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The Ability of Brain Waves Activity to Detect Patient Susceptibility to Post-Operative Pain

Research proposal submitted to Department of Endodontics, Faculty of Dentistry, Ain Shams University, in partial fulfilment of the requirements of the Master's Degree in Endodontics.

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Introduction

Pain is an unpleasant sensory and emotional experience associated with actual or potential tissue damage. It is the primary reason for patients to seek dental therapy and mostly this pain is related to endodontics.

Pain and fear of pain is at the root of many problems between patient and dentist. Endodontic treatment, because of its strong association with preoperative, operative and postoperative pain, is prominent in this regard. Pain prevention is, thus, of prime importance in endodontics.

Root canal treatment is usually associated with pain before, during or even after the treatment done. Dentists, especially endodontists, have the ability to deal primarily with pain intraoperatively by local anesthesia but sometimes it is difficult to control post-operative pain or even expect its degree as it is related to many factors. Knowledge of the causes and mechanisms behind endodontic postoperative pain is necessary for the clinician to properly manage this undesirable condition.

Pain measurement is usually subjective; it is not always possible to quantify pain. Mostly the physicians rely on tools to measure pain as the visual analogue scale (VAS) for assessment of the patient's pain intensity. Although it has many pros, it is still highly subjective.

According to a recent study, brain rhythms can be used to predict how sensitive individuals are to pain. An electroencephalogram (EEG) is used to measure brain activity by placing electrodes on the brain or outer skull surface. This study claimed that measuring the frequency of alpha waves in the resting state can predict patient sensitivity to pain. Alpha waves occur in healthy awake adults while resting with their eyes closed. They vanish during sleep and become

replaced by beta waves when a person concentrates on a specific task. Alpha wave rhythms can range in frequency from 8 to 14 Hz. Alpha waves are maximal in the occipital region. In most cases, a neurologist will measure the alpha rhythm in the back of the patient's head while the patient's eyes are closed. [1]

An electroencephalogram (EEG) is a printed record of the electrical activity of the brain. The billions of brain neurons and their activities generate a measurable electrical field that changes constantly when areas are stimulated or reduced in activity. The observed electrical patterns are referred to as brain waves. Brain waves are any number of patterns of rhythmic electric impulses produced in various parts of the brain. There are four types of brain waves: alpha, beta, theta, and delta.

This interesting study that stated that the patient’s susceptibility to postoperative pain can be detected according to alpha brain waves activity is of a huge benefits and interest. The ability to predict the group of patients who are more likely to experience higher post-operative pain intensity than other patients will allow the implementation of the proper pain management protocols especially for this group of the patients, and that’s why this study will be conducted.

Literature review

Pain is a signal in your nervous system that something may be wrong. It is an unpleasant feeling. Pain may be sharp or dull. It may come and go, or it may be constant.

Postoperative pain is defined as pain of any degree that occurs after the initiation of root canal treatment while flare up is a severe pain or swelling after initiation or continuation of endo treatment that require an emergency visit for the patient. [2]

The incidence and degree of post endodontic pain occurring in asymptomatic patients who started endodontic treatment were recorded. It was found that postoperative pain is most likely to occur during the first 24 hours after obturation. If a patient is free of symptoms 24 h after obturation, it is unlikely that symptoms will develop during the 60 days after obturation. Postoperative pain has no statistically significant relationship with the vitality status of the pulp, the presence or absence of a periapical radiolucent area, the number of roots, previous emergency treatment for pain, or the level of obturation of the root canal. It was also found that patients who felt pain intraoperatively or between visits are more likely to develop postoperative pain. [3]

Mild discomfort following root canal treatment is a common occurrence for patients. However, there can be numerous causes of postoperative pain. The most common causes are mechanical, chemical, or microbial injuries to the periapical tissues, which result in acute inflammation. In a clinical study, it is difficult to determine whether a single or multiple factors cause pain. If a root canal system was not properly cleaned, residual infection may cause exacerbation through imbalances in the host-bacteria relationship, synergistic or additive

microbial interactions, or the presence of decisively pathogenic bacteria prior to treatment initiation. Over instrumentation may be a mechanical cause, while chemical causes include the extrusion of medications, filling materials, or irritants. [4]

A study compared the effect of a one-visit root canal treatment (RCT) versus a two-visit RCT on post-obturation pain experience in single-rooted teeth with vital pulps. The findings were consistent with the majority of published reports that post-obturation pain in teeth with vital pulps following one-visit RCT was comparable to pain experienced following two-visit treatment. As a result, the prevalence or intensity of post-obturation pain was not significantly different between the one-visit and two-visit RCTs. [5]

Occlusal reduction can prevent postoperative pain if the tooth was vital, sensitive to percussion or without periapical radiolucency. That is because occlusal reduction reduces occlusal stresses from periodontal ligament. [6]

It seems that women are at a greater risk for many clinical pain conditions. An extensive review reported that a survey of the currently available epidemiological and laboratory data indicates that there is strong evidence for clinical and experimental sex differences in pain. Numerous reasons for these findings have been given, including hormonal and genetically driven sex differences in brain neurochemistry. [7]

There is link between a patient's level of anxiety and how they react to an endodontic procedure. Many patients are dentophobic and don’t usually visit their dentist unless they feel severe pain lading to deterioration of their oral health condition. As the level of anxiety increases, the patient's pain threshold decreases. An implant study determined that pain experienced by patients was best predicted

by their anxiety level during each procedure; these results could be correlated to endodontics. [8].

As endodontic treatment is always associated with pain, analgesics are always prescribed to avoid or decrease the postoperative pain. A respectful clinical study with a double-blind design compared the analgesic effect of different analgesic combinations and concluded that one or two tablets of the single-tablet combination of ibuprofen/paracetamol were statistically significant in reducing postoperative pain than two tablets of paracetamol/codeine and significantly superior pain relief compared to ibuprofen/codeine. [9]

A systematic review and meta-analysis provided that there is no statistically significant difference in the risk of complications between single and multiple visit root canal treatment, however there is increased risk of flare-ups in case of single-visit root canal treatment in certain cases like those with periapical lesions. [10]

A Visual Analogue Scale (VAS) is a subjective measurement instrument that tries to measure the intensity of pain and to follow up pain progression or regression. It is a line with "least possible pain" labelled at one end and "worst possible pain" at the other. The patient is asked to mark the line at a point corresponding to his present pain level. [11]

Even though pain is a subjective first-person experience, and self-report is considered the gold standard for evaluating pain intensity in clinical situations, self-reports of pain intensity are not available in some vulnerable populations, which may result in inadequate or suboptimal pain treatment. An objective measurement of pain intensity that can supplement self-reports, for example, to monitor the effect of analgesic drugs or the recovery of the nociceptive system in non-communicative patients, is in high demand in clinical practice. [12]

Pain vision PS-2100 (PV) is an objective analytical instrument that was designed to quantitatively and objectively assess sense perception and nociception in patients. A study compared PV to VAS to assess pain perception in the same patients and found that a weak correlation observed between VAS and PV. [13]

Tissue injury, inflammatory illness, pathogen invasion, and neuropathy all contribute to pain, one of the most unpleasant feelings. The pain signal is transmitted to the brain via the spinal cord by nociceptors on the A- and C-fibers that innervate the skin, joints, and bodily organs, and is interpreted as pain. Neuronal activity in the brain is thought to play a role in pain perception. The dynamics of the neural activity that underpins pain perception, however, are not completely understood. [14]

A study aimed to create a new method for predicting pain perception from single-trial laser-evoked potentials that was practical (LEPs). To automatically and accurately estimate single-trial LEP features, they used a unique single-trial analytic method that incorporated common spatial pattern and multiple linear regression. They also used a Nave Bayes classifier to predict low and high pain discretely, as well as a multiple linear prediction model to predict pain intensity continuously from single-trial LEP characteristics, at both within- and cross-individual levels. The proposed approach provided a binary prediction of pain (classification of low pain and high pain) with an accuracy of 86.3 8.4% (within-individual) and 80.3 8.5 percent (cross-individual), as well as a continuous prediction of pain (regression on a continuous scale from 0 to 10) with a mean absolute error of 1.031 0.136 (within-individual) and 1.821 0.202 (cross-individual) (cross-individual). As a result, the proposed method could aid in the

development of a quick and accurate tool for pain prediction that could be used in a variety of basic and clinical settings. [15]

Quantitative EEG is an objective noninvasive tool for studying the mechanisms involved in chronic pain. Increased alpha and theta power at spontaneous EEG and low amplitudes of ERP (event-related potentials) during various stimuli seem to be clinical characteristics of individuals with chronic pain. However, more studies are necessary before drawing any conclusion on the utility of qEEG on chronic pain. [16]

A recent study looked at the relationship between healthy people's pain-free resting alpha oscillation speed and their sensitivity to two types of prolonged pain, Phasic Heat Pain and Capsaicin Heat Pain, over the course of two visits separated by an average of eight weeks (n = 61 Visit 1, n = 46 Visit 2). The speed of a person's pain-free alpha oscillations was shown to be negatively correlated with sensitivity to both models, and this association was found to be consistent across short (minutes) and long (weeks) timescales. Furthermore, the speed of pain-free alpha oscillations can be used to accurately identify people who are particularly sensitive to pain. These findings imply that alpha oscillation speed is a viable biomarker of long-term pain sensitivity that might be used to predict pain sensitivity in clinics [1]

Alpha wave is the main brain wave of normal relaxed adults. It’s also about relaxation and freedom. When it is high (10-12hz), it is related to the active activity of the brain and when the energy released by the alpha wave is strong, it represents the brain wave in the best state of learning and thinking. [17]

Tissue injury, inflammatory illness, pathogen invasion, and neuropathy are all causes of pain. The brain's neuronal activity is thought to play a role in pain perception. The patterns of neural activity that underpin pain perception,

however, are unknown. A recent study examined theta oscillation patterns of local field potentials in the primary somatosensory cortex of a mouse model of formalin-induced pain. Formalin injection caused a reversible shift in theta-peak frequency toward a slower frequency. This shift was found during nociceptive phases but not during the pain-free interval, and it was inversely related to the degree of immediate pain. Furthermore, instantaneous oscillatory analysis revealed that during nociceptive phases, the likelihood of slow theta oscillations increased, accompanied by increasing slow theta power. Finally, cross frequency coupling between theta and gamma oscillations revealed that theta oscillations' coupling peak frequency was pushed toward slower oscillations, with no effect on coupling strength or gamma power. These findings imply that theta oscillations in the mouse primary somatosensory cortex reflect the continuing condition of pain sensation. [18]

The cortical representation of relevant sensory information has been linked to neuronal oscillations in the gamma frequency band. Using magnetoencephalography, selective nociceptive stimuli induce gamma oscillations between 60 and 95 Hz in the primary somatosensory cortex. The amplitudes of pain-induced gamma oscillations vary with the objective stimulus intensity and the subjective pain intensity. However, around the pain threshold, perceived stimuli produced stronger gamma oscillations than unperceived stimuli of equal stimulus intensity. So painful stimuli cause high-frequency oscillations in the electrical activity of the human primary somatosensory cortex. The amplitudes of these pain-induced gamma oscillations were more closely related to the subjective perception of pain than to the objective stimulus attributes. These findings suggest that gamma oscillations may be an important mechanism for processing behaviorally relevant sensory information. [19]

Aim of this study

The aim of this study is to investigate the correlation between brain waves and prediction of postoperative pain in endodontic patients.

Null Hypothesis

There is no difference in post endodontic pain susceptibility between patients with different frequency of alpha brain waves.

Materials and methods

Materials

EMOTIV®| EPOC X (EPOC X, Emotiv Inc, San Francisco, California, U.S.A)

Methods

- **Setting and location**

  After the approval of the ethics committee in Faculty of dentistry, Ain Shams University, patients who are regularly visiting the endodontic clinic on daily basis will be asked to participate in the study. The patients will be asked to wear an EEG device to record the alpha brain waves before and after receiving the required endodontic treatment.

- **Sample size determination**

  A power analysis is designed to have adequate power to apply a 2-sided statistical test of the research hypothesis (null hypothesis) that there will be no difference in post endodontic pain susceptibility between patients with different frequency of alpha brain waves. The predicted sample size (n) is a total of (100) cases i.e. (50) cases per group.

- **Ethical consideration**

  Patients will be asked to follow general instructions to sign a printed consent explaining the aim of the study and obligating them to fill the

VAS scale during the procedure. Any patient who refused to participate in the study will have his endodontic needs fulfilled without any prejudice.

- **Patient selection**

The individual diagnosis will be confirmed by obtaining a dental history, performing pulp vitality testing, taking periradicular radiographs, periodontal evaluation, percussion, and a record of previous NSAID or antibiotic treatment.

Inclusion criteria:

1. Patient's age ranges from 20-40.
2. Vital lower first molar with signs and symptoms of acute irreversible pulpitis and indicated for single visit root canal treatment.
3. Patients that had not received any medicinal therapy after endodontic treatment.
4. Patients who are mentally and physically capable to record pain intensity estimated every 6 hours after endodontic treatment using VAS.

Exclusion criteria:

1. Patient systemic disease or neurogenic disease that contraindicates the use of the EEG or have sensitivity to the electrode material.

2. Cases that root canal treatment could not be finished in a single visit such as teeth with apical periodontitis, pulpal necrosis, chronic apical abscess.
3. Patients who took analgesics within 24 hours after endodontic treatment.

Procedure steps:

- All teeth will be cleaned, shaped, and obturated during the patients' first visit. Local anesthesia will be achieved by inferior alveolar nerve block with 4% articaine with 1:100,000 epinephrine. After anesthesia, an endodontic access cavity will be done using suitable round bur and fine tapered stone with rounded end.
- Canals will be prepared using crown down technique using manual and rotary instruments. Patency will be established and verified with #10 k files.
- The ideal working length will be determined using an electronic apex locator and periapical radiographs
- Glide path will be maintained with stainless steel hand instruments up to size #15. Shaping with rotary files 20 .04 and 25 .06 then final apical preparation by manual flex files.
- The final instrumentation size will be determined as three sizes larger than the first file engaging at the working length. Master apical files ranging from #35 to #50, depending on both root anatomy and initial diameter of the root canal.
- Irrigation performed with 5.25% NaOCl solution.

- Teeth will be obturated with cold lateral compaction, using resin sealer and gutta-percha.

- **Sample classification**

  This is an observational study. Alpha brain waves activity will be measured for all patients before root canal treatment and patients will be divided into 2 groups:

  Group I: patients with low alpha frequency preoperatively ranging from 8 to 10.

  Group II: patients with high alpha frequency ranging from 11 to 13.

  The alpha brain waves activity will be recorded immediately after the endodontic treatment and 24 h post-treatment. The pain intensity will be recorded by the patient post-operatively every 6h using the VAS.

- **Method of evaluation**

  The data from the EEG and the VAS records pre-and post-treatment will be evaluated, tabulated, correlated and statistically analyzed using the appropriate statistical test.

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