

The potential of heart rate variability for exploring dental anxiety in mandibular third molar surgery

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Abstract. An objective method to recognize patient psychology using heart rate variability (HRV) has recently been developed and is increasingly being used in medical practice. This study compared the potential of this new method with the use of conventional surveys measuring anxiety levels in patients undergoing impacted third molar (ITM) surgery. Patient anxiety was examined before treatment in 64 adults who required ITM surgery, using two methods: measurement of HRV and conventional questionnaire surveys (state section of the State-Trait Anxiety Inventory (STAI-S) and Dental Fear Survey (DFS)). Both methods were assessed for their respective abilities to determine the impact of personal background, the amount of information provided, and the surgical procedure on patient psychology. Questionnaires and HRV yielded the same finding: dental experience was the single background factor that correlated with patient anxiety; the other factors remain unclear. The STAI-S showed a significant relationship between the information provided to the patient and their anxiety level, while the DFS and HRV did not. In addition, HRV demonstrated its ability to assess the effects of the surgical procedure on patient psychology. HRV demonstrated great potential as an objective method for evaluating patient stress, especially for providing real-time information on the patient's status.

Key words: electrocardiography; test anxiety scale; autonomic nervous system; psychological stress; physiological reaction; psychological test; survey; questionnaire.

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Dental anxiety has been ranked the second most common barrier to dental treatment¹. This anxiety may not only delay a necessary examination, but may also have a marked impact on numerous aspects of

overall health². However, clarifying this problem remains an immense challenge for researchers and practitioners due to the lack of a clear methodology. Previous research has relied mostly on psychologi-

cal assessment questionnaires, which are subjective and somewhat biased^{3,4}.

Since the first dental-fear questionnaire was introduced in 1969, several dental anxiety scales have been developed and

applied widely to assess patient attitudes towards oral treatment⁵. In spite of their convenience and affordability, these surveys have demonstrated some crucial defects that might limit knowledge regarding patient psychology. Firstly, most of these psychological assessments are not based on a strong theoretical construct or definition⁵. Secondly, although each dental procedure has its own specific features, all of these dental anxiety scales were developed for general assessment rather than focusing on any specific treatment⁶. Thirdly, the fear provoked by dental treatment is based on a combination of personal traits, state anxiety, social impact, and coping ability rather than a particular 'dental anxiety'⁴. Therefore, the cumulative results regarding dental anxiety are controversial; for instance, the relationship between dental anxiety prior to impacted third molar (ITM) surgery and other correlative factors⁶.

It would be expected that the use of an objective method to assess either biochemical or physiological parameters would help avoid many of the problems described above. Among the objective methods considered to date, heart rate variability (HRV) is thought to be a promising solution offering several significant advantages. Not only is it a non-invasive method that is easy to perform, but it also provides real-time information regarding autonomic nervous system activity in response to triggering events⁷. Due to the convenience of HRV, there has been a dramatic increase in its use in psychophysiological research in various medical fields⁸. Conversely, the use of HRV in dental studies has remained limited, and in such studies it has most often been used simply to describe changes during a procedure rather than being used to monitor sympathetic nervous system and parasympathetic nervous system activity under different circumstances. Thus, HRV has great potential for the objective measurement of patient stress in dental clinical research⁹.

Among dental procedures, ITM surgery has received considerable attention as the most anxiety-provoking event^{10,11}. This treatment usually involves complicated procedures, including anaesthesia and drilling, which have been rated by patients as two of the most frightening aspects in relation to dentistry^{12,13}. In addition, several studies have demonstrated that offering procedural and sensory information is a useful non-drug pathway for moderately anxious individuals¹⁴.

The aim of this study was to investigate the utility of HRV in comparison with

conventional psychological assessments for exploring dental anxiety in patients undergoing ITM surgery. The hypotheses were: (1) the results of both conventional psychological assessment and HRV for the evaluation of patient stress would not be affected by the patient's personal background; (2) neither method would demonstrate the effects of providing information on patient stress; and finally (3) HRV would not demonstrate the effects of the ITM surgery procedure on patient stress in real time.

Materials and methods

Study subjects

Subjects were recruited from patients requiring surgical removal of ITM between March 2016 and June 2016 at the Department of Oral Surgery, Faculty of Odontostomatology, Ho Chi Minh City University of Medicine and Pharmacy, Vietnam. The eligibility criteria were: (1) at least 18 years old, (2) no history of prior ITM surgery, (3) absence of any systemic disease that could affect the cardiovascular condition, and (4) absence of any mental problems.

Before the procedure, the subjects were fully informed of the research purpose and information to be collected, and participant's rights were carefully explained. A written consent form was obtained from each participant, and all subjects were advised that they could withdraw at any time without giving a reason. The study protocol was approved by the ethics committees of Tokyo Medical and Dental University and Ho Chi Minh City University of Medicine and Pharmacy.

Questionnaire measurements

The Vietnamese versions of three assessments, i.e., the State-Trait Anxiety Inventory (STAI), short version of the Dental Anxiety Inventory (S-DAI), and the Dental Fear Survey (DFS), were used in this study to determine the participants' general and dental anxiety. The validity and reliability of the original versions of these scales have been confirmed several times by previous researchers^{5,15}. It was ascertained that each subject had a clear understanding of each question, and the survey was completed under the researcher's supervision.

This research used form Y of the STAI, which contains 40 items divided equally into two parts for assessing state anxiety and trait anxiety¹⁶. Each question has four possible answers, with the score ranging

from 1 to 4. The total score for each part may vary from 20 (not anxious) to 80 (extremely anxious).

The S-DAI is a shortened version of the Dental Anxiety Inventory, which was designed with a comprehensive facet approach, including anxiety-provoking circumstances, timing of appearance, and body reaction in response to dental anxiety¹⁷. In contrast, the DFS focuses on the patient's avoidance, autonomic reaction, and fear of specific dental stimuli¹². Therefore, the S-DAI and DFS have been considered measures of dental trait and state anxiety, respectively⁵. The S-DAI includes nine items which are answered on a five-point Likert scale. The sum score ranges from 9 (not anxious) to 45 (extremely anxious)¹⁷. Similar to the S-DAI, each question of the DFS has five possible answers which are scored from 1 to 5. The total DFS score ranges from 20 (no fear) to 100 (very frightened).

Real-time HRV measurements

In this research, an HRV measurement device (Relax Meijin; Crosswell Co. Ltd, Tokyo, Japan) was used to obtain real-time autonomic nervous system data. The procedure was as follows: the electrocardiographic (ECG) signal was collected using biomonitors and the data were transferred successively to a computer. Frequency analysis of the R-R interval on the ECG waveform was then performed using software, in order to obtain the amount of low frequency component (0.05–0.15 Hz, hereafter LF) and high frequency component (0.15–0.40 Hz, hereafter HF) for every second. The absolute values of these components were used to calculate the ratio of LF to HF (LF/HF) and the HF normalized unit (HFnu) using the following equation: $HFnu = HF / (LF + HF)$ ¹⁸.

Study design

The procedure was separated into two appointments: appointment 1 (A1) was the day on which the patients presented for assessment; appointment 2 (A2) was the day of surgery.

At A1, a researcher collected the subject's background factors, including age, sex, educational level, body mass index (BMI), and predicted difficulty of the surgery according to the Pederson classification¹⁹. Following this, the participants answered the trait section of the STAI (STAI-T) and the S-DAI. Next, the subjects were divided randomly into two groups, making certain that the distribu-

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