Universidade do Minho
Escola de Medicina

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Trabalho efetuado sob a orientação da
Professora Doutora Patrícia Ribeiro Pinto

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DIREITOS DE AUTOR E CONDIÇÕES DE UTILIZAÇÃO DO TRABALHO POR TERCEIROS

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STATEMENT OF INTEGRITY

I hereby declare having conducted this academic work with integrity. I confirm that I have not used plagiarism or any form of undue use of information or falsification of results along the process leading to its elaboration.

I further declare that I have fully acknowledged the Code of Ethical Conduct of the University of Minho.

Ansiedade dentária, dor e *mindfulness* em pacientes submetidos a procedimentos dentários

RESUMO

A dor e a ansiedade são experiências comuns no consultório médico-dentário que podem resultar no evitamento dos cuidados de saúde oral. A ansiedade dentária é um tipo de apreensão associada com a odontologia. É caracterizada por uma resposta física e/ou emocional a tais estímulos, e tem sido associada a níveis mais elevados de dor e ansiedade durante as consultas. O *mindfulness* é um processo de atenção sustentada e consciente para as experiências do momento presente, com uma atitude de não julgamento e aceitação, o que pode contribuir para reduzir a dor e a ansiedade em diferentes contextos. No entanto, pouco se sabe sobre a possível influência deste construto no contexto dentário.

O objetivo deste estudo foi investigar a associação entre ansiedade dentária, dor e *mindfulness,* e ainda explorar os preditores de dor/desconforto e ansiedade em pacientes submetidos a procedimentos dentários. Este foi um estudo observacional e exploratório, realizado com 111 pacientes adultos, avaliados antes (T0) e após (T1) uma consulta dentária. Em T0, foram avaliadas medidas sociodemográficas e clínicas, bem como a ansiedade dentária (*Dental Fear Survey*), *mindfulness* (Escala de Atenção Plena e Consciência), sintomas gerais de ansiedade e depressão (*Patient Reported Outcomes Measurement Information System*, versões abreviadas), catastrofização da dor (Questionário de Estratégias de Coping - revisto), ansiedade pré-procedimento (Escala de Classificação Numérica - *NRS*) e dor esperada (*NRS*). Em T1, os pacientes reportaram os níveis de dor, desconforto e ansiedade (*NRS*) experimentados durante o procedimento e o dentista preencheu um relatório clínico sobre o tratamento.

Os resultados mostraram que a ansiedade dentária estava associada aos níveis de *mindfulness* ($r=-.363$, $p<.001$), sintomas de ansiedade e depressão ($r=.304$, $p=.001$ e $r_{sp}=.236$, $p=.013$, respetivamente), catastrofização da dor ($r=.677$, $p<.001$), ansiedade pré-procedimento ($r=.574$, $p<.001$) e dor esperada ($r=.449$, $p<.001$). Os modelos de regressão linear hierárquica revelaram que os preditores significativos de dor/desconforto durante o procedimento dentário foram queixa prévia de dor na cavidade oral ($ß=.253$, $p=.001$), dor esperada ($ß=.458$, $p<.001$) e ansiedade dentária ($ß=.197$, $p=.015$). A ansiedade dentária ($ß=.288$, $p<.001$), a ansiedade pré-procedimento ($ß=.639$, $p<.001$) e a idade ($ß=-.113$, $p=.045$) surgiram como preditores significativos de ansiedade durante o procedimento.

Globalmente, este estudo revelou a influência significativa de fatores psicológicos na predição de dor/desconforto e ansiedade durante a consulta dentária. Estes resultados podem ser úteis no desenho de intervenções para a gestão da dor, desconforto e ansiedade no contexto odontológico, de forma a promover a adesão aos tratamentos dentários e melhorar a saúde oral da população.

Palavras-chave: *Ansiedade dentária, Dor, Mindfulness, Predição, Saúde oral*

Dental anxiety, pain and mindfulness in patients undergoing dental procedures

ABSTRACT

Pain and anxiety are common experiences in the dental office that can result in avoidance of oral health care. Dental anxiety is a kind of apprehension experienced in association with dentistry. It is characterized by a physical and/or emotional response to such stimuli and has been associated with higher levels of pain and anxiety during the appointments. Mindfulness is a process of sustained attention and awareness to the experiences occurring in the present moment, with an attitude of nonjudgment and acceptance, which can contribute to reduce pain and anxiety in different contexts. However, little is known about a possible influence of this construct in the dental context.

The aim of this study was to investigate the association between dental anxiety, pain and mindfulness and further explore predictors of pain/discomfort and anxiety in patients undergoing dental procedures. This was an observational and exploratory study, conducted among 111 adult patients, evaluated before (T0) and after (T1) an appointment. At T0, sociodemographic and clinical measures were assessed, as well as dental anxiety (Dental Fear Survey), mindfulness (Mindful Attention Awareness Scale), general anxiety and depression symptoms (Patient Reported Outcomes Measurement Information System short forms), pain catastrophizing (Coping Strategies Questionnaire - revised), pre-procedural anxiety (Numeric Rating Scale - NRS) and expected pain (NRS). At T1, the patients reported pain, discomfort and anxiety levels (NRS) experienced during the procedure and the dentist filled a clinical report about the treatment performed.

The results showed that dental anxiety was associated with mindfulness ($r=-.363$, $p<.001$), anxiety and depression symptoms ($r=.304$, $p=.001$ and $r_{sp}=.236$, $p=.013$, respectively) pain catastrophizing ($r=.677$, $p<.001$), pre-procedural anxiety ($r=.574$, $p<.001$) and expected pain ($r=.449$, $p<.001$). Linear hierarchical regression models revealed that the significant predictors of pain/discomfort during the dental procedure were previous oral pain complaint ($ß=.253$, $p=.001$), expected pain ($ß=.458$, $p<.001$) and dental anxiety ($ß=.197$, $p=.015$). Dental anxiety ($ß=.288$, $p<.001$), pre-procedural anxiety ($ß=.639$, $p<.001$) and age ($ß=-.113$, $p=.045$) emerged as the significant predictors of anxiety during the procedure.

Globally, this study revealed the significant influence of psychological factors in the prediction of pain/discomfort and anxiety during dental appointment. These findings could be useful for the design of interventions targeting pain, discomfort and anxiety management in dental context, and ultimately promote patients' adherence to dental care and improve general oral health of the population.

Key-words: *Dental anxiety, Mindfulness, Oral health, Pain, Prediction*

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LIST OF ABBREVIATIONS

DFS - Dental Fear Survey

CSQ-R - Coping Strategies Questionnaire – revised form

fMRI - Functional magnetic resonance imaging

HRV - Heart rate variability

IASP - International Association of the Study of Pain

MAAS - Mindful Attention Awareness Scale

MBCT - Mindfulness-based cognitive therapy

MBP - Mindfulness-based programs

MBSR - Mindfulness-based stress reduction

NICE - National Institute for Health and Clinical Excellence

NARS - Numeric Anxiety Rating Scale

NDRS - Numeric Discomfort Rating Scale

NPRS - Numeric Pain Rating Scales

NRS - Numeric Rating Scales

PROMIS - Patient Reported Outcomes Measurement Information System

SPSS - Statistical package for the social sciences

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INTRODUCTION

1. Anxiety and fear

Anxiety and fear are ordinary human experiences, being a normal reaction to many different kinds of events and situations in people's lives (1).

In an evolutionary context, anxiety and fear played an important role in the survival of the human species. These two states are activators of survival responses, such as the "flight or fight response", which are incredibly adaptive in a situation of real danger. On the other hand, in situations where there is no actual threat, such as an appointment with the dentist, these instinctive reactions are not helpful and can instead lead to a very unpleasant experience (2). Anxiety and fear are considered to be closely related (3). Despite that, a distinction often made between these two constructs is that fear is an adaptive emotional response to a realistic and immediate threat, whereas anxiety is a more diffuse emotion triggered by a current or future perceived threat (2,3).

While anxiety might be an intrinsic aspect of current life, it can also be exaggerated and pervasive, turning into a disorder. In these cases, anxiety may become a permanent state that can exacerbate over time, interfering negatively with various domains of life, such as daily activities, job performance and interpersonal relationships (4).

Anxiety disorders are the most prevalent mental disorders (5). These are associated with significant distress and impairment in several domains of life, and are highly comorbid with other mental illnesses, resulting in an increase of health care costs (5).

According to the mental health survey in the United States of America (2001-2003), approximately 30% of the population is affected by an anxiety disorder during their lifetime (6). Regarding the Portuguese population, data from the National Epidemiological Study on Mental Health, estimated the prevalence of anxiety disorders among adult population to be 16.5% (7).

There are several types of anxiety disorders, such as generalized anxiety disorder, specific phobia, social anxiety disorder, panic disorder or agoraphobia (4). The first-line treatment strategies for anxiety disorders are pharmacotherapy (*e.g.* benzodiazepines, antidepressants, beta-blockers) and psychological intervention (*e.g.* cognitive behavioural therapy) (8). Still, some patients are reluctant to take medication and may avoid mental health treatment due to stigma (9).

2. Dental anxiety

2.1. Conceptualization

Most people reveal some kind of apprehension or anxiety when they have to undergo a dental procedure (10). Indeed, dentistry and dental treatment have always been associated with pain and anxiety. This is probably because treatment used to be extremely unpleasant and painful before the development of modern techniques and anaesthetics (10). The idea of facing an uncomfortable situation during a dental treatment, such as the discomfort of keeping the mouth open, receiving an injection, or the sound of the drill, can cause uneasiness and apprehension (10,11). Several authors have debated on what is the best terminology to define this state experienced by the patients. Despite the lack of consensus in the scientific literature, three different terms have been widely used: dental anxiety, dental fear and dental phobia (12).

The concepts of dental anxiety and dental fear have been used interchangeably (2,10,13) and can be defined as a physical and/or emotional response to a potential threat related to dental procedures (11). Dental anxiety often occurs before the dental appointment and represents a state of apprehension about an unclear, ambiguous, or not immediately present threat (*e.g.* thoughts that something threatening is going to happen) (2,13). Dental fear, in turn, happens during the dental appointment and is a reaction to an immediate and specific stimulus, which is perceived as threatening (*e.g.* dental drill, needles) (13).

Dental phobia represents the most severe form of dental anxiety. Patients suffering from this disorder experience fear of dental procedures that is considered as disproportionate, being also characterized by severe psychological and physiological symptoms (2). It is less prevalent than dental anxiety, but more difficult to manage by the dentist (12).

In clinical situations, it is challenging to discriminate between dental anxiety and dental fear. Moreover, in the clinical setting, patients are likely to experience different combinations of anxiety and fear responses. As both terms, "dental anxiety" and “dental fear”, have been employed to describe negative feelings associated with the dental setting, both are often used synonymously (2,14). In this thesis, the term dental anxiety will be used.

2.2. Prevalence

Dental anxiety is considered a frequent phenomenon with detrimental consequences for patients, and frequently a challenge for oral health professionals (3,10). Several studies report its prevalence to be around 10 to 20% in adult populations (11,12,15,16). This variability can be explained by

differences in measurement methods and sample selection, as well as ethnic and sociocultural variables (3,10).

Regarding the Portuguese population, a study aimed to evaluate the prevalence of dental anxiety in a sample of 150 patients, found that 23.3% (n= 35) reported "high anxiety" and 76.7% (n = 115) showed "low to moderate anxiety" about dental procedures (17).

2.3 Aetiology

Different mechanisms have been proposed to explain the development of dental anxiety, but the reasons behind why a person might develop it or not will vary among individuals (2).

The cause of dental anxiety is multidimensional and includes both exogenous and endogenous sources (3,18). Exogenous sources are external contributory factors that include direct learning experiences (*e.g.* traumatic experience) and indirect learning experiences (*e.g.* vicarious learning or exposure to threatening information). Endogenous sources are internal contributory factors that make individuals susceptible to the development of dental anxiety, such as gender, age, psychological characteristics and genetic vulnerability (2,3).

2.3.1 Exogenous factors

Morgan and Porritt (2017) describe the development of dental anxiety as a result of direct or indirect conditioning pathways. The first hypothesis seems to have the strongest evidence (2).

According to the direct conditioning pathway, dental anxiety can be developed as a consequence of negative or difficult experiences, which can be divided into four categories: (i) episodes of pain or feelings of helplessness, (ii) behaviour or personality of the dental professional, (iii) serious treatment failures or clinical errors and (iv) feelings of embarrassment over neglected teeth or the fear of being ridiculed (2,19). These negative dental experiences can contribute to dental anxiety through the processes of classical conditioning (3). A neutral stimulus (*e.g.* the dentist) becomes associated with a negative experience such as pain. The dentist is then perceived as a “conditioned stimulus” which can elicit a conditioned (learnt) fear response. With time, in addition to the fear of the dentist, the patient may start to develop a fear of other objects or situations associated with the dentist, such as the dental chair or the smell of the dental clinic (2). Supporting the conditioning pathway is the fact that many adults with dental anxiety can recall the occurrence of a traumatic dental past experience (2,3,19).

The indirect pathway includes vicarious learning (modelling) or exposure to threatening information. Vicarious learning is based on social learning theory and proposes that anxiety can develop during childhood as a result of the child observing the anxious behaviour of another person, generally the mother, and imitating that behaviour (2). Dental anxiety may also develop as a result of direct exposure to negative information about dental procedures. According to this pathway, children will learn to be fearful as a result of the negative information they have seen or heard from family members, peers or media (2).

2.3.2 Endogenous factors

An alternative explanation to the development of dental anxiety is that some individuals may be particularly vulnerable to feelings of anxiety. Endogenous factors which may increase the susceptibility to dental anxiety include gender, age, psychological characteristics and eventually genetic vulnerability (2,3).

Two trends revealed in research are that females have increased levels of dental anxiety when compared to males (2,14) and that younger individuals usually report higher levels of dental anxiety than older individuals (20,21). Additionally, several psychological characteristics (such as low self-esteem, general fearfulness, alcohol dependence), together with psychiatric diagnoses (*e.g.* conduct disorder, agoraphobia, simple phobia, etc.) are more frequent in patients with high dental anxiety (3). Regarding the heritability of dental anxiety, little is known, but a genetic predisposition for its development has been suggested (2,14,16).

2.4 Consequences and impact

Dental anxiety may result in the avoidance of dental care and in subsequent oral health deterioration, which is likely to have a detrimental impact in quality of life (15,16). As oral health deteriorates, pain symptoms may appear, which can have a negative interference in daily activities, disturbing sleep, decreasing vitality and culminating in withdrawal from school or work activities. In addition to pain, patients presenting dental anxiety have a higher probability of developing aesthetic flaws caused by tooth decay, fractures or parafunctional habits (*e.g.* bruxism, fingernail biting, etc.) (15,22). In a society where healthy teeth are among the accepted norms, an unsatisfactory dental appearance may negatively affect social relationships, with negative psychological impact as well as lower self-confidence and self-esteem (10,15,22,23).

Additionally, a vicious cycle of anxiety and avoidance has been proposed, whereby feeling anxious about attending the dentist can result in nonattendance of regular appointments, with a subsequent greater need for more extensive, complex and expensive treatments, and consequently greater avoidance of dental situations (10,11,15,19,22). Figure 1 illustrates this negative cyclical pattern of dental anxiety.

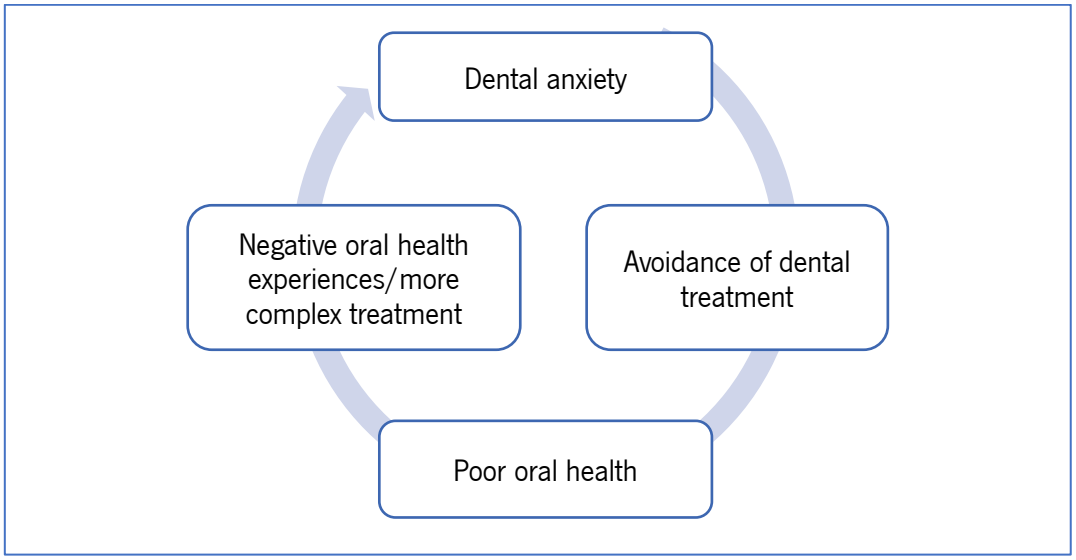


Figure 1. Negative cyclical pattern of dental anxiety [adapted from Daniel et al. (2008) (24)]

From the perspective of the dentist, treating patients with dental anxiety may cause irritation, anger and frustration, and may negatively affect the performance of the dental practitioner due to the stress experienced. The treatment of these patients is often considered time-consuming and economically unprofitable (16,25). Patients suffering from dental anxiety tend to have more appointment cancellations or fail to attend completely, together with a heightened perception of pain (26). Moreover, these patients usually have longer recovery periods and higher analgesic consumption after dental invasive treatments (25).

There is also a well-documented association between oral health and the development and/or severity of certain systemic diseases or disorders, reinforcing the importance of adequate dental care (27). Several studies have linked poor oral health with cardiovascular disease, poor glycaemic control in diabetics, low birth weight pre-term babies, respiratory diseases and a few other conditions, including rheumatoid arthritis and osteoporosis (27–30). The infection and inflammation that occurs in oral/periodontal environment is a risk factor for these systemic diseases. These associations are biologically plausible due to the potential direct effects of oral

microorganisms (*e.g. lipopolysaccharides*) on distant tissues and organs, as well as the systemic effects of inflammatory mediators, produced in the periodontal tissues (27,29).

2.5 Management strategies

Modern dentistry has undergone a major evolution in the last century, with great advances in biotechnology procedures, upgrades in patient comfort, as well as the available pharmacology (3,25). Considering dental anxiety, some strategies have been used to manage this condition, such as pharmacological approaches (*e.g.* benzodiazepines and nitrous oxide), careful explanation of the treatment procedure, biofeedback, hypnosis, guided imagery, aromatherapy, acupuncture, behavioural interventions and relaxation approaches (1,3,10,18,25). Mindfulness-based approaches may also be potentially useful strategies (31).

3. Pain

3.1 Conceptualization

Similarly to anxiety, pain has a primary role in survival, acting as an alarm system or a warning device, activated in face of real or potential damage. It enables the organism to avoid possible harm and to ensure that body healing occurs (32,33).

Over the years, the pain definition proposed by the International Association for the Study of Pain (IASP) has been a target of criticism and discussion in the pain field, with several alternatives being proposed (34). As a result, the definition of pain has been recently revised to "an unpleasant sensory and emotional experience associated with, or resembling that associated with, actual or potential tissue damage" (35). Pain is always a subjective experience, and it can be reported even in the absence of tissue damage or any likely pathophysiological cause (36). In a more simplistic way, "pain is what the individual says it is" (37).

3.2 Pain theories – a brief overview

Throughout the history of humanity, some theories have been proposed to explain why and how individuals feel pain. Early pain theories conceptualized pain as a unidimensional phenomenon, resulting directly from a physical stimulus in the realm of the biomedical model. This perspective only focused on biological variables and did not acknowledge other influences on pain perception, such as emotions or cognitions (38). Pain was considered as a mere result of nociception (39).

Nociception is the process that comprehends the initial physical stimulus causing body damage and the subsequent neurobiological chain of reactions. It is a non-conscious process (39), consisting in the physiological detection of tissue damage through the activation of specialized sensory receptors, called nociceptors, attached to A delta (Aδ) and C fibres (40). Pain, in its turn, is a conscious phenomenon, not only a primitive sensory message of tissue trauma, but rather a complex psychological experience (41). This is in accordance with the gate control theory of pain (42), which questioned the direct and causal relationship between stimulus intensity and pain perception. It was the first theory conceiving pain through a mind-body perspective and as a multidimensional experience, suggesting that both physiological and psychological variables accounted for pain experience (42). Overall, it advanced with the premise that pain is modulated at the level of the spinal cord by both peripheral and central nervous system inputs. Accordingly, the theory proposes the existence of a mechanism in the dorsal horn of the spinal cord, acting as a "gate", which modulates the transmission of pain-related nerve impulses, opening or closing according to the type of stimuli arriving. This mechanism is influenced by the balance between small-diameter and large-diameter non-nociceptive nerve fibers activity. While small-diameter fibers facilitates pain transmission, opening the gate, large-diameter fibers inhibits pain transmission, closing the gate. Hence, the activation of these latter fibers, due to stimuli such as rubbing the skin, can inhibit pain that arises from the activation of nociceptive fibers. In this case, the gate closes, and the brain does not receive the nociceptive information that is coming from the periphery. Contrarily, when the gate opens, the nociceptive stimuli can travel to the brain where it is processed, and as a result the individual experiences pain (42) (Figure 2).

Besides the influence of the gate at the peripheral afferent nerve activity level, the authors also proposed that processes in the brain modulate the gating mechanism, suggesting a descendent modulatory system. In this line, central pathways, descending from the brain, have the potential of opening or closing the gate, modulating the transmission of nociceptive information at spinal cord level and thus facilitating or inhibiting pain perception (43,44). Psychological processes, such as attention, beliefs, expectations and mood would exert an influence on pain perception at this level (42). For example, while attention directed toward pain opens the gate, attention directed away from pain closes it. Thus, by emphasizing the modulation of inputs at the spinal dorsal horns level by the dynamic role of the brain in pain process, this theory was the first one acknowledging the integration of psychological factors into pain experience (45). Later, in 1968, Melzack and Casey further extended the model in order to better integrate the affective, motivational and cognitive

aspects of pain. They posed that pain results from a complex and dynamic interaction among three dimensions: a sensory-discriminative dimension, a cognitive-evaluative dimension and an emotional-motivational dimension, each of one having a reciprocal influence on the others. The gate-control model transformed the conceptualization and understanding of pain, by recognizing and explaining that pain is influenced by multiple factors, therefore expanding the range of potential interventions aimed at pain prevention and control (46).

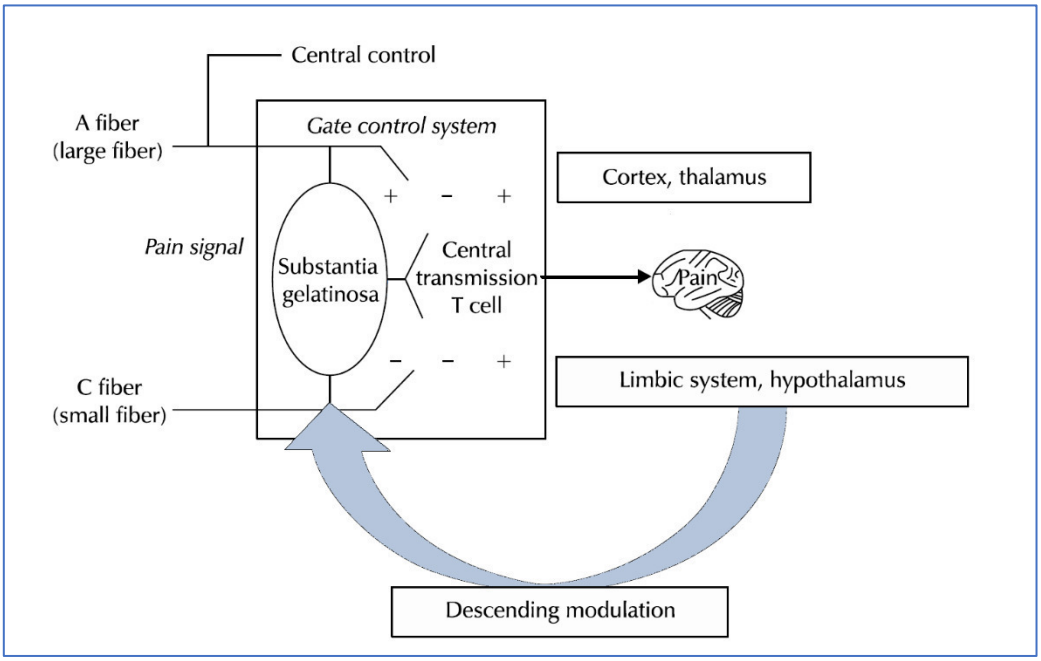


Figure 2. The gate control theory of pain [adapted from Cho and Min, 2015 (47)]

Another relevant theory to understand pain is the biopsychosocial model, which also conceptualizes pain as a multidimensional experience. This theory postulates that pain results from a complex interaction among biological, psychological and social factors, which affect the individual's physical and mental well-being. George Engel (1977) claimed that the approach of a disease must consider its multidimensional nature and regard the patient as a whole instead of focusing on a single dimension (48). The interaction of psychosocial factors, such as personality, stressful events and social context, with genetic and biological characteristics, influences the severity and course of diseases (49). Following Engels work, Loeser (1982) added to the biopsychosocial model of pain, suggesting that four elements need to be taken into consideration and distinguished when evaluating a patient with pain. These elements include nociception, pain, suffering and pain behaviours. Nociception, as mentioned above, corresponds to the signal that is sent to the brain from the periphery to alert the body that there is some degree of injury or tissue damage. Pain, on

the other hand, is the subjective experience that occurs after the brain has processed the nociceptive input. Regarding the last two components, suffering is the individual emotional response triggered by the experience of pain and pain behaviours are the actions that people carry out in response to experiencing pain. These two components can be either conscious or subconscious (48).

3.3 Dental pain

Pain is a common experience for patients undergoing dental treatments. Dental pain is characterized as pain originating in the teeth and supporting tissues as a result of disease or injury (50,51). It is frequently subsumed under the broad term of "orofacial pain" (50), that in turn comprises multiple painful conditions affecting the oral, head, face and neck area (52). Several oral clinical conditions are associated with reports of dental pain, such as dental caries or tooth decay, infected pulpal tissue, abscesses, oral ulceration, trauma, among others (53,54).

Dental pain is the most common symptom that compels patients to seek dental treatment and it has physical, psychological and emotional consequences to patients (51,55). Studies have shown that school/job absenteeism, sleep disturbances, difficulty in chewing and difficulty in socialization are events commonly associated with dental pain, which may negatively affect patient's well-being and daily life (50,51).

3.3.1 Prevalence

A review of 23 studies published in Medline from 1966 to 2001 found a prevalence of dental pain ranging from 7 to 66% (51). This variation may be explained by the use of different definitions for dental pain as well different sample dimensions and selection (*e.g.* community dwelling adults, patients attending dental practices, factory workers, armed forces, etc). Additionally, this review showed that younger patients and those from lower socio-economic groups were more likely to report pain (51). Two subsequent empirical studies reported a prevalence of dental pain of 43% among working population (56) and of 77.6% among adults with severe dental anxiety (50). Regarding the Portuguese population, a study with a sample of 1102 individuals, over 15 years of age, aiming to characterise oral-health status, habits and perceptions, found that 69.3% had experienced toothache or gingival pain at least once in their life (57).

3.3.2 Structures and mechanisms involved in dental pain

Dental pain is caused by noxious stimuli that may cause an insult of the dental pulp. Some examples are bacterial infections, chemical or mechanical erosion of enamel, or recession of gingiva (58,59). The dental pulp resides in a rigid compartment consisting of dentin and enamel, which provides a support structure and protects it from the microbes present in the mouth (59). When that protective chamber is damaged, exposing the dentinal tubules, the pulp becomes susceptible to the hostile elements present in the oral cavity. An inflammation of the pulp, or pulpitis, may occur, which is characterized by increasingly intense and prolonged painful responses to thermal or osmotic stimulation. In an early stage, the inflammatory responses may be reversible, but as the pathology advances, the process becomes irreversible, and may result in the development of spontaneous pain. When left untreated, infection and inflammation progress, eventually leading to pulpal necrosis and periapical pathology (59). Caries removal and filling therapy are adequate procedures during reversible pulpitis. However, endodontic therapy is necessary when pulpitis has reached an irreversible stage (60). Figure 3 illustrates the anatomy of the dentin-pulp complex.

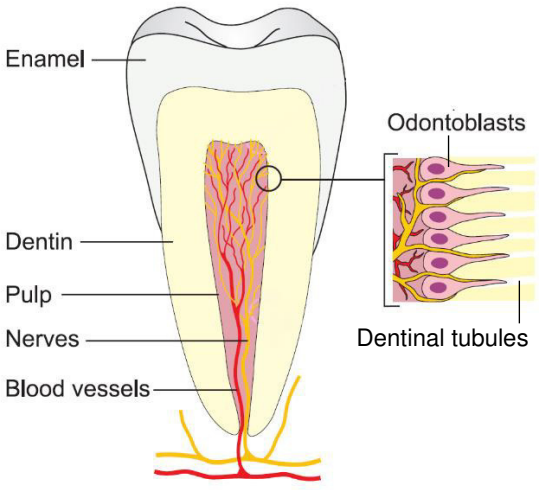


Figure 3. Dentin-pulp complex anatomy

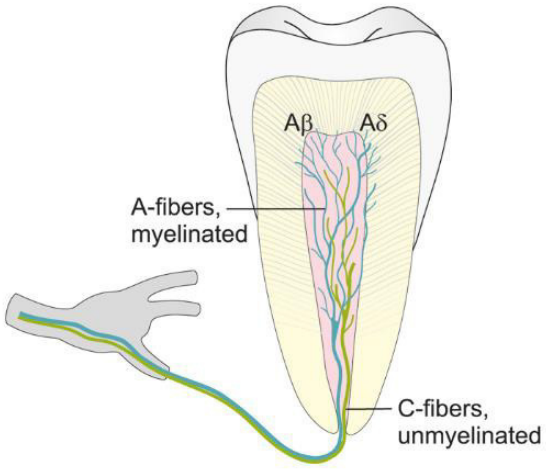


Figure 4. Intradental innervation

Figure 3. Illustration of the anatomy of the dentin-pulp complex [adapted from Närhi et al. (2016) (60)]

Figure 4. Illustration of the distribution of intradental A- and C-fibers [adapted from Närhi et al. (2016) (60)]

According to the hydrodynamic theory, movement of fluid within the dentinal tubules induces pain via nociceptive fibers located around the odontoblast process and at the dentin-pulp border (60). Both trigeminal nerve and trigeminal *nucleus caudalis* play an important role in processing the orofacial sensory information and may also be involved in dental pain transmission (32). The activation of intradental nerves is able to induce extremely intense pain, which can be explained by the dense and predominantly nociceptive innervation of the dental pulp. Each tooth is innervated by about a thousand trigeminal axons and approximately 20 000 – 30 000 nociceptive nerve endings/mm^2 are found in the dentin-pulp border (60).

The nerve supply of the dentin-pulp complex is mainly made up of mechanosensitive nociceptors, namely A fibers (both δ and β) and C fibers. Figure 4 illustrates the intradental innervation.

The A-δ fibers transmit nociceptive stimuli directly to the thalamus inducing a sharp pain that can be easily localized. The C fibers are influenced by many modulating interneurons before reaching the thalamus thus resulting in a slow pain, which is generally characterized as dull and aching (58). A-fibers react to cold or mechanical stimuli, such as cold drinks or toothbrushing, while C-fibers are mainly activated by inflammatory mediators (60). In addition, nerve fibers release neuropeptides, such as calcitonin gene-related peptide, substance P, neurokinin A and neuropeptide Y. The increased release of these neuropeptides in the dental pulp causes vasodilation, leading to increased local tissue pressure and capillary permeability, causing plasma extravasation and edema formation. Clinically, this can be perceived as throbbing pain, sometimes difficult to localize, making diagnosis a challenging situation for the dentist (60).

3.3.3 Associated factors

The sensory reaction to pain is complex and individuals vary widely in their pain sensitivity. Not everyone feels the same pain intensity with the same stimulus (59). The main factors that are thought to influence pain intensity in dental context are previous pain experiences, emotional state and gender (32).

First, previous pain experiences may influence pain perception since the repetition of similar circumstances can amplify nociception, such as in face of former traumatic experiences. Another possible explanation is that a patient who had experienced painful dental treatments could feel more pain due to increased sensitization (2,32). Second, the role of emotional state in pain perception can be explained by the activation of the limbic system, within the process of descending modulation (Figure 2). When nociceptive impulses reach the thalamus, they are directed to cortex

and limbic structures where pain experience is processed at an emotional level, in which emotions such as fear, rage, sadness or depression can be triggered and affect pain experience (32). Additionally, a positive correlation between stress and the frequency and severity of pain has been reported. Prolonged stressful experiences increase sympathetic nervous system activity even in the absence of the real physical threat. Previous studies have shown that dental anxiety is a significant predictor of expected and experienced pain during oral treatments (26,61,62). Anxiety may lower the pain threshold levels and cause a usually innocuous stimulus to be perceived as painful. Third, according to the results of classical pain studies, women are more likely than men to report more severe pain and for longer duration (32). In turn, men tend to present greater pain thresholds together with higher pain tolerance. It has been proposed that gender effects on pain result from an interaction of biological, psychological, and sociocultural factors (52). For example, males are thought to have been socialized to suppress outward signs of pain (32,63).

3.4 Pain catastrophizing

Pain catastrophizing can be defined as an exaggerated negative mental set of cognitions and emotions in response to an actual or anticipated painful experience (64). People who catastrophize have exaggerated negative thoughts when interpreting their pain (65). They are more likely to excessively focus on pain, pain related objects or procedures (rumination), they tend to magnify the threat value of pain (magnification) and they have an inability to successfully cope with pain (helplessness) (66).

Pain catastrophizing is associated with higher levels of dental anxiety (10,61,66). Moreover, previous studies suggest that pain catastrophizing is directly associated with increased pain in dental context (64,66,67). In the same line, Lin et al. (2013) demonstrated that participants with higher pain catastrophizing scores reported increased levels of pain and anxiety in an unpredictable and stressful dental context (61). Additionally, the authors found that brain activation at the right posterior hippocampus, a region critically related to associative learning of aversive stimuli and context, was correlated with the individual pain catastrophizing level. The study highlights therefore the role of cognitive-affective factors in pain control of dental patients (61). Another research reported statistically significant differences in pain between patients with high and low pain catastrophizing scores, following the application of orthodontic separators (a dental treatment procedure) (68). Another study (69), among patients who underwent removal of an impacted mandibular third molar, found that postoperative pain and analgesic consumption was higher in

patients with higher pain catastrophizing. According to the authors, individuals who catastrophize more have a tendency to exaggerate the sensation of pain and also a lower ability to cope with it, which may adversely affect the dental treatment (69). Besides the direct influence of pain catastrophizing on the experience of pain and anxiety, it also indirectly reinforce avoidance behaviour (66).

3.5 Discomfort

Discomfort is a subjective concept, often related to pain (70). Discomfort associated with dental treatment can be defined as a set of emotions felt during the treatment, caused mainly by pain and anxiety. This implies that discomfort is multidimensional, consisting of a combination of behavioural, cognitive and physiological components (71,72). According to Ashkenazy and Ganz (2019), who recently proposed a clarification of the concept, discomfort can be defined as a negative physical and/or emotional state, causing unpleasant feelings or sensations (70). This results in a natural response of avoidance or reduction of its source. It can be divided in two main domains, physical and psychological (70).

Physical discomfort is defined as an unpleasant body feeling or sensation, such as fatigue, sleeplessness, shortness of breath, or thirst. Pain is often described as the main source of physical discomfort, but there are other non-pain-related sources, such as adverse environmental conditions, postoperative discomfort or pregnancy (70).

Psychological discomfort refers to unpleasant emotions that a person might experience and can lead to feelings such as anxiety, fear, depression, embarrassment, isolation or vulnerability. Researchers have found strong and significant correlations between some of the physical symptoms of discomfort (*e.g.* thirst, hunger, and dyspnoea) and anxiety (73). Furthermore, one of the conditions that can accelerate psychological discomfort is physical discomfort (70).

In the dental context, there are several moments during the appointment that may cause discomfort to patients. Examples are the discomfort of local anaesthesia injection (74); discomfort during treatment of carious lesions when using rotating instruments, such as burs, as well as during application of the matrix and wedge (72); discomfort during oral surgery procedures (71); or discomfort after placement of orthodontic appliances, which is expressed as feelings of pressure, tension, soreness of teeth and pain (32).

4. Mindfulness

4.1 Conceptualization

The concept of mindfulness has its roots in Buddhist meditative practice, an ancient tradition born in Northern India that has been recently extended into science and Western contemporary culture (75,76). It is commonly accepted that mindfulness is the English translation of *sati* (Pali) or *smriti* (Sanskrit), which means "bare attention" or "present-centred awareness" (76).

The term mindfulness has been used to describe: i) a psychological trait (dispositional or trait mindfulness), which varies between individuals; ii) a particular state of awareness that may fluctuate across the day and (iii) a contemplative practice, such as mindfulness meditation (77). This state or trait has been pointed as an intrinsic human capacity, capable of being developed and refined (78). Mindfulness has been defined as a process of sustained attention and awareness to the experiences occurring in the present moment, with an attitude of nonjudgment and acceptance towards one's current experiences (78,79).

Bishop et al. (2004) developed an operational definition of the concept, in which they reinforce that mindfulness is a process of regulating attention in order to bring nonelaborative awareness to current experience, with curiosity, openness and acceptance. According to the authors, mindfulness involves the adoption of a decentred perspective on thoughts and feelings so that they can be experienced in terms of their subjectivity (*versus* their necessary validity) and transient nature (*versus* their permanence) (80).

4.2 Mindfulness-based programs (MBP)

Mindfulness-based approaches in health context were initially proposed and applied as an intervention for stress reduction, but have been subsequently extended to anxiety, depression and chronic pain disorders (78). As the interest in mindfulness increased, its use extended to a range of other fields, such as eating disorders (81), substance abuse and addictions (82), sleep disturbance (83), well-being (84), chronic heart failure (85), athletic performance (86) and also in schools (87), among others.

The most well-known mindfulness intervention program, proposed by Kabat-Zinn in 1979, is mindfulness-based stress reduction (MBSR). It was developed initially to relieve stress in patients suffering from chronic pain (88). Overall, MBSR is an eight-week programme in which participants learn and practice meditation-based cognitive and behavioural methods (88). Currently, there are multiple other mindfulness-based programmes that follow the structure of MBSR (89), such as

mindfulness-based cognitive therapy (MBCT), developed by Teasdale et al. (2000) (90). MBCT combines mindfulness meditation with cognitive therapy. It was originally conceived for patients suffering from chronic-recurrent depression and has been endorsed by the National Institute for Health and Clinical Excellence (NICE) as an effective treatment for prevention of relapse (90).

Regarding MBP, an underpinning premise is the understanding that individual reactions to various forms of distress (rather than the distress itself) lies at the core of many problems and disorders. The aim of MBP is to enable participants to become more familiar with their arising thoughts and feelings, realizing that they are not necessarily valid representations of reality (89,91,92). In other words, participants should gradually recognize habitual modes of reacting and make a radical shift in how they cope with their thoughts, feelings and body sensations. In this way, distress can be managed in a more adaptive and effective way (89). Furthermore, MBP seek to cultivate an internal climate of friendliness towards experience, whether it might be pleasant or unpleasant. Instead of battling with the present experience, individuals should develop greater flexibility and less reactivity (89,91), accepting things as they are. The ability to openly observe inner processes, with acceptance, without being overwhelmed, avoidant, suppressant or feeling the need to act on them is a core feature of mindfulness (78,91).

4.3 Health benefits

Mindfulness skills have been found to be associated with less difficulties with emotional regulation and better coping with emotions (91). A wealth of studies confirm that higher levels of mindfulness are related with reduced symptoms of rumination/worry, fewer depressive symptoms, anxiety and stress (93), improved psychological well-being and adaptive functioning (92,94), and associated with higher levels of happiness and life satisfaction (95). Mindfulness is strongly correlated to both physical and psychological health (96). Additionally, higher levels of trait mindfulness have been correlated with some markers of cardiovascular health, like lower blood sugar and obesity (97). Recent publications suggest that mindfulness practice may influence some biological pathways, such as the autonomic nervous system, immune system, neuroendocrine and brain function and structure (functional and neural plasticity) (79).

The mechanisms underlying the effects of mindfulness training on health are diverse and include improvements in attention control, coping and management of life stressors, as well as improvements in emotional and body awareness (98). According to Ramaci et al. (2019), a flexible

and mindful attitude towards difficult events, requires greater openness and acceptance of hindrances that may occur (99).

Finally, developing mindfulness may also serve as a preventive factor against disease and disease progression. For example, mindful perspectives may decrease negative and reactive behaviours like smoking, poor diet and a sedentary lifestyle that are associated with chronic diseases, and may increase, on the other hand, positive and purpose-driven health behaviours (97).

4.4 Mindfulness and anxiety

Anxiety, as other affective disorders, may contribute to great suffering. Several studies have presented MBP as valuable options in the treatment of anxiety disorders (78,100–103). Along with the research based on mindfulness interventions, the relationship between anxiety and mindfulness has also been investigated. The evidence found an inverse relationship between these two variables (104,105). For example, an observational study with a sample of 201 middle-aged participants with chronic musculoskeletal pain, found that lower levels of mindfulness were significantly associated with more anxiety and chronic pain, with mindfulness significantly predicting variance in chronic pain and anxiety outcomes (105). In another study, Hoge et al. (2013) compared the mindfulness levels of two groups: generalized anxiety disorder patients and healthy stressed individuals (104). Results showed that the former had lower mindfulness levels than the latter, and that the mindfulness score was negatively correlated with levels of anxiety, worry, and anxiety sensitivity (104).

Besides anxiety, the influence of mindfulness on depression has also been evaluated (106–109). Anxiety and depressive disorders are highly comorbid and share some characteristics. Both cause impairments in everyday physical and psychological functioning, from decreased energy to deficits in cognitive functioning (109). A recent study found that oncology professionals with higher scores of trait mindfulness were able to use this strategy as a positive response to psychological distress. It was also shown that mindfulness was highly and negatively correlated with depression and anxiety (106). Another study conducted among patients with functional gastrointestinal disorders, concluded that mindfulness was a predictor of anxiety and depression (107). The same conclusion was reached by Nekić and Mamić (2019) and Tubbs et al. (2019) in two recent studies, done among 282 and 2336 college students, respectively (108,109). Both studies concluded that higher levels of mindfulness were associated with lower levels of depression and anxiety symptoms severity (108,109).

These studies provide insight into the strength and direction of the relationships between anxiety, depression and mindfulness (105). The idea is that both anxiety and depression symptoms may be experienced but, with increased mindfulness, patients might feel less disabled by those symptoms (104).

According to a recent review (110), reports from studies on behavioural measures indicate that conflict control and working memory capacity are two cognitive functions which are sensitive to both mindfulness and anxiety. Impaired conflict control and working memory has been observed in high-anxiety or low mindfulness individuals (110). Moreover, electrophysiological studies indicate that heart rate variability (HRV), the index that measures the beat-to-beat variation in electrocardiogram, is often found to be reduced in patients suffering from anxiety. On the contrary, mindfulness meditation is associated with higher HRV. Increased HRV is an indicator of better well-being and cardiovascular health and may serve as a potential index for measuring features associated with mindfulness and anxiety (110). Additionally, functional magnetic resonance imaging (fMRI) studies have shown that individuals with higher trait mindfulness presented enhanced prefrontal cortex activity and attenuated amygdala activity while performing an affect-labelling task, compared to effects in a control task. High-trait anxiety individuals have shown an opposite pattern (110).

4.5. Mindfulness and pain

Similarly to anxiety disorders, several studies have presented MBP as valuable options in the treatment of chronic and acute pain (111,112). Mindfulness interventions seem to have a positive impact on patients suffering from pain on providing pain relief (113), decreasing pain intensity and unpleasantness, as well as improving secondary outcomes like relaxation, pleasant body sensations and less desire for opioids (114).

In fact, an inverse relationship between mindfulness and pain has been observed across the literature (115–119). For example, Schütze et al. (2010) explored the relationship between mindfulness and chronic pain using a heterogeneous chronic pain sample (115). The results demonstrated that mindfulness was significantly negatively related to pain severity, negative affect, pain catastrophizing, pain-related fear, pain hypervigilance and functional disability (115). In 2018, Komandur et al. replicated this same study with headache patients and achieved similar results (116).

A cross-sectional study including patients with upper extremity illness (*e.g.* carpal tunnel syndrome, nonspecific arm pain, osteoarthritis, etc), investigated if mindfulness had a relationship with physical function and pain intensity. This research showed that greater overall mindfulness was associated with lower pain intensity (117).

Another study done among knee osteoarthritis patients found that participants reporting higher mindfulness tended to have lower depressive symptoms and perceived stress, as well as higher self-efficacy and health-related quality of life. Mindfulness was not directly associated with pain, but it did moderate the influence of pain in stress (118). In the same way, Petter et al. (2013) found that mindfulness had an indirect relationship with experimental pain intensity and tolerance (120). Higher trait mindfulness individuals tend to experience less arousal, less anxiety and greater tolerance when subjected to induced pain experiments (121). These findings suggest that mindfulness may alter the way one copes with pain (118).

Senders et al (2018). evaluated the association between pain interference and trait mindfulness in people with multiple sclerosis (119). Pain interference assesses the impact of pain on relevant domains of life (122). Results showed a clinically meaningful and highly significant relationship between these two variables. Higher dispositional mindfulness predicted lower pain interference scores (119). Petter et al. (2013) also found, in a study with healthy participants undergoing an acute experimental pain task, that mindfulness was a significant predictor of pain interference and that this relationship was partially mediated by pain catastrophizing (120).

As mentioned before, pain catastrophizing usually correlates with increased pain (61). Being mindful, on the contrary, is thought to reduce the negative cognitive-affective elaboration of pain and emotional distress. This is possible when the patient develops an open and accepting attitude towards pain experience (117,121,123). Pain sensations can be mindfully experienced as sensory experiences and patients might not necessarily need to suffer from them, since pain and suffering are highlighted as two distinct and independent processes (104). The acceptance skills cultivated by mindfulness practice have been shown as a more adaptive strategy than experiential avoidance. Indeed, excessive fear and avoidance behaviours are consistently linked to poorer clinical outcomes (123), which is especially true when chronic pain conditions are present (78,80).

4.6 Mindfulness in dental context

From the perspective of the patient in the dental context, the capacity to maintain awareness moment by moment, along with an attitude of acceptance, may improve the ability to tolerate pain

or decrease its perception, and may even reduce stress and anxiety associated with dental procedures. In 2013, Gordon et al. proposed the use of mindfulness as a coping technique in dental anxiety treatment (124). According to these authors, it would be interesting to examine mindfulness among individuals with dental anxiety and possibly incorporate elements of mindfulness training into current treatments (124). Afterwards, Tellez et al. (2015) hypothesized that individuals with dental anxiety would have lower mindfulness skills, based on the fact that interventions targeting mindfulness tended to be efficacious in the treatment of several anxiety disorders (125). However, to the best of our knowledge, that is the only study analysing the association between mindfulness and dental anxiety (125), while no other has investigated the association between the ability to be mindful and pain in dental context.

Therefore, this thesis aims to investigate the association between dental anxiety, pain and mindfulness, exploring also their relationship with general anxiety symptoms, depression symptoms, pain catastrophizing and perception of discomfort related to dental procedures.

AIMS

1. General aim

– To investigate the association between dental anxiety, pain and mindfulness and further explore predictors of pain, discomfort and anxiety in patients undergoing dental procedures.

2. Specific aims

– Assess the baseline levels of dental anxiety and mindfulness in patients undergoing dental procedures.
– Describe the intensity of pain, discomfort and anxiety reported by patients during dental procedures.
– Examine the differences on demographic (age, sex), clinical (previous traumatic experience, previous oral pain complaint) and psychological baseline measures, as well as on the outcome measures intensity of pain, discomfort and anxiety, according to the type of dental procedure performed ("Conservative and Prophylactic" *versus* "Invasive and Urgency").
– Compare the demographic (age, sex), clinical (previous traumatic experience, previous oral pain complaint) and psychological baseline measures, as well as the outcome measures intensity of pain, discomfort and anxiety, according to the level of dental anxiety (low/moderate *versus* high).
– Investigate the predictive value of psychological baseline measures (dental anxiety, mindfulness, general anxiety symptoms, depression symptoms, pain catastrophizing, pre-procedural anxiety and expected pain), on the outcome measures pain, discomfort and anxiety.

METHODS AND MATERIALS

1. Design

This study has an observational and exploratory design with longitudinal assessment at two moments: before and after the dental appointment. Immediately before the dental appointment (T0), participants were assessed in terms of sociodemographic and clinical information, dental anxiety, mindfulness, general anxiety and depression symptoms, pain catastrophizing, pre-procedural anxiety and expected pain.

Right after the dental appointment (T1), pain, discomfort and anxiety, experienced during the procedure, were assessed and the dentists filled in a clinical report.

2. Participants

The study was conducted in three dental clinics: Clínicas Dentárias FA - Carvalhos (Vila Nova de Gaia), Clínica das Granjas (Braga) and Clínica Dentária Medivila (Vila Verde). Recruitment took place between August 2019 and July 2020. No data was collected from the 6th of March to the 17th of May 2020, due to the Covid-19 pandemic and the contingency measures that were in place at that time.

The inclusion criteria were: adult female or male individuals attending one of the dental clinics referred above, with ages between 18 to 75 years old. Due to the exploratory nature of this study, all types of dental treatments were included, to analyse potential associations between the outcomes and the procedure type.

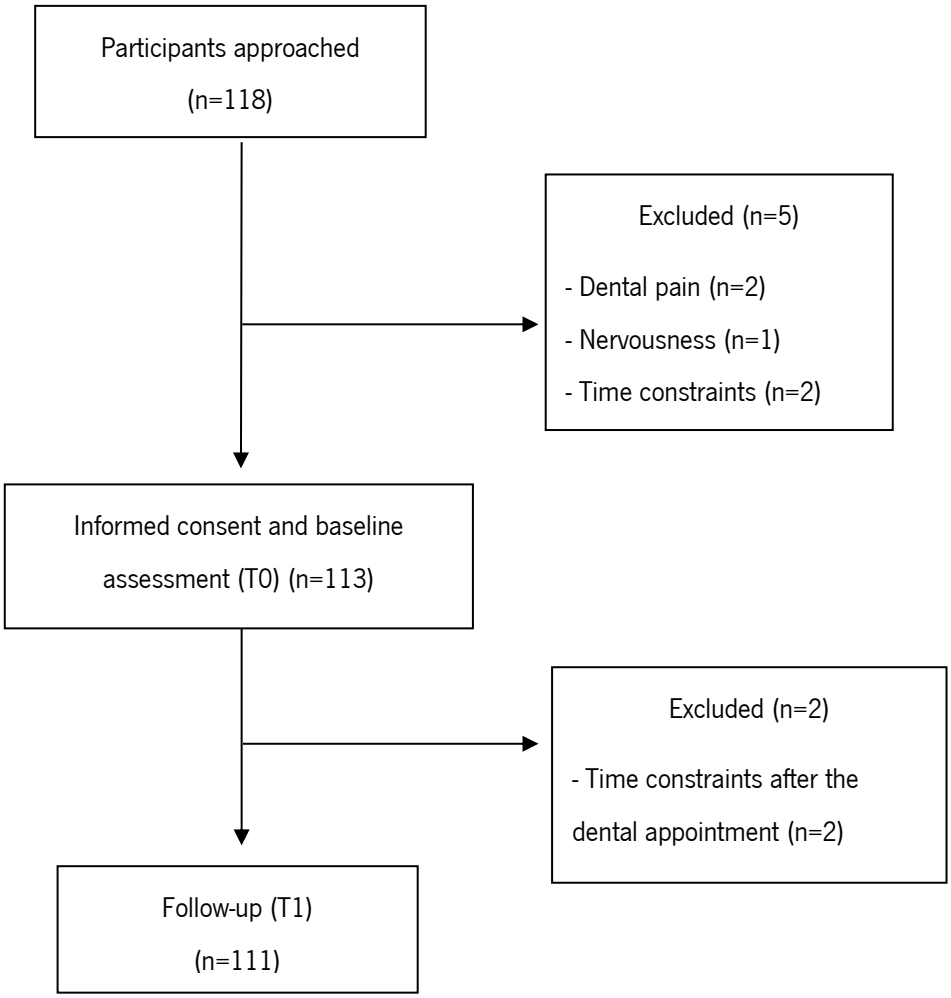
The exclusion criteria were: individuals that were reporting intense pain that could influence their focus and interfere with the completion of the questionnaires; inability to understand, speak and write Portuguese or to give informed consent to the study; severe and debilitating organic or neurological conditions (*e.g.* cancer, dementia); and severe psychiatric conditions (*e.g.* schizophrenia). There were no restrictions in recruitment based on pain treatments or other medications (*e.g.* antidepressants).

Sample size estimations were performed using G*Power V.3.1.9, accounting for a multiple linear regression, medium effect size ($f^2 = 0.15$), significance level (α, type I error) of 0.05 and statistical power (1-β, type II error) of 0.95. The sample size estimation indicated a total of 146 participants,

which was not possible to reach due to the recruitment limitations imposed by the Covid-19 containment measures. After these were lifted, the number of patients attending the clinics decreased and the strict protection rules adopted made it difficult to collect data. Recruitment stopped in July 2020 in order to comply with the planned timeline of this study. This was a convenience sample in which the first 111 participants who met the inclusion criteria and were willing to participate in the study were recruited. From the approached patients (n=118), five denied participating due to dental pain, nervousness and time constraints. Other two patients did not complete the T1 assessment due to lack of time after the end of the dental appointment. The flow diagram of study enrolment is described in figure 5.

The statistical power for the final sample (n=111) is 0.86.

Figure 5. Flow diagram of the study enrolment



3. Procedure

Before the study started, the researcher received training to ensure proficiency and uniformity in data collection. All instruments and study procedures were piloted in a sample of 10 patients, to evaluate comprehension and feasibility.

For data collection, the patients were approached by the researcher in the waiting room, before the dental appointment, to present the study, invite for participation and clarify possible doubts. After acceptance, patients signed the informed consent and answered the questionnaires (T0). Following the dental appointment, the participants completed T1 assessments, and the dentist filled in the clinical report.

4. Variables and Measures

The information was collected using the Portuguese versions of the following questionnaires:

4.1 Baseline Measures (T0)

- **Dental anxiety** was evaluated using **The Dental Fear Survey (DFS)** (126–128), which has 20 items answered through a 5-point Likert scale (1= "never" or "not at all", 2= "once or twice" or "a little", 3= "few times" or "some", 4= "often" or "great" and 5= "nearly every time" or "very much"). It has three subscales: avoidance of dental treatments, physiological arousal during dental treatments and fearfulness of dental stimuli (126). The score ranges from 20 (lower level of dental anxiety) to 100 (higher level of dental anxiety). A cut-off for high dental anxiety has been suggested at ≥ 60 (1,129). This questionnaire has as target population adult individuals and presents satisfactory data regarding fidelity and validity (127). The Portuguese version of the DFS has good psychometric properties and follows the original factorial structure of 3 factors, with a Cronbach's alpha (α) of 0.94 (127). In the current study, internal consistency was very high for the global scale (α= 0.97), as well as for the three subscales: avoidance (α= 0.94), physiological arousal (α= 0.91) and fearfulness of stimuli (α= 0.95).

- **Mindfulness** was assessed through **The Mindful Attention Awareness Scale (MAAS)** (130,131), containing 15 items intended to assess a central feature of trait mindfulness, that is, the general tendency to be aware of the present moment, in the various experiences of daily life (131). In the original version, the items are assessed using a 6-point Likert

scale (1= almost always, 2= very frequently, 3= somewhat frequently, 4= somewhat infrequently, 5= very infrequently, 6= almost never) and give rise to a score that can range from 15 to 90, where higher scores reflect greater mindfulness capacity (131). However, in the pilot study, the participants had some difficulty in understanding the Likert scale options, especially when it was necessary to differentiate between the options 3 "somewhat frequently" and 4 "somewhat infrequently". Therefore, it was decided to change the scale to a 5-point Likert scale (1= almost always, 2= very frequently, 3= frequently, 4= less frequently, 5= almost never). This new answer format was well accepted by the study sample. Another change had to be made, with the item number 12 that asks about mindfulness attitude while driving: "I drive to places on 'automatic pilot' and then wonder why I went there." Some patients that did not drive, could not answer the question properly, so an extra option was added to answer this question: "I don´t drive". With these two changes, the total score had to be modified and is now given by the sum of the scores obtained in each item (ranging from 15 to 75), divided by the total number of questions items and varies between 1 and 5, where higher scores indicate greater mindfulness skills.

The authors of the original version reported strong psychometric properties for this scale and a one-dimensional structure, with internal consistency coefficient (Cronbach's alpha) of 0.84 (130). The subsequent studies of MAAS confirmed a single factor structure through factor analyses. The Portuguese version reported also a single-factor model, with good psychometric properties, and a Cronbach´s alpha of 0.90 and 0.89 (tested in two different samples) (131). In the current sample, the Cronbach's alpha coefficient was 0.86, indicating good reliability.

- **General anxiety and depression symptoms** were evaluated through the short form **PROMIS 1.0 anxiety and depression questionnaire**, translated from the original version of Pilkonis (2011) (132). The PROMIS (Patient Reported Outcomes Measurement Information System) is a National Institute of Health item bank that enables the quantification of symptoms and key health concepts of various chronic diseases. The questionnaires used in this study consist of a total of 4 items each and evaluate symptoms of general anxiety and depression according to a 5-point Likert scale (1= never, 2= almost never, 3= sometimes, 4= almost always and 5= always). Scores range from 4 (lowest possible score) to 20 (highest score), with higher scores indicating more severe symptoms (132). A score

of 8 has been proposed as the cut-off for clinically relevant symptoms in both scales (133). In the current sample, internal consistency was adequate for both anxiety (α= 0.82) and depression (α= 0.91).

- **Pain catastrophizing** was assessed using the pain catastrophizing subscale from the **Coping Strategies Questionnaire – revised form** (134), which has 6 items, classified on a 5-point Likert scale (1= never, 2= almost never, 3= sometimes, 4= almost always and 5= always). The total score is given by the sum of the scores obtained in each item and varies between 6 and 30, with higher scores revealing a greater trend to catastrophize (135). In this study, the internal consistency for the pain catastrophizing subscale scores was high (α= 0.89).

- **Pre-procedural anxiety** was evaluated through a **Numeric Anxiety Rating Scale (NARS)**, from 0 to 10, with the value "0" corresponding to the absence of anxiety and the value "10" corresponding to the worst possible anxiety.

- **Expected pain** was assessed by a **Numeric Pain Rating Scale (NPRS)** from 0 to 10, with the value "0" meaning the absence of pain and the value "10" indicating the worst possible pain.

4.2 Outcome Measures (T1)

- **Pain** during the dental procedure was assessed by the **NPRS** described above.

- **Discomfort** associated with the dental procedure was assessed by the **Numeric Discomfort Rating Scale (NDRS),** analogous to the NPRS, from 0 to 10. The value "0" corresponds to the absence of discomfort and the value "10" corresponds to the worst possible discomfort.

- **Anxiety** during the dental procedure was evaluated through the **NARS** described for T0 assessment of pre-procedural anxiety.

For all the Numeric Rating Scales (NRS) mentioned above, the values between "1-3" correspond to mild pain, discomfort or anxiety, those between "4-6" correspond to moderate pain, discomfort or anxiety and finally those between "7-10" reflect severe pain, discomfort or anxiety.

Participants were also asked to fill in a **sociodemographic and clinical questionnaire**, to collect data regarding age, sex, marital status, level of education, profession and professional status, among other information. Additionally, the presence or absence of oral pain complaint before the appointment, the existence of a previous traumatic experience during a dental appointment, as well as first-time attendance, were also registered.

The dentists completed a **clinical report** with relevant information regarding the treatment performed, such as the reason for the appointment (routine or emergency), type of treatment, duration of the appointment, and type and dose of local anaesthesia, if administered.
The type of treatment was classified, a posteriori, in two categories "Conservative and Prophylactic" (oral examination, scaling, dental restoration, orthodontics, fixed or removable prosthesis) or "Invasive and Emergency" (simple or surgical tooth extraction, endodontic treatment, implant placement, urgency-resolution painful situation). When more than one treatment was performed, only the most invasive one was considered (127).

5. Statistical analysis

Data was analysed using IBM Statistical Package for the Social Sciences version 25 (IBM © SPSS Statistics; Chicago, IL, USA). Internal consistency of responses to the questionnaires was assessed using Cronbach's alpha (136). For self-report instruments, the scales or subscales were only considered acceptable if alpha coefficients were above 0.70 (137). All variables were tested for normality using Kolmogorov–Smirnov and Shapiro-Wilk tests. When the results of these tests were statistically significant ($p < 0.05$, suggesting non-normality of distribution), the absolute skewness and kurtosis values were analysed. Values below 2.0 and 7.0, respectively, indicate small departures from normality and, in these cases, the indication to proceed with parametric statistics was followed (138). No significant violation of normality was observed, except for the variable depression (PROMIS) (skewness = 2.303).
Descriptive statistics were computed on sample characteristics. These are expressed as absolute and relative frequencies (n, %) for categorical data. To provide a thorough account of continuous variables, these are described as mean (M), standard deviation (SD), median (Md), minimum and maximum values (Min-Max).

A new composite dependent variable "pain/discomfort" was created by computing the mean value of the variables pain and discomfort during dental treatment. This decision was based on the fact that the participants were not always able to discriminate between these two concepts. This new variable was used in the remaining statistical analyses.

Fisher´s exact tests and Mann-Whitney tests (for categorical and continuous variables, respectively) were performed to analyse differences between groups: type of dental procedure performed (conservative and prophylactic *versus* invasive and emergency) and dental anxiety level [low/moderate (DFS < 60) *versus* high (DFS ≥ 60)]. Fisher´s exact tests was used due to the fact that more than 20% of cells had expected frequency of less than five (139). Mann-Whitney non-parametric test was used due to largely different sample sizes in each group (140). To determine the meaningfulness of the differences (practical significance), since statistical significance (p-value) is dependent on group size, the associated effect sizes (ES) were also computed. They were expressed as Phi (φ) for categorical variables and r score ($r= Z/\sqrt{n}$) for continuous variables. Cohen's guidelines for r score are that a large effect is above 0.5, a medium effect is above 0.3, and a small effect is above 0.1 (141). The same guidelines are applied for Phi (φ) effect size of 1 degree of freedom (142).

In addition, Pearson's and point-biserial correlation coefficients were computed to determine the strength of relationships between variables and to select the set of demographic (age and sex), clinical (previous traumatic experience, previous oral pain complaint and anaesthesia) and psychological (dental anxiety, mindfulness, general anxiety symptoms, depression symptoms, pain catastrophizing, pre-procedural anxiety and expected pain) predictors to include in the regression models, based on the presence of a significant correlation with the dependent variables. Due to non-normality of distribution, Spearman correlation was computed for the variable depression.

Multiple linear hierarchical regression models were used to find associations between the psychological baseline measures (dental anxiety, mindfulness, general anxiety and depression symptoms, pain catastrophizing, pre-procedural anxiety and expected pain) and the outcome measures pain/discomfort and anxiety reported during the dental treatment.

For each regression model, a maximum of 7 variables were selected, based on the principle of 15 participants per independent variable (143). The influence of age and sex was controlled in the first block of each model irrespectively of their statistical significance. The second block included relevant clinical variables that presented a significant correlation with each outcome. The third block included the psychological variables that showed a significant association with the outcome

variables. In case of a strong correlation between independent variables ($r \geq 0.7$) (144), only the variable with the strongest correlation with the outcome was selected.

For the regression model to be valid, the assumptions of normal distribution of the residuals, homoscedasticity, linearity and multicollinearity were checked (145). Additionally, the presence of outliers was identified through visual inspection of histograms and frequency distributions (146), and by looking at the standardised residual, making sure that the minimum and maximum values do not exceed $\pm$ 3 (147). Statistical significance for all tests was set at $p < 0.05$.

6. Ethical Considerations

Ethical approval for this study was granted by the Life Sciences and Health Ethics Subcommittee (University of Minho) (CEICVS 024/2019). Also, the clinic directors of the clinics involved in the research authorized the recruitment of patients in their clinics. All procedures were conducted following the guidelines and good ethical research practices, in order to fulfil the precepts of the Declaration of Helsinki and the Convention on Human Rights and Biomedicine.

Before data collection, the study was explained to all participants and the written informed consent was obtained. The study was conducted ensuring the anonymity and confidentiality of the participants. Furthermore, participation was entirely voluntary, with participants being free to refuse or abandon the study at any time. The involvement in the study did not interfere with dental treatment and did not interfere with physical and/or psychological integrity.

RESULTS

1. Sociodemographic, clinical and dental appointment characteristics

Sociodemographic and clinical characteristics for the total sample (N=111) are presented in Table 1. The sample mean age was 38.83 years (SD=13.92). It included 73 (65.8%) women and 38 (34.2%) men. Half of the patients were married/cohabiting (56, 50.5%). The majority of the patients had a college or postgraduate education (73, 65.8%) and were employed (80, 72.1%).

Regarding clinical indicators (Table 1), 23 (20.7%) participants suffered from a chronic disease. High blood pressure, asthma and depression were the most commonly reported. The same number of patients (23, 20.7%) reported taking medication daily.

With respect to variables related to dental appointment (Table 2), 26 (23.4%) patients stated having experienced a previous traumatic experience during a dental appointment. The majority of the participants visited the dentist every 6 months (46, 41.4%) or once a year (35, 31.5%) and 15 (13.5%) participants went to the dentist just in emergency situations (pain/other problems). One patient took an anxiolytic medication before the appointment. The type of treatment administered was most frequently conservative or prophylactic (97, 87.4%), often planned as a routine procedure (101, 91.0%). The majority of the participants did not present any oral pain complaint pre-treatment (90, 81.9%) and 9 (8.1%) participants were meeting that dentist for the first time. Most of the dental procedures took less than 30 minutes (63, 56.8%) or 30 to 60 minutes (43, 38.7%), often without anaesthesia (67, 60.4%).

Table 1. Sociodemographic and clinical characteristics of study participants (N=111)

Sociodemographic characteristics	n (%)
Age (years)	M=38.83, SD=13.92
	Md=37.00, Min-Max=18 - 74
Sex	
Female	73 (65.8%)
Male	38 (34.2%)
Marital status	
Single	45 (40.5%)
Married/cohabiting	56 (50.5%)
Separated/divorced	10 (9.0%)

Education	
Primary school (1st-4th grade)	2 (1.8%)
Middle school (5th-9th grade)	7 (6.3%)
High school (10th-12th grade)	29 (26.1%)
College/Postgraduate	73 (65.8%)
Professional status	
Student	15 (13.5%)
Employed	80 (72.1%)
Unemployed	6 (5.4%)
Retired	7 (6.3%)
Other (seasonal employment)	3 (2.7%)
Clinical characteristics	
Chronic diseases	23 (20.7%)
High blood pressure	10 (9.0%)
Asthma	5 (4.5%)
Depression	4 (3.6%)
Diabetes mellitus	2 (1.8%)
Heart problem	2 (1.8%)
Other[1]	7 (6.3%)
Usual Medication	23 (20.7%)
Antihypertensive	11 (9.9%)
Antidepressant	8 (7.2%)
Antidiabetic	4 (3.6%)
Antiasthmatic	4 (3.6%)
Antihyperlipidemic	3 (2.7%)
Other[2]	13 (11.7%)

Abbreviations: M, mean; SD, standard deviation; Md, median; Min-Max, minimum and maximum

[1] Other diseases: allergy, back problems, fibromyalgia, high cholesterol, neuromuscular disease, prostatic hyperplasia, stomach problems [1 (0.9%) each]

[2] Other medication: analgesic, antiallergic, antiplatelet agent, benzodiazepine, levothyroxine, [2 (1.8%) each]; antiadrenergic agent, angiotensin converting enzyme inhibitors, proton pump inhibitor [1 (0.9%) each]

Table 2. Characteristics related to dental appointment (N=111)

	n (%)
Dental clinic	
Granjas	20 (18.0%)
FA – Carvalhos	31 (27.9%)
Medivila	60 (54.1%)

Reported by the patient	
Previous traumatic experience*	
Yes	26 (23.4%)
No	78 (70.3%)
Frequency of dental visits	
Once a month	10 (9.0%)
Every 6 months	46 (41.4%)
Once a year	35 (31.5%)
Every 2 years	5 (4.5%)
Only on emergency	15 (13.5%)
Anxiolytic before the appointment (Yes)	1 (0.9%)
Reported by the dentist	
Type of treatment	
Conservative and prophylactic	97 (87.4%)
Check-up	8 (7.2%)
Scaling	35 (31.5%)
Dental restoration	33 (29.7%)
Orthodontic	13 (11.7%)
Fixed prosthesis	5 (4.5%)
Removable prosthesis	3 (2.7%)
Invasive and emergency	14 (12.6%)
Tooth extraction (simple or surgical)	5 (4.5%)
Endodontic treatment	5 (4.5%)
Implant placement	4 (3.6%)
Reason for the appointment	
Routine	101 (91.0%)
Emergency	10 (9.0%)
Previous oral pain complaint	
Yes	21 (18.9%)
No	90 (81.9%)
First appointment with this dentist	
Yes	9 (8.1%)
No	102 (91.9%)
Duration of the appointment (minutes)	
<30	63 (56.8%)
30-60	43 (38.7%)
>60	5 (4.5%)
Anaesthesia	
Yes	44 (39.6%)
No	67 (60.4%)

Type of anaesthesia (n=44)	
Lidocaine	14 (12.6%)
Xylocaine	10 (9.0%)
Articaine	20 (18.0%)

* Variable with 7 missing values

2. Psychological and pain characteristics

Concerning psychological characteristics (Table 3) patients revealed a mean level of baseline dental anxiety of 36.01 (SD=17.31), which is below the clinically relevant cut-off of 60 (1,129), while the mean level of mindfulness was 4.20 (SD=0.59). Moreover, the mean score for general anxiety symptoms was 6.81 (SD=2.78) and for depression symptoms was 5.69 (SD=2.82), which were below the cut-off of 8, for relevant clinical symptomatology (133).

Regarding the remaining baseline psychological variables, Table 3 shows that the mean score for pain catastrophizing was 9.33 (SD=4.22), the pre-procedural anxiety mean score was 1.95 (SD=2.33), while the expected pain mean was 2.51 (SD=2.22). Concerning the outcomes of this study, evaluated after the dental procedure (T1), mean pain intensity was 1.84 (SD=2.05), the mean level of discomfort was 2.18 (SD=2.36), whereas mean anxiety level was 1.86 (SD=2.30).

Table 3. Psychological and pain characteristics of study participants (N=111)

	M (SD)	Md	Min-Max
Before dental procedure (T0): Baseline measures [range]			
Dental anxiety (DFS) [20-100]	36.01 (17.31)	30	20 - 90
Subscale: Avoidance [8-40]	11.64 (5.92)	9	6 – 36
Subscale: Physiological arousal [5-25]	9.62 (4.93)	8	5 – 25
Subscale: Fearfulness of stimuli [7-35]	14.77 (7.61)	13	7 – 35
Mindfulness (MAAS) [1-5]	4.20 (0.59)	4.27	2.33 - 5
General anxiety symptoms (PROMIS) [4-20]	6.81 (2.78)	6	4 - 15
Depression symptoms (PROMIS) [4-20]	5.69 (2.82)	4	4 - 19
Pain catastrophizing (CSQ-R) [6-30]	9.33 (4.22)	8	6 - 24
Pre-procedural anxiety (NARS) [0-10]	1.95 (2.33)	1	0 – 10
Expected pain (NPRS) [0-10]	2.51 (2.22)	2	0 – 10

During dental procedure (T1): Outcome measures [range]			
Pain (NPRS) [0-10]	1.84 (2.05)	1	0 - 10
Discomfort (NDRS) [0-10]	2.18 (2.36)	1	0 - 9
Anxiety (NARS) [0-10]	1.86 (2.30)	1	0 - 10

Abbreviations: M, mean; SD, standard deviations; Md, median; Min-Max, minimum and maximum; DFS, Dental Fear Survey; MAAS, Mindful Attention Awareness Scale; PROMIS, Patient-Reported Outcomes Measurement Information System; CSQ-R, Coping Strategies Questionnaire – revised form; NARS, Numeric Anxiety Rating Scale; NPRS, Numeric Pain Rating Scale; NDRS, Numeric Discomfort Rating Scale.

The graphs in figure 6 (A-C) illustrate the distribution of outcome variables in T1 (pain, discomfort and anxiety during dental treatment). Figure 6A shows that 37 (33.3%) participants felt no pain during the appointment. Fair over half of the participants (59, 53.2%) experienced mild pain, 9 (8.1%) experienced moderate pain and 6 (5.4%) experienced severe pain. Regarding discomfort, represented in Figure 6B, 33 (29.7%) participants felt "no discomfort". Around half of the participants (52, 46.8%) experienced mild discomfort, 18 (16.2%) experienced moderate discomfort and 8 (7.2%) severe discomfort. Figure 6C represents the anxiety experienced during the dental procedure, with 43 participants (38.7%) reporting "no anxiety". Near half of the participants (46, 41.4%) experienced mild anxiety, 15 (13.5%) experienced moderate anxiety and 7 (6.3%) severe anxiety.

Figure 6. Graphical representation of pain, discomfort and anxiety levels during dental treatment (T1)

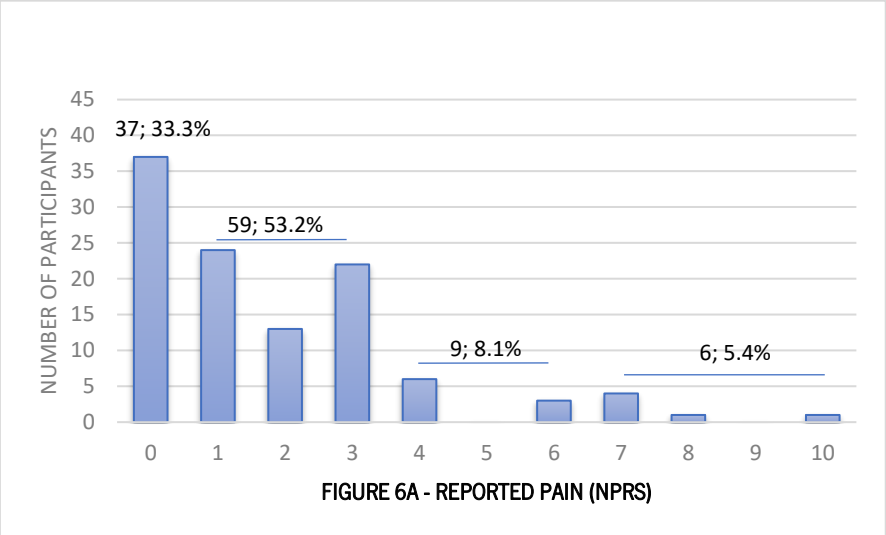


FIGURE 6A - REPORTED PAIN (NPRS)

NOTE.
0: no pain
1-3: mild pain
4-6: moderate pain
7-10: severe pain

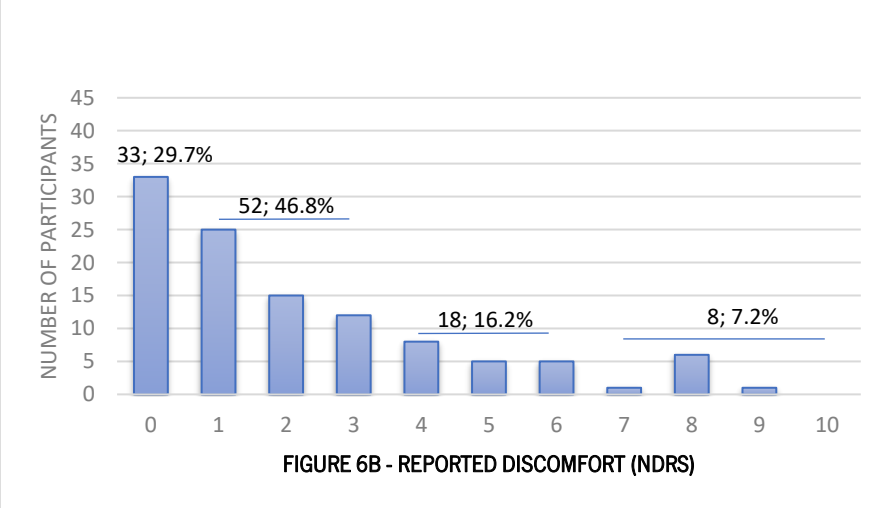


FIGURE 6B - REPORTED DISCOMFORT (NDRS)

NOTE.
0: no discomfort
1-3: mild discomfort
4-6: moderate discomfort
7-10: severe discomfort

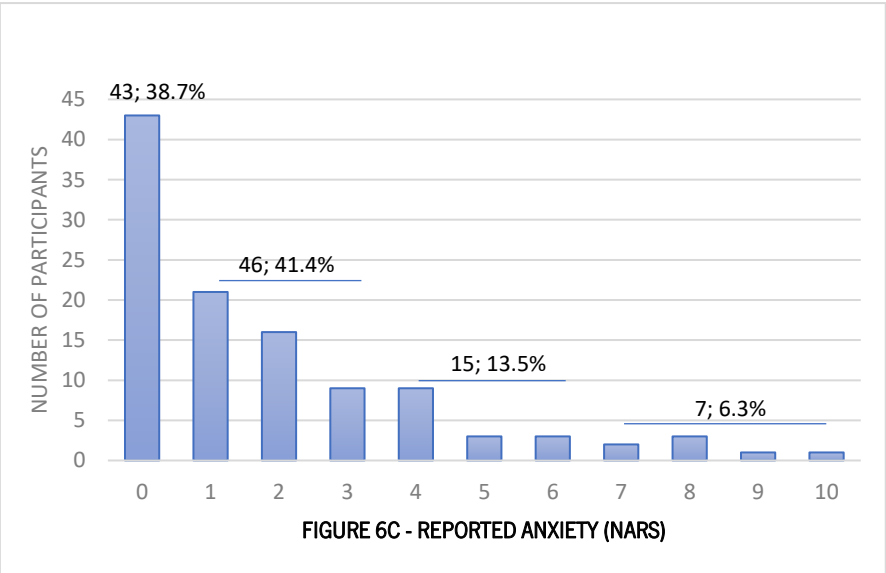


FIGURE 6C - REPORTED ANXIETY (NARS)

NOTE.
0: no anxiety
1-3: mild anxiety
4-6: moderate anxiety
7-10: severe anxiety

3. Differences on baseline demographic, clinical and psychological measures, and on pain/discomfort and anxiety levels during the dental procedure, according to the type of dental procedure

Patients were compared in terms of baseline and outcome measures according to the type of treatment performed during the dental appointment: "Conservative and prophylactic" *versus* "Invasive and emergency". Table 4 reveals significant differences between the two groups only for the variable pain catastrophizing, with a small effect size (ES) (U=391.00, p=.009, r=-.25).

Table 4. Differences on baseline demographic, clinical and psychological measures, and on pain/discomfort and anxiety levels during the dental procedure, according to the type of dental procedure (Fisher's exact test and Mann-Whitney test)

	Type of Dental Procedure				
	Conservative and prophylactic (n=97)	Invasive and emergency (n=14)	U/ $\chi 2$ (df)	*p*-value	Effect size r /φ
Baseline measures (T0): Before dental procedure					
Age	54.90	63.61	572.50	.344	-.09
Sex (woman)	61 (62.9%)	12 (85.7%)	2.832 (1)	.133	.160
Previous traumatic experience (yes)	22 (24.2%)	4 (30.8%)	.264 (1)	.733	.050
Previous oral pain complaint (yes)	17 (17.5%)	4 (28.6%)	.973 (1)	.299	.094
Dental anxiety (DFS)	56.79	50.50	602.00	.493	-.07
Subscale: Avoidance	56.78	50.57	603.00	.483	-.07
Subscale: Physiological arousal	56.15	51.07	610.00	.575	-.05
Subscale: Fearfulness of stimuli	56.64	51.57	617.00	.580	-.05
Mindfulness (MAAS)	54.24	68.21	508.00	.128	-.14
General anxiety symptoms (PROMIS)	56.07	55.50	672.00	.950	-.01
Depression symptoms (PROMIS)	57.39	46.36	544.00	.184	-.13
Pain catastrophizing (CSQ-R)	53.03	76.57	391.00	**.009**	-.25
Pre-procedural anxiety (NARS)	55.80	57.36	660.00	.862	-.02
Expected pain (NPRS)	54.24	68.18	508.50	.124	-.15
Outcome measures (T1): During dental procedure					
Pain/discomfort (NRS)	54.59	65.79	542.00	.219	-.12
Anxiety (NARS)	54.92	63.50	574.00	.334	-.09

NOTE: Continuous variables are presented as Mean Rank; Categorical variables are presented as n (%); sex, 0= men and 1= women; previous traumatic experience, 0= no and 1= yes; previous oral pain complaint, 0= no and 1= yes; Abbreviations: df, degrees of freedom; DFS, Dental Fear Survey; MAAS, Mindful Attention Awareness Scale; PROMIS, Patient-Reported Outcomes Measurement Information System; CSQ-R, Coping Strategies Questionnaire – revised form; NARS, Numeric Anxiety Rating Scale; NPRS, Numeric Pain Rating Scale; NRS, Numeric Rating Scale.

4. Differences on baseline demographic, clinical and psychological measures, and on pain/discomfort and anxiety levels during the dental procedure, according to the level of dental anxiety

Patients were compared according to the level of dental anxiety: low or moderate dental anxiety (DFS < 60) and high dental anxiety (DFS ≥ 60) (1,129) (Table 5).

Patients with high dental anxiety presented statistically significant lower levels of mindfulness with a small ES (U=354.00, p=.004, r=-.27), than those with low or moderate dental anxiety. Moreover, high dental anxious patients presented higher levels of pain catastrophizing (large ES) (U=95.50, p<.001, r=-.50), pre-procedural anxiety (medium ES) (U=296.50, p<.001, r=-.33) and expected pain (medium ES) (U=329.00, p=.002, r=-.30), as well as pain/discomfort (small ES) (U=431.50, p=.027, r=-.21) and anxiety (medium ES) (U=278.50, p<.001, r=-.35), than those with low or moderate dental anxiety.

Looking at the demographic and clinical variables, only age (small ES) (U=434.50, p=.030, r=-.21) and the presence of previous traumatic dental experience (medium ES) ($\chi 2(1)=21.363$, p=<.001, r=.453) provided statistically significant results.

Table 5. Differences on baseline demographic, clinical and psychological measures, and on pain/discomfort and anxiety levels during the dental procedure, according to the level of dental anxiety (Fisher's exact test and Mann-Whitney test)

	Dental Anxiety				
	Low/Moderate (n=97)	High (n=14)	U/ $\chi 2$ (df)	*p*-value	Effect size r /φ
Baseline measures (T0): Before dental procedure					
Age	53.48	73.46	434.50	**.030**	-.21
Sex (woman)	63 (64.9%)	10 (71.4%)	.228 (1)	.768	.045
Previous traumatic experience (yes)	16 (17.6%)	10 (76.9%)	21.363 (1)	**<.001**	.453

Previous oral pain complaint (yes)	17 (17.5%)	4 (28.6%)	.973 (1)	.299	.094
Mindfulness (MAAS)	59.35	32.79	354.00	**.004**	-.27
General anxiety symptoms (PROMIS)	53.84	71.00	469.00	.058	-.18
Depression symptoms (PROMIS)	55.11	62.14	593.00	.397	-.08
Pain catastrophizing (CSQ-R)	49.98	97.68	95.50	**<.001**	-.50
Pre-procedural anxiety (NARS)	52.06	82.32	296.50	**<.001**	-.33
Expected pain (NPRS)	52.39	81.00	329.00	**.002**	-.30
Outcome measures (T1):					
During dental procedure					
Pain/Discomfort (NRS)	53.45	73.68	431.50	**.027**	-.21
Anxiety (NARS)	51.87	84.61	278.50	**<.001**	-.35

NOTE: Continuous variables are presented as Mean Rank; Categorical variables are presented as n (%); sex, 0= men and 1= women; previous traumatic experience, 0= no and 1= yes; previous oral pain complaint, 0= no and 1= yes; Abbreviations: df, degrees of freedom; DFS, Dental Fear Survey; MAAS, Mindful Attention Awareness Scale; PROMIS, Patient-Reported Outcomes Measurement Information System; CSQ-R, Coping Strategies Questionnaire – revised form; NARS, Numeric Anxiety Rating Scale; NPRS, Numeric Pain Rating Scale; NRS, Numeric Rating Scale.

5. Association of baseline demographic, clinical and psychological measures with pain/ discomfort and anxiety levels during dental procedure

As shown in Table 6, the levels of pain/discomfort and anxiety reported during the dental procedure are significantly correlated with each other (r=.688, p<.001). None of the demographic factors (age and sex) were significantly correlated with these outcome measures.

In terms of clinical factors, patients who had a previous traumatic experience during a dental appointment had more pain/discomfort (r=302, p=.002) and anxiety (r=.356, p<.001) than those who did not. Previous oral pain complaint was significantly associated with pain/discomfort intensity (r=.400, p<.001), but not with anxiety.

Regarding psychological measures, pain/discomfort reported during the dental procedure was significantly correlated with the baseline measures dental anxiety (r=.421, p<.001), the DFS subscales of avoidance (r=.458, p<.001), physiological arousal (r=.333, p<.001) and fearfulness of stimuli (r=.384, p<.001), as well as with pain catastrophizing (r=.360, p<.001), pre-procedural anxiety (r=.548, p<.001) and expected pain (r=.620, p<.001). Other psychological variables, such as mindfulness, general anxiety and depression symptoms, did not correlate significantly with pain/discomfort.

In a similar way, the level of anxiety reported during the dental procedure was significantly correlated with dental anxiety (r=.670, p<.001) and the respective subscales of avoidance (r=.718, p<.001), physiological arousal (r=.523, p<.001) and fearfulness of stimuli (r=.626, p<.001), as well as with general anxiety symptoms (r=.277, p=.003), depression symptoms (r_{sp}=.237, p=0.12), pain catastrophizing (r=.420, p<.001), pre-procedural anxiety (r=.748, p<.001) and expected pain (r=.687, p<.001). The variable mindfulness did not correlate significantly with the anxiety reported during the procedure.

Table 6 also reveals that dental anxiety was significantly associated with previous traumatic experience (r=.457, p<.001), as well as with its subscales of avoidance, physiological arousal and fearfulness of stimuli (r=.930, p<.001; r=.922, p<.001; r=.955, p<.001; respectively). Moreover, dental anxiety significantly correlates with all baseline psychological variables under study. Apart from the variable mindfulness, with which it shows a negative association (r=-.363, p<.001), a positive correlation is presented with the remaining variables: general anxiety symptoms (r=.304, p=.001), depression symptoms (r_{sp}=.236, p=.013), pain catastrophizing (r=.677, p<.001), pre-procedural anxiety (r=.574, p<.001) and expected pain (r=.449, p<.001).

Regarding mindfulness, this variable significantly correlates with dental anxiety and the respective subscales: avoidance (r=-.312, p=.001), physiological arousal (r=-.385, p<.001) and fearfulness of stimuli (r=-.336, p<.001). Additionally, mindfulness presents a negative significant correlation with general anxiety symptoms (r=-.505, p<.001), depression symptoms (r_{sp} =-.495, p<.001) and pain catastrophizing (r=-.354, p<.001).

Besides the abovementioned significant correlation with mindfulness, general anxiety symptoms are also significantly correlated with dental anxiety and its subscales: avoidance (r=.229, p=.015), physiological arousal (r=.314, p=.001) and fearfulness of stimuli (r=.310, p=.001), as well as with depression symptoms (r_{sp}=.628, p<.001), pain catastrophizing (r=.301, p=.001) and pre-procedural anxiety (r=.302, p=.001). In addition to the significant correlations with mindfulness and general anxiety symptoms, depression symptoms are also significantly correlated with the DFS subscales of physiological arousal (r_{sp}=.251, p=.008) and fearfulness of stimuli (r_{sp}=.196, p=.039), and with pre-procedural anxiety (r_{sp}=.226, p=.017). Finally, pain catastrophizing reveals a significant correlation with all three dental anxiety subscales of avoidance (r=.615, p<.001), physiological arousal (r=.622, p<.001) and fearfulness of stimuli (r=.659, p<.001), with pre-procedural anxiety (r=.436, p<.001) and expected pain (r=.382, p<.001), as well as with mindfulness and general anxiety symptoms, as reported above.

Table 6. Pearson and point-biserial correlation coefficients between baseline demographic, clinical and psychological measures and pain/discomfort and anxiety during dental procedure

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1. Pain/discomfort T1 (NRS)	1																
2. Anxiety T1 (NARS)	.688***	1															
3. Age	.003	.048	1														
4. Sex	.045	.087	-.138	1													
5. Previous traumatic experience	.302**	.356***	.140	-.069	1												
6. Previous oral pain complaint	.400***	.141	-.045	-.136	.041	1											
7. Anaesthesia	.073	.131	-.078	-.114	.023	.314**	1										
8. Dental anxiety (DFS)	.421***	.670***	.097	.040	.457***	.080	-.043	1									
9. Avoidance[1]	.458***	.718***	.073	.024	435***	.127	.078	.930***	1								
10. Physiological arousal[1]	.333***	.523***	.102	.043	.452***	.047	-.127	.922***	.800***	1							
11. Fearfulness of stimuli[1]	.384***	.626***	.097	.041	.406***	.051	-.073	.955***	.820***	.827***	1						
12. Mindfulness (MAAS)	-.091	-.063	-.033	-.115	-.084	-.080	-.051	-.363***	-.312**	-.385***	-.336***	1					
13. General anxiety symptoms (PROMIS)	.169	.277**	.151	.177	.089	.025	-.031	.304**	.229*	.314**	.310**	-.505***	1				
14. Depression symptoms (PROMIS)[2]	.158	.237*	.036	.075	-.009	.093	-.039	.236*	.174	.251**	.196*	-.495***	.628***	1			
15. Pain catastrophizing (CSQ-R)	.360***	.420***	.185	.093	.446***	.082	.032	.677***	.615***	.622***	.659***	-.354***	.301**	.134	1		
16. Pre-procedural anxiety (NARS)	.548***	.748***	.204*	.133	.288**	.178	.087	.574***	.582***	.488***	.536***	-.050	.302**	.226*	.436***	1	
17. Expected pain (NPRS)	.620***	.687***	.078	.047	.273**	.294**	.170	.449***	.469***	.335***	.437***	-.071	.167	.163	.382***	.770***	1

*p<.05, **p<.01, ***p<.001

NOTE. T1, during the dental procedure; sex, 0= men and 1= women; previous traumatic experience, 0= no and 1= yes; previous oral pain complaint, 0= no and 1= yes; anaesthesia, 0= no and 1= yes; Abbreviations: NRS, Numeric Rating Scale; NARS, Numeric Anxiety Rating Scale; DFS, Dental Fear Survey; MAAS, Mindful Attention Awareness Scale; PROMIS, Patient-Reported Outcomes Measurement Information System; CSQ-R, Coping Strategies Questionnaire – revised form; NPRS, Numeric Pain Rating Scale.

[1] Dental Fear Survey Subscale

[2] For the variable depression Spearman correlation was used

6. Prediction of pain/discomfort and anxiety levels during dental procedure

To determine the predictors of pain/discomfort and anxiety levels during the dental procedure, separate hierarchical multiple regression analyses were conducted (Tables 7 and 8).

In each regression, age and sex were included in the first block. For pain/discomfort prediction, previous oral pain complaint was added to the second block due to its significant correlation with the dependent variable (DV) (r=.400, p<.001). For the third block, dental anxiety and pain catastrophizing were selected along with pre-procedural anxiety and expected pain. However, dental anxiety and pain catastrophizing presented high correlation between them (r=.677 ≃.7), what made that pain catastrophizing was excluded due to lower correlation with DV (r=.360) than dental anxiety (r=.421). In the same way, pre-procedural anxiety and expected pain were highly correlated (r=.770), and pre-procedural anxiety was thus excluded from this block as it presented values of correlation with DV (r=.548) lower than expected pain (r=.620).

For anxiety prediction, previous traumatic experience was added in the second block due to a significant correlation with the DV (r=.356, p<.001). For the third block, four variables were selected: dental anxiety, pain catastrophizing, pre-procedural anxiety and expected pain. For the same reason mentioned above, pain catastrophizing was excluded from this step due to lower correlation with DV (r=.420) than dental anxiety (r=.670). Additionally, expected pain was also excluded as it presented values of correlation with DV (r=.687) lower than pre-procedural anxiety (r=.748). General anxiety and depression symptoms did not enter the model since only 7 variables were selected from the beginning and these were the psychological variables with lower correlation with the DV (r=.277 and r_{sp}=.237 respectively).

Table 7 shows the results of the hierarchical multiple regression model for the prediction of pain/discomfort intensity during dental procedures. All the assumptions were checked and fulfilled. Age and sex in the first block did not reach statistical significance (ß=.010, p=.922; ß=.047, p=.632, respectively). When adding previous oral pain complaint (block 2), it emerged as a significant predictor (ß=.416, p<.001), accounting for an additional 16.9% of the variance. Psychological variables, dental anxiety and expected pain, were entered in the third block, both yielding significance (ß=.197, p=.015 and ß=.458, p<.001, respectively), and explaining an additional 29.9% of the variance in pain/discomfort intensity. The final model explained 44.5% of the variance with previous oral pain complaint keeping its significance (ß =.253, p=.001).

Table 7. Hierarchical multiple regression results for predictors of pain/discomfort level during dental procedure (N = 111)

Variables	B	Beta (ß)	t	CI 95% [LL, UL]	R^2	Adj. R^2	ΔR^2	ΔF
Block 1					.002	-.016	.002	.116
Age	.001	.010	.098	[-.027; .030]				
Sex	.199	.047	.480	[-.624; 1.023]				
Block 2					.171	.148	.169	**21.849*** **
Age	.005	.037	.098	[-.020; .031]				
Sex	.458	.107	.480	[-.304; 1.220]				
Previous oral pain complaint	2.158	.416	**4.674*** **	[1.243; 3.073]				
Block 3 (Final model)					.470	.445	.299	**29.653*** **
Age	-.005	-.034	-2.034	[-.026; .016]				
Sex	.195	.046	.049	[-.424; .814]				
Previous oral pain complaint	1.318	.253	**3.356** **	[.539; 2.096]				
Dental anxiety	.023	.197	**2.464***	[.005; .042]				
Expected pain	.422	.458	**5.485*** **	[.269; .574]				

*p<.05, **p<.01, ***p<.001
NOTE. sex, 0 = men and 1 = women; previous pain complaint, 0 = no and 1 = yes.
Abbreviations: CI, confidence interval; LL, lower limit; UL, upper limit; Adj. R^2, Adjusted R^2

The results of the multiple hierarchical regression for the prediction of anxiety intensity during dental procedures are presented in Table 8. The assumptions to perform regression were checked. Looking at the standardised residuals, two participants had values greater than 3 and a decision was made to remove these two outliers, resulting in the fulfilment of all the assumptions.

In this model, age and sex entered in the first block, without reaching a statistical significance (ß=.038, p=.711; ß=.108, p=.288, respectively). Previous traumatic experience was added in the second block demonstrating to be a significant predictor (ß=.359, p<.001), explaining 12.6% of the variance in anxiety. Dental anxiety and pre-procedural anxiety were included in the last block, both emerging as significant predictors (ß=.288, p<.001 and ß=.639, p<.001; respectively) and adding 58.4% to the explained variance. In the final model, previous traumatic experience ceased to be significant (ß=.068, p=.257) while age became significant (ß=-.113, p=.045). This final model explained 70.8% of the total variance in anxiety with dental anxiety and pre-procedural anxiety remaining the best predictors of anxiety during dental procedures.

Table 8. Hierarchical multiple regression results for predictors of anxiety level during dental procedure (N = 102)

Variables	B	Beta (ß)	t	CI 95% [LL, UL]	R^2	Adj. R^2	ΔR^2	ΔF
Block 1					.012	-.008	.012	.593
Age	.006	.038	.371	[-.026; .038]				
Sex	.494	.108	1.068	[-.424; 1.411]				
Block 2					.138	.112	.126	**14.344*** **
Age	.000	.002	.024	[-.029; .030]				
Sex	.631	.138	1.449	[-.233; 1.496]				
Previous traumatic experience	1.871	.359	**3.787*** **	[.891; 2.851]				
Block 3 (Final model)					.772	.708	.584	**100.980*** **
Age	-.018	-.113	**-2.034***	[-.035; .000]				
Sex	.012	.003	.049	[-.493; .518]				
Previous traumatic experience	.357	.068	1.141	[-.264; .978]				
Dental anxiety	.038	.288	**4.170*** **	[.020; .056]				
Pre-procedural anxiety	.604	.639	**9.582*** **	[.479; .729]				

*p<.05, ***p<.001

NOTE. sex, 0 = men and 1 = women; previous traumatic experience, 0 = no and 1 = yes.

Abbreviations: CI, confidence interval; LL, lower limit; UL, upper limit; Adj. R^2, Adjusted R^2

DISCUSSION

This study aimed to investigate the association between dental anxiety, pain and mindfulness in patients undergoing dental procedures, and to explore the predictors of pain, discomfort and anxiety during the appointment. The results showed that higher dental anxiety is significantly associated with lower mindfulness levels, more general anxiety and depression symptoms, increased pain catastrophizing levels, more pre-procedural anxiety and expected pain.

Furthermore, this study revealed the significant main influence of psychological factors in the prediction of pain/discomfort and anxiety during dental appointment. For pain/discomfort levels reported during the dental procedure, previous oral pain complaint, dental anxiety and expected pain were the significant predictors. For anxiety levels, dental anxiety and pre-procedural anxiety emerged as significant psychological predictors, along with age. These findings could be useful for the design of interventions targeting pain, discomfort and anxiety management in dental context and ultimately promote patients' adherence to dental care and improve general oral health of the population.

1. Sociodemographic, clinical and dental appointment characteristics

Looking at the demographic characteristics of the sample, most of the participants in the study were female. The same trend was observed in other studies conducted in dental clinics (25,57,148,149). Higher attendance of women may occur due to a greater concern with health and aesthetics in this group (150). Cultural factors may also justify this greater female demand, as women are more predisposed to seek clinical care (15,150).

With respect to variables related to dental appointment, just over a fifth of patients reported having experienced a previous traumatic dental experience. Another study (148) conducted with a Portuguese sample reported a higher percentage of positive answers to this question (48%). According to that study (148), there is a significant association between individuals with previous traumatic experience and those who avoid the dental appointment due to fear. Indeed, most of the individuals that used to miss dental appointments reported having suffered a previous traumatic experience and a tendency to postpone the appointment, until the onset of painful symptoms. In addition, another study revealed that those who did not have previous traumatic experiences were less dental anxious (26). Similar conclusions can be drawn from current study, where the previous traumatic experience is associated with higher levels of dental

anxiety. Together, these findings support the direct conditioning pathway for the development of dental anxiety. It seems likely that, after a negative experience in the dental office, patients begin to associate all or most of dentistry stimuli as fearful or aversive (2).

Findings from this study also showed that the majority of the participants visited the dentist with some regularity: every six months or once a year, as recommended by international and national dental federations (151–153). The same tendency was reported by Siviero et al. (2008)(154) and Ferreira et al. (2008) (148), where more than half of the evaluated patients reported to visit the dentist at least once a year.

Regarding the type of dental treatment administered, conservative and prophylactic treatments (check-up, scaling, dental restoration, orthodontic, fixed and removable prosthesis) were the most frequent in current study, often planned as a routine procedure, which might explain that the majority of the participants did not present any oral pain complaint pre-treatment and reported lower levels of pain and anxiety during the dental procedure. Actually, previous studies show that patients undergoing more invasive dental procedures such as dental extractions and root canal therapy, tend to experience more pain (155–157) and anxiety (127) during the appointment. However, some patients also report experiencing no pain at all, even when undergoing these more invasive procedures (155). Congruently, in the present study, patients scheduled for invasive/emergency procedures only differed from patients undergoing conservative/prophylactic treatments in terms of pain catastrophizing, with no significant differences on the other variables, namely on pain/discomfort and anxiety reported during the procedure. One possible explanation is that, although patients tend to catastrophize previous to more invasive procedures, the administration of local anaesthetics prior to these treatments decreases, or even eliminates, the pain sensation that may be caused. Additionally, several patients used to meet the same dentist or the same clinic regularly, which may have contributed to a successful and trustful patient-dentist relationship. Establishing a good communication with the patient may induce feelings of ease and confidence, which can help to reduce anxiety and possible fears in relation to the treatment approach (158,159). Even when facing more complex and possibly painful treatments, the trust already established with the dentist may help to mitigate anxiety and possibly also the pain/discomfort intensity.

2. Psychological and pain characteristics

Concerning psychological characteristics, participants revealed low levels of dental anxiety, without clinically relevant general anxiety or depressive symptoms, as well as low tendency for pain catastrophizing. The majority scored as having high mindfulness skills. Moreover, participants also

reported low levels of pre-procedural anxiety and expected pain before the dental procedure. Lastly, few patients reported oral pain complaint pre-treatment.

About dental anxiety, the scores reported in current work are similar to those reported by other authors using the Dental Fear Survey (DFS) questionnaire (127,160). Additionally, the prevalence of high dental anxious individuals found in current study (12.6%; DFS>60) is within the interval of 10-20% (11,12,15,16) shown in the literature for adult populations. It is although below the figures reported in another study with Portuguese patients, where 23.3% presented "high dental anxiety" (17). A possible explanation for this discrepancy is that in that study 33% of patients had suffered a previous traumatic experience in a dental office (17). Given the reported association between traumatic experiences and dental anxiety (2,3,19), it is likely that the high frequency of these traumatic experiences has contributed to increased dental anxiety levels in the abovementioned study (17). Consistently, patients in current study with high dental anxiety have undergone more often a previous dental traumatic experience.

For the variable mindfulness, the mean level reported by this sample of participants was surprisingly high, when compared with the results reported by other studies using the same questionnaire, the Mindful Attention Awareness Scale (MAAS) (130,161–165). This was an unexpected result, since a literature search on articles using MAAS questionnaire with more than 6000 individuals, showed that participants do not generally have mindfulness scores as high as those achieved in the present study (130,161–168). Nevertheless, it may be the case that most participants of current study did actually possess high mindfulness skills. One could also wonder whether participants understood the items appropriately, despite the fact that in the pilot study no doubt or question was posed concerning those. Regardless of these considerations, it should be noted that the reduced variability of responses to MAAS in this study may preclude findings regarding the potential association between this variable and the outcomes under study.

The results also indicate that the individuals engaged in this study seem to have good mental health indicators. On average, patients' levels of general anxiety and depression symptoms were below the cut point of 8 for relevant clinical symptomatology (133). Thus, the great majority of the participants did not present noticeable anxiety (75.68%) or depressive symptoms (89.19%). Regarding pain catastrophizing, participants revealed low levels of this maladaptive pain-coping strategy, corroborating the results published in previous Portuguese studies conducted on postsurgical pain context (134,135,169–172), where the same scale (Coping Strategies Questionnaire - revised form, CSQ-R) was used.

One relevant finding of this study is that higher dental anxiety is associated with lower mindfulness levels, but also with higher psychological distress, increased pain catastrophizing and expected pain. In the same line, comparing patients with high dental anxiety *versus* low/moderate dental anxiety revealed that the former group were older and exhibited lower mindfulness skills, as well as higher levels of pain catastrophizing, pre-procedural anxiety and expected pain. Besides this, high dental anxious patients also scored higher on all outcome measures: intensity of pain, discomfort and anxiety.

Several studies show that higher dental anxiety is associated with higher anxiety and depression symptoms (149,173–177), which in turn have been related with unfavourable oral health behaviours (178). Indeed, anxious patients tend to be less cooperative during dental procedures, more prone to delay or cancel their appointments, and are usually unsatisfied with dental treatment (179). This more likely contributes to deterioration of oral health and development of aesthetic flaws, with a negative impact on quality of life and self-esteem (10,15,22,23). In addition, dental care of these patients is challenging for dentists and possibly a source of stress and frustration (180).

The present study also found that higher levels of dental anxiety are associated with higher levels of pain catastrophizing, which corroborates findings from previous studies (10,61,66). This association highlights a relevant key intervention target in dental care, namely the importance of identifying dental patients who catastrophize. These patients tend to have an exaggerated negative mental set of cognitions and emotions in response to painful experience (64) and a lower ability to cope with it, which may adversely affect the way they experience dental treatment (69). Therefore, when treating these high pain catastrophizing patients, the dental practitioners should work with them with the aim of lower and reframe the threat value of pain-related dental procedures. This can be implemented during the dental procedure, by redirecting their attention from the threatening procedures through distraction techniques, pain ignoring strategies, and also by promoting the use of positive coping self-statements. The application of mindfulness strategies seems to be of great value too, given the results found in current study concerning the significant association of high mindfulness levels and a lower tendency for pain catastrophizing. A possible explanation for this might be that the practice of mindfulness has been shown to be positively linked to the development of adaptive cognitive processes, yielding a decrease in the process of rumination, which is a central dimension of pain catastrophizing (181). The skill of noticing and letting go of thoughts, one of the main components of mindfulness, may facilitate the acceptance of difficult and pain-related thoughts, without striving for fighting or eliminating them, which subsequently fosters the reduction of maladaptive thinking patterns, such as pain catastrophizing (92).

Actually, mindfulness has been conceptualized as a general tendency towards greater awareness of one's experiences, bringing an attitude of acceptance and non-judgment to these experiences, whether they might be pleasant or unpleasant (20). Besides several benefits, a myriad of studies revealed evidence of how mindfulness practice can be valuable to improve mental health conditions, such as anxiety (78,100–103) and depression (92,94,110,182). This is in agreement with current findings, which showed that higher mindfulness levels were associated with lower general anxiety and depression symptoms. In fact, although anxiety symptoms may still be experienced, patients with increased mindfulness might feel less disabled by anxiety symptoms (104). They tend to approach their experiences with greater openness, flexibility, less reactivity and again greater ability to "let go" of negative thoughts (89,91). Furthermore, individuals who have higher mindfulness capacity may benefit from "buffering actions" of mindfulness which may attenuate reactions, such as worry, reappraisal, nonacceptance, or rumination and consequently mitigate the symptoms associated with anxiety (110). Taking this into account, it would therefore be likely that individuals with higher mindfulness levels would exhibit lower levels of dental anxiety (125), which is precisely supported by the significant inverse association reported in this research. In the same line, the present results show that patients with high (*versus* low/moderate) dental anxiety have higher mindfulness skills. Surprisingly, the relationship between the construct mindfulness and dental anxiety has been sparsely approached (125), and thus this is a very relevant finding of present work, giving additional evidence in favour of integrating mindfulness strategies in dental clinical practice.

3. Pain, discomfort and anxiety during dental procedures

With respect to the outcome measures, the present study aimed to describe the intensity of pain, discomfort and anxiety reported by patients during dental procedures. While several studies have been performed in order to evaluate pain intensity during dental appointments (21,155,183,184), little work has been published to quantify the discomfort (185) and anxiety reported during these procedures (186–188).

In regard to pain, the present data show that most of the participants reported "no pain" or "mild pain" during the procedure. Only a small percentage experienced "moderate pain" and even less felt "severe pain". The same tendency was observed for discomfort and anxiety experienced during dental treatment. Concerning pain and discomfort, these observed low pain values could be attributed to the administration of local anaesthetic at any time during the procedure if the patient so required, together with the performance of a reduced number of invasive procedures, potentially more painful. Yet, these pain scores are in agreement with the values presented in other similar studies (155,186–189). For example, Tickle

et al. (2012) reported that 75% of the participants felt no pain during routine dental treatments, such as examination, scale/polish, restoration and tooth extraction (155).

Concerning anxiety, Tuk et al. (2017) reported that 22.7% of patients experienced severe levels during mandibular block injection (186). This value is higher than in the present study, possibly due to the fact that anxiety was exclusively measured during dental injections, a more invasive procedure that may cause increased distress and apprehension (186). Nevertheless, data from studies reporting the mean value of pain and anxiety during dental procedures, using Visual Analogue Scale (VAS) or Numeric Rating Scale (NRS), show that on average patients usually experience mild pain (<4, in a 0-10 scale) (21,186–188) and mild anxiety (<4, in a 0-10 scale) (186–188), which matches the results of present work. Regarding the experienced discomfort, Tomasi et al. (2006) reported mean levels varying from 1.9 (SD=1.7) to 5.1 (SD=2.4), in a 0-10 scale, during pocket debridement (a non-invasive periodontal procedure) (185). It should be noted that several authors do not distinguish between pain and discomfort, rather reporting jointly the levels of "pain/discomfort" associated with dental treatment (70,190–192). For that reason and to improve comparison we also adopted this strategy in the current study.

One central aim of this study was to explore the predictors of pain, discomfort and anxiety during the dental appointment.

For the prediction of the intensity of pain/discomfort during dental procedures, previous oral pain complaint, expected pain and dental anxiety were the strongest predictors.

Regarding previous oral pain complaint, the role of this variable in the prediction of pain/discomfort during dental procedures has been poorly investigated. Nevertheless, previous studies (184,193) found that when painful diagnoses are present before the procedures, patients tend to report higher levels of pain during the procedure, which is in line with current results. A study aiming to determine pain experienced during root canal treatment (193), found that the treatment was significantly more painful in the group of teeth with irreversible pulpitis and apical acute periodontitis, often characterized by intense pain and associated with a decrease in the effectiveness of local analgesic, compared to the group of teeth with necrotic pulps and chronic apical periodontitis, often asymptomatic. The associated between painful dental diagnoses, such as severe pulp inflammation, and a decrease in the effectiveness of local analgesic (193,194), may support the role of previous oral pain complaint in the prediction of pain/discomfort during dental treatment. Furthermore, another study that aimed to assess orofacial pain, found evidence that patients who presented either acute or chronic dental conditions (*e.g.* periodontitis, pulpitis, caries,

pericoronitis, gingivitis), which often cause dental pain, may experience higher levels of pain both before and during the appointment, than those without previous painful dental conditions (184).

Expected pain revealed as another predictor of experienced pain/discomfort, in line with other studies (21,186,195). In a study among patients undergoing periodontal surgery (21), patients who expected a higher amount of pain were more likely to actually experience a higher level of pain than those who anticipated lower amounts of pain. Furthermore, authors found that anticipated pain was a significant predictor of post-surgical pain, matching the results from the current study and highlighting the potential benefits of implementing interventions conceived to decrease pain expectations (21).

Concerning dental anxiety, which was the other significant psychological predictor of pain/discomfort, previous studies have shown that this variable is a significant predictor of experienced pain during various dental procedures (26,61,62,155,157,189). For example, Klages et al. (2004, 2006) (183,196) and Siviero et al. (2008) (154) reported that subjects with high dental anxiety, both expected and experienced more pain than those with low dental anxiety. When a patient feels anxiety, the perception of pain may be affected. In fact, anxiety may lower the pain threshold levels and cause a usually innocuous stimulus to be perceived as painful (32). This is in accordance with the gate control and biopsychosocial models of pain, postulating that emotional states can modulate pain experience (42,46,48). Additionally, it has been proposed that people who are predisposed to respond fearfully to pain are at an increased risk of falling into a vicious circle of anxiety and avoidance of dental treatment which could, ultimately, affect oral health (197). Therefore, reducing anxiety levels and promoting a relaxed and calm state, is likely to help patients to tolerate their own subjective experience of pain (198). Yet, accurate and formal assessment of dental anxiety is not routinely undertaken by general dental practitioners (155).

The present findings underline that previous assessment of dental anxiety and appropriate management of the anxious patient are key requirements for high-quality dental care (63,155). Taken together, this set of predictors (previous oral pain complaint, expected pain and dental anxiety) highlight the need to encourage patients to express their worries regarding pain and to drive dentists to listen to those concerns and adjust their procedures accordingly (155,157). Furthermore, dental practitioners should allow patients to have a more active role in treatment decision making and improve communication based on trust (14,157,199,200). These strategies, along with effective local anaesthetic techniques, have the potential to mitigate pain experience during dental procedures and, in the long term, influence people attitudes and beliefs regarding dental treatment (157).

Still regarding the prediction of pain/discomfort, divergent results have been found in the literature for the role of age and sex in this outcome. Some studies show that women generally report higher pain

levels during dental treatment than men (63,187,188) and that older patients were likely to experience less pain (21,157,195). On contrary, studies such as Guzeldemir et al. (2008) and Murillo-Benítez et al. (2020) found no correlation between age and sex and pain perception levels during scaling (201) or root canal treatment (189), respectively. The current results better support the idea that age and sex are not relevant predictors.

Regarding anxiety reported during the dental procedure, the current results reveal that pre-procedural anxiety and dental anxiety are the significant psychological predictors of its intensity. Curiously, little studies have been conducted in order to investigate the relationship between the level of anxiety reported before and during the dental procedure. Moreover, very few studies investigated the predictive role of dental anxiety. Most of the studies are designed using dental anxiety as a dependent variable.

The present findings show that higher levels of dental anxiety, as measured through the Dental Fear Survey (DFS), are predictive of higher levels of anxiety during the dental appointment. Similarly, Heaton et al. (2007) concluded that higher DFS scores appear as an accurate predictor of observed anxiety during treatment (202). From a practical point of view, these findings underline the need for dental practitioners to adopt effective communication (157,203) and establishing a relationship with the patient based on trust, providing perception of control, realistic information, and applying a high level of predictability by explaining the performed procedures (14,199), in order to reduce patients' dental anxiety levels.

In the anxiety prediction model, previous traumatic experience emerged initially as a clinical significant predictor, in line with other previous studies (26,202,204). Indeed, patients anxious about dental care often report having had a painful or traumatic dental experience (202). Nevertheless, when psychological variables were added in the final model, previous traumatic experience ceased to be significant, while age became significant. According to the results of the present study, younger participants reported higher levels of anxiety, a trend that has previously been reported (192–194). Caltabiano et al. (2018) suggested that the increased exposure over time to dental procedures, allows patients to develop a higher tolerance to treatment, and therefore experiencing less anxiety as they age (26). Another explanation could be a state of habituation or adaptive resignation toward anxiety, as people get older and suffer from other diseases and treatments (205). Additionally, it has also been hypothesized that older people are better at rationalizing the dental situation, leading to a decrease in feelings of anxiety (206). Concerning the other demographic variable included in the model, the current results reveal that sex did not have a predictive role contrary to other studies, where women generally report higher anxiety about dental treatment than men (26,154,155,186,202).

In the prediction models, mindfulness was not a significant predictor of either pain/discomfort or anxiety. Indeed, it was somewhat surprising that the variable mindfulness did not present a significant correlation with any of the outcome measures, since mindfulness had been inversely related with pain (115–119) and anxiety (104,105). This may be explained by the low variability of responses to MAAS in this study, as well as by the low variability of responses to the outcome variables (pain/discomfort and anxiety), which may have influenced current results regarding outcomes prediction. However, the association between mindfulness and dental anxiety should be noted, as this latter variable predicts both pain/discomfort and anxiety during dental procedures. In this sense, there is a need for future research exploring mindfulness skills among individuals with dental anxiety, and further understand how mindfulness relates with pain/discomfort and anxiety in dental context.

4. Limitations

There are some limitations to this study, the most important being the reduced sample size and the existence of some methodological limitations, such as the exclusive use of self-report measures and a non-random sample. It was not possible to reach the sample size initially estimated for the study, due to the recruitment limitations imposed by the Covid-19 containment measures. After these were lifted, the number of patients attending the clinics decreased and the strict protection rules adopted made it more challenging to collect data. However, a power of 0.86 was still achieved with the final sample size of 111 patients.

The exclusive use of self-report measures is another possible limitation, that could be tackled by the integration of methods to objectively assess anxiety and physiological responses during dental treatments. Some examples include heart rate, oxygen saturation, blood pressure, and galvanic skin response measures (154,186). However, the incorporation of these methods would require more time per treatment which could affect the productivity of the clinic, leading to a very difficult recruitment of private dentists for the study.

Another important limitation is that this study only included patients from three clinics, due to the difficulty in engaging dentists in this type of studies. In Portugal, dentists often work in the private health sector running small businesses, which poses a problem when trying to involve them in this research. This fact may compromise external validity. According to Tickle et al. (2012), it is unlikely that a truly representative sample of dentists or patients could ever be recruited with this type of studies (155). Therefore, multiple studies of different populations are required in order to get a complete and realistic picture that actually represents the population using general dental services. In the present study, only patients voluntarily

visiting a dentist were approached, while patients with an aversion to dental visits were probably underrepresented in the sample.

Finally, a greater range and hence greater complexity of treatment procedures would have been preferred to better account for their influence on the outcomes.

CONCLUSIONS AND IMPLICATIONS FOR CLINICAL PRACTICE

The present study focused on variables that have been scarcely analysed in scientific research, such as the association between mindfulness and dental anxiety and the assessment of discomfort during dental procedures. The results identified psychological factors influencing pain/discomfort and anxiety during dental procedures, namely expected pain, dental anxiety and pre-procedural anxiety, which can be managed beforehand with appropriate interventions. This knowledge has the potential to guide prevention and treatment strategies, aiming to improve patients' experience in the dental office.

Concerning expected pain, the present study suggests that patients who anticipated painful procedures would likely experience a greater amount of pain, and could thus benefit from interventions to decrease this variable. Dentists should be trained to better manage patients' expectations of pain by the use of interpersonal and psychological strategies (157), besides applying effective local anaesthetic techniques. Altogether, these actions would potentially reduce patients perceptions of pain and, in the long term, improve their attitudes and beliefs regarding dental treatment (157).

Dental anxiety and pre-procedural anxiety can be managed by pharmacological (sedation or general anaesthesia) and non-pharmacological interventions or a combination of both (1,18,199). In this scope, brief interventions such as "tell-show-do", distraction, positive reinforcement, stop-signalling modelling or relaxation would be particularly useful in the dental context. These could be used by the dentist, in a time-effective manner, before appointments with dental anxious patients. Other techniques, such as systematic desensitization, guided imagery, aromatherapy, biofeedback, hypnosis or acupuncture relaxation, have also been used (1,18,199), yet requiring more time and specific knowledge and training. Overall, these techniques aim to stimulate a positive attitude towards dentistry (206), reversing the fear/anxiety into a state of acceptance and calm (18).

Regarding mindfulness, the interest in incorporating it into clinical interventions in medicine and psychology is growing (78). Although the results of present study have not revealed mindfulness as a predictor of pain/discomfort or anxiety during dental procedures, mindfulness-based approaches may also represent potentially useful strategies, particularly if we consider its association with dental anxiety. Further studies are needed to investigate the role of mindfulness among individuals with dental anxiety and to analyse the usefulness of incorporating mindfulness techniques into current treatments.

It is thus clear that pain and anxiety in the dental office should be controlled for as much as possible. The first step should be the use of anxiety measurement scales as a routine (207). Using a simple 0 – 10 rating scale would be an effortless and time-effective way to achieve this, but this method has been rarely reported in research papers. Already in 1988, Corah drew attention to the fact that patient satisfaction improved when dentists inquired about their anxiety (208). In fact, practitioners who address these issues demonstrate concern, promote communication and increase patients' confidence and comfort (202). The current findings also demonstrate that age and previous oral pain complaint should be taken into consideration. Dentists should pay special attention to younger patients, who seem to have higher anxiety levels, as well as to patients complaining about pain prior to the procedure and thus more prone to experience higher levels of pain.

The present study also emphasizes the importance of taking into consideration the patient's perspective to the development of patient-centred dental care (2). This development reflects the recognition that somatic and psychological processes are integrated and thereby have a great impact on anxiety and pain (10). This seems to point that the emphasis on purely biological aspects should be shifted by giving greater focus to psychological and social aspects, in the scope of a biopsychosocial approach, thus making dental care more individualized and integrated, which will promote patient's health and well-being (15).

In conclusion, present findings suggest that dental patients could benefit from pre-treatment interventions, targeting pain expectations and anxiety before treatment, to reduce pain and anxiety during the treatment. More precisely, interventions targeting dental anxiety, a predictor of both outcomes, could benefit experienced pain/discomfort and anxiety, favouring a less aversive treatment and more positive experiences in the dental office. This can be promoted by incorporating behavioral and psychosocial curricula in the training of dentists, with current findings drawing attention to the need of implementing such in Portuguese dental medical schools. Ultimately, this could contribute to improve patients' adherence to dental care and improve general oral health of the population.

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