Work-In-Progress - The Impact of Virtual Reality on Pain Management During Orthodontic Debonding

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***Abstract*—Several previous studies reported that the use of Virtual Reality (VR) can reduce patient anxiety and pain, and can decrease the need of analgesics during medical care. Although patients may experience pain when their fixed orthodontic appliance is removed, this topic is poorly documented, as evidenced by the scarcity of publications. This paper is aiming to present a Work-In-Progress about an experiment investigating the impact of a VR system on pain and anxiety for patients during their orthodontic appliance debonding, with an experiment conducted with more than 100 adolescents and adults. Moreover, we investigate the correlation between patients' anxiety before debonding and their perception of pain, by comparing with other techniques to manage pain. To our knowledge, VR has never been tested during orthodontic procedures and our experiment is the first one investigating the benefits of VR for patients during orthodontic debonding.**

***Keywords*—Orthodontic; Debonding; Virtual Reality; Pain; Anxiety**

I. Introduction

Some orthodontic procedures, such as the application of an orthodontic force (e.g., archwire, elastomeric chain), the installation of mini screws and the appliance debonding involve discomfort and/or pain [1]. Pain is recognized to have a negative impact on physical, psychological and social dimensions of quality of life. Although numerous treatments are available for pain reduction, people suffering moderate to severe pain are often unable to find adequate pain relief and this has led to a great interest in finding novel strategies to reduce pain [2].

Because Virtual Reality (VR) distraction techniques, as a non-invasive technique, seems to be promising non-pharmacological approach for pain management [3][4][5], VR has become popular in clinical research studies as an innovative distractor technique and is a promising technology to enhance dental education [6][7] and to help patients [8][9].

However, there are very few studies dedicated to the effectiveness of VR on pain management for dentistry patients and more specifically during orthodontic debonding [10][11]. So, the purpose of this paper is to present a Work-In-Progress about an experiment investigating the impact of a VR system on pain and anxiety for patients during their orthodontic appliance debonding.

The remainder of this article is organized as follows. Section II describes the context on VR and pain management. This is followed by the method applied to assess the efficiency of VR on pain management during the removal of fixed orthodontic appliance (in section III). Section IV presents the progresses of the study, and outlines several elements of future research to be conducted on the subject.

II. Context

This section gives an overview over the patients' pain felt during their orthodontic treatment, especially during the appliance debonding procedure (Subsection II-A). Subsection II-B describes the existing methods to manage patients' pain during orthodontic treatment (e.g., communication, video, music, finger pressure). The interests of using VR as an innovative means to decrease patients' pain and anxiety during orthodontic debonding are described in Subsection II-C. Finally, Subsections II-D and II-E outline the goal of this study and its ethical aspects, respectively.

A. Pain during Orthodontic Treatment

The orthodontic bracket bonding interface, between bracket and tooth, should be powerful to endure forces during two years (i.e., the average orthodontic treatment duration) and weak enough to allowed a comfortable, harmless, and quick removal [12][13]. However, the second requirement does not seem to be accomplished [13].

As Figure 1 shows, the current method to remove a metal orthodontic bracket is to position the blades of the ligature cutting pliers between the base and the dental surface [13]. The pain and discomfort felt during this procedure depend on, amongst others, the force required to remove the bracket.

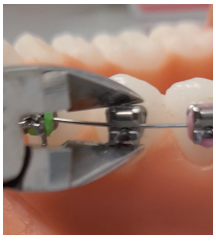

Fig. 1. Metal bracket debonding using a cutting ligature plier

Orthodontic current procedures involve pain and discomfort. Indeed, 95 percents of orthodontic patients experienced various levels of pain or discomfort during their orthodontic

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treatment, including the removal of their appliance [12][14–20], orthodontic pain resulting from ischemia, inflammation, pressure and oedema of the periodontium [17]. The required forces to remove fixed appliance increase the pressure and ischemia of the periodontal ligament.

Several factors have an influence on pain for patients during orthodontic procedures, such as the area concerned by the intervention [21][22][23] or the bracket material (ceramic or metal) [21].

Moreover, because pain is a subjective response with important individual variations, various factors, such as gender [1][24], individual pain threshold [18][20], motivation, cultural differences, and previous negative dental experience [16], could influence the level of pain perception (and modulate pain expression) of the patient [24].

B. Current Methods to Manage Pain During Debonding

Several methods have been already tested to minimize pain during debonding, like using different orthodontic pliers, laser application, analgesics, ultrasound, biting cotton roll, practitioner finger pressure or occlusal bite wafers [1][16][21][24][25].

But there is weak evidence indicating using the (i) debonding dedicated tool rather than the most common instrument (ligature cutting plier), (ii) laser, (iii) ultrasounds during debonding reduce patients' pain perception [22]. Even if some studies tend to show that premedication can have a positive impact on pain during debonding [1], alternative pain management approaches are essential to consider [26].

Neutral statements, positive suggestions, or providing distraction are essential to improve patient treatment experience [27][28]. The practitioner's chosen words during care have a significant influence on the experience of pain. Moreover, clear communication decrease patients' anxiety [29]. Conversely, an inadequate communication can affect negatively the pain (i.e., as a *nocebo* effect) [27].

C. VR as an Innovative Technique to Manage Pain

Recent theories of pain highlighted that sensory stimuli from the environment can also influence the patient pain experience [30][31]. For example, in conscious patients undergoing surgery, watching a movie and listening to music can significantly reduce anxiety with equivalent results [32]. In the same way, VR can have a positive impact on pain by modulating the activation of some brain zones, including the anterior cingulate cortex, insula and amygdala, which are involved in the emotional and attentional pain pathways [33]. VR is efficient in reducing anxiety, decreasing pain levels, and improving patient satisfaction, and several studies have demonstrated that VR have positive effects for the care of several diseases and patient of different ages, such as burned patients [34], patients with breast cancer [35], children with cancer [36][37], children with tooth decay [38][39], elderly patients with cancer [40].

There are some years ago, VR was investigated exclusively for relaxation sessions before care and especially general anesthesia [41], all the systems being expensive and oversized. Today, VR headsets are henceforth smaller, comfortable and easy to use, usable during dental care as well [29].

D. Objectives of the Study

The current goal of this paper is to present a Work-In-Progress performed to investigate positive benefits on patient pain perception by using VR distraction during orthodontic debonding. With an experiment conducted on more than 100 adolescents and adults, this study investigates the benefits of VR on patient pain perception depending on the appliances type (i.e., ceramic or metal brackets), and the correlation between patients' anxiety before debonding and their perception of pain, by comparing with other techniques to manage pain.

E. Ethics

This study has been registered in the French General Register of Data Protection before commencement of the study. A non-opposition document was given to patients and/or the parents prior to participation.

III. Method

In this section, the chosen methodology to assess the impact of VR on patients' pain and anxiety during the debonding of their orthodontic appliance is described and justified (i.e., sample, VR headset, debonding procedure and scales).

A. Participants

All participants are patients (over 12 years-old) undergoing orthodontic treatment with a debonding of their fixed appliance scheduled between September 2023 and December 2024. They are distributed in two groups: VR group vs No-VR group. Included patients are all taken care of in our department or in the liberal practice, had benefited from a mandibular and maxillary orthodontic treatment by bonded metal or ceramic brackets (GC self-ligating brackets or AO non self-ligating brackets). Several criterias have been used (non inclusion: Cognitive disorder; Non-French understanding; Medical history of epilepsy; Blindness; Refusal, Medical history of taking analgesic or anxiolytic in the last 24h; Incomplete appliance at the time of debonding; Active periodontal disease with tooth mobility; Craniofacial dysmorphology; Presence of miniscrews).

B. Design and the Independent Factor

From early May 2024, VR distraction during debonding will be offered to patients as a new standard care protocol. To evaluate this practice, we carry out an observational before–after multicentric study (i.e., Hospital of Reims and Association Dentaire pour l'Enfance of Maisons-Alfort). We compare demographic data (gender and age), orthodontic treatment characteristics, anxiety and pain scores (general and by sextant) of 122 patients during the debonding of their orthodontic fixed appliance with or without the us of VR. The removal of the orthodontic appliance must take place from September 2023 to december 2024, over the two periods defined as "before" (called the No-VR group) and "after" (called the VR group) implementing the VR protocol.

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To calculate the number of subjects required, we used the Wilcoxon–Mann–Whitney test, with a power of 90 percents, an alpha risk at 0.05 percent and 15 percents to make up for missing data. As Figure 2 shows, the inclusion of 122 patients (33 per group) was necessary to show a statistically significant difference on the primary objective.

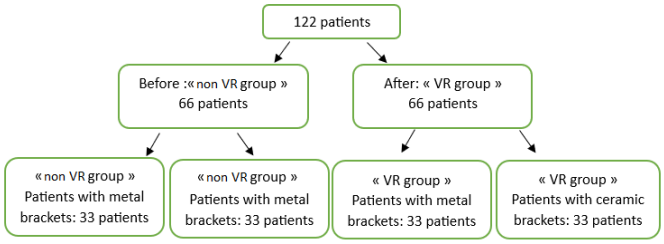

Fig. 2. design of the study

Only one independent factor is manipulated, with two modalities: some patients are in the VR group while the other patients are in the Non-VR group.

C. VR Used and Protocol

The VR device used for patients in the VR group is a stand-alone virtual reality headset from Lumeen® CE marked medical device.

Before debonding, each practitioner is instructed about the study objectives. All the patients will be debonded by a constant team (five residents and three seniors). They must remove the appliances with common methods. If there is no contraindication, VR system will be proposed to the patient by the practitioners before the orthodontic debonding. As Figures 3 and 4 show, patients will have the choice among nine immersive universes (five for adults relaxation and four dedicated to pediatric care). All were developed in cooperation with hypnotherapists and anesthesiologists. The presence of medical contraindications and refusal by a patient will be registered. the VR headset will be set up by the practitioner after installation on the dental chair and removed at the end of the procedure. The immersion will be stopped anytime for medical reasons or by simple request from the patient.

Fig. 3. immersive relaxing environments dedicated to pediatric care

Fig. 4. immersive relaxing environments developed for adults

D. Assessment of Pain and Dependent Factors

Before debonding, each participant is asked to complete (i) a Likert scale to assess the Anxiety score, as Figure 5 illustrates, (ii) the Numerical and Visual Rating Scale to assess pain scores, as Figure 6 shows. After the debonding procedure, patients will complete a more precise score for each dental area, as Figure 7 shows. So, there are three dependent factors.

Fig. 5. Visual Analog Scale (VAS) and Numerical Rating Scale (NRS), used to assess patients anxiety during debonding (usable for both adults and children).

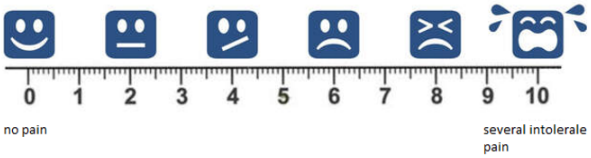

Fig. 6. Visual Analog Scale (VAS) and Numerical Rating Scale (NRS), used to assess patients pain during debonding (usable for both adults and children).

All the patients will be debonded by a constant medical team. Practitioners will remove the appliances with common methods, without adjunctive measures (finger pressure, biting cotton roll, music or video).

IV. Conclusion and Perspectives

Several studies have already shown that VR distraction can decrease patients' pain perception and anxiety. However, because there are very few studies dedicated to the effectiveness of VR on pain management during orthodontic debonding, the purpose of our study is to compare the patient reported pain and anxiety during their orthodontic appliance debonding with or without the use of a virtual reality headset.

For the moment (January 2024), we have included in the "No-VR" group 15 patients with metal brackets, and 11 patients with ceramic ones.

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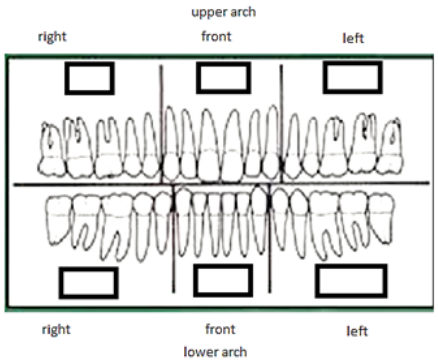

Fig. 7. Oral cavity diagram used to assess patients' pain through Numerical Rating scale (NRS) within each sextants.

To our knowledge, our experimental study is the first one investigating the effectiveness of the VR headset during orthodontic debonding. Of course, the potential impact of our research is not limited to orthodontic and dentistry patients. We hope that our future results will encourage speculation that VR pain reduction will also generalize to other acute pain populations/etiologies (e.g., oral and other ambulatory surgery, chemotherapy, radiation therapy) [42].

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