulation
- Areas for flossing: back molars / Lingual zones
- Difficult areas or inflamed zones

☐ **Explain, no judgement***:*

The most inflamed areas need to be more controlled – maybe the toothbrush can play that role.

☐ **Can you show me how do you use the TB?**

(Give a toothbrush to the patient)

☐ **Positive feedback:**

Do you mind if I suggest something?

(See what the patient needs in terms of toothbrushing and make suggestions.)

☐ **Explain, demonstrate, and do the tooth brushing in the most inflamed areas**

☐ **Make connections with the images**.

Now show that toothbrushing is not helping interproximal.

☐ **Interproximal control suggestions:**

I will suggest that, due to the existing inflammation, and because is not possible to clean those areas with the brush, maybe we need use this dental floss with special characteristics (Show and teach how to use GumChucks). What do you think?

☐ **Awareness of standards:**

There will be normal bleeding, but if the treatment goes well, after approximately 3 days the bleeding will disappear.

☐ **Reaffirm:**

I see that you are trying and your oral hygiene is not bad, but brushing alone cannot help the inflammation. We will have to think about how we can change this situation. Do you think all this makes sense to you?

The bacteria that accumulate between your teeth are causing problems in those areas. Also, here the toothbrush is doing great work on your teeth, but it's not helping the gingiva.

Remind me, what is your relation with the (interproximal device)?

☐ **Suggest**:

Okay, so let's take that situation into account and try to see if we can help each other with this. We need to control this gingivitis (do you know what it is?)

☐ **Goal setting**

☐ **Farewells and Rescheduling the Next Appointment**

Second/Third Dental Appointments - 4 Months/8 Months

1. Patient History/Assess Clinical Oral Health Status

(Call the patient in, ask them to sit in the chair but don't yet lower the back):

☐ **Establish rapport**

(patient engagement, create environment):

☐ **Objectives**:

Welcome, so how's everything since the last time? Have you been well? Thank you very much for taking the survey and coming back again.

Well, well, let's start. You know, I'm really curious to see how things went.

How did it go with all the things we talked about? Was the flossing difficult?

☐ **Responsibilities**

☐ **Have a question, anything you want to ask?**

Okay, now I'm going to lower the chair. (Lower the chair and fit patient with protective goggles.)

☐ **Patient perception/ Patient rapport**:

The process is similar: I will examine the state of your gums and explain what I see. If necessary, we will make a small intervention to remove any deposits that may still exist.

☐ **Opinion and perception about oral health (gingival and teeth)**:

So, tell me how you feel about your gingiva. Any differences?

☐ **When you brush your teeth, do your gums still bleed?**

☐ **And if you've been flossing, how do you think the bleeding is? Is it the same, or decreased?"**

☐ **Do you experience any bad breath or a bad taste in the mouth** (*ask only if this symptom was previously detected*)? **Has it improved or is it still the same?**

☐ **Overall, how do you feel?**

Intraoral camera group

☐ **Ask for permission to take photos:**

I am going to use a camera to help me with the oral diagnosis. It's that ok? If you want you do not need to look.

☐ **Ask for permission to show the photos:**

Would you mind taking a look at your photos?

☐ **Gingival/dental exam:**

After looking at your gums and according to a previous exam, I could see that your gums are… Talk about the first pictures. Compare, but show after scaling.

☐ **Report without judgment**

☐ **No hygiene words**

2. Provide Treatment: Biofilm Removal Advices. Behavioral Modification Treatment

Clinical treatment: Ex: Calculus removal, stain removal, removal of biofilm, polishing.

Behavioral modification treatment

Control group

Doubts?

How do you feel? Was it difficult?

☐ **Feedback:**

Dialogue based on the reported situation.

If the patient has improved, focus on positive feedback.

If the situation persists, try to understand the reasons and ask the patient for suggestions to improve the control.

☐ **Self-Monitoring:**

Review standards.

Can you see/feel that?

☐ **Listen, explain, no judgement***:*

The most inflamed areas need to be more controlled – maybe the toothbrush can play that role.

☐ **Explain, demonstrate, and perform the oral hygiene techniques (If needed).**

☐ **Goal setting:**

(Planning.) Okay, so let's take this situation into account. I would like to see you again in 4 months. Does that work for you?

TM group

Doubts?

How do you feel? Was it difficult?

☐ **Feedback:**

Dialogue based on the reported situation.

If the patient has improved, focus on positive feedback.

If the situation persists, try to understand the reasons and ask the patient for suggestions to improve the control. Related with TM

☐ **Self-Monitoring:**

Review standards.

Can you see that?

☐ **Listen, explain, no judgement***:*

The most inflamed areas need to be more controlled – maybe the toothbrush can play that role.

Related with TM

☐ **Explain, demonstrate, and perform the oral hygiene techniques (If needed)**

☐ **Goal setting:**

(Planning.) Okay, so let's take this situation into account. I would like to see you again in 4 months. Does that work for you?

Intraoral camera group

How do you feel? Was it difficult?

☐ **Feedback:**

Dialogue based on the reported situation.

If the patient has improved, focus on positive feedback. Compare with the first session pictures.

If the situation persists, try to understand the reasons and ask the patient for suggestions to improve the control. Compare with the first session pictures.

☐ **Self-Monitoring:**

Review standards. *Can you see that?* Compare with first session pictures.

☐ **Listen, explain, without judgement***:*

The most inflamed areas need to be more controlled – maybe the toothbrush can play that role. Compare with first session pictures. Use pictures to explain where he/she could improve.

☐ **Explain, demonstrate, and perform the oral hygiene techniques (If needed)**

☐ **Goal setting:**

(Planning.) Okay, so let's take this situation into account. I would like to see you again in 4 months. Does that work for you?

Intraoral camera/TM group

How do you feel? Was it difficult?

☐ **Feedback:**

Dialogue based on the reported situation.

If the patient has improved, focus on positive feedback. Compare with the first session pictures. Related with TM

If the situation persists, try to understand the reasons and ask the patient for suggestions to improve the control. Compare with the first session pictures. Related with TM

☐ **Self-Monitoring:**

Review standards. *Can you see that?* Compare with the first session pictures.

☐ **Listen, explain, no judgement***:*

The most inflamed areas need to be more controlled – maybe the toothbrush can play that role. Compare with the first session pictures.

Use pictures to explain where he/she could improve.

Related with TM

☐ **Explain, demonstrate, and perform the oral hygiene techniques (If needed)**

☐ **Goal setting:**

(Planning.) Okay, so let's take this situation into account. I would like to see you again in 4 months. Does that work for you?

☐ **Closing**

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