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Original Article

Reliability of clinical examination methods for postoperative pain after primary root canal treatment

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Abstract *Background/purpose:* Clinical test results may have lower reliability due to the varying range of test stimulation or patient subjectiveness. This study aimed to verify a reliable clinical test method by comparing pain intensity levels of a tooth at rest, during function, and after the clinical tests of percussion and chewing.
Materials and methods: A total of 36 asymptomatic necrotic teeth that required root canal treatment, one in each patient, were included. All treatment procedures were performed in a single visit by an experienced endodontist. Patients were asked to mark their pain levels on a vertical visual analog scale (VAS) while the relevant tooth was at rest and during function 24 h after the treatment. In addition, patients marked their pain levels after the clinical tests of percussion and chewing. Finally, the pain levels were compared using Pearson's correlation for the reliability of the test methods at a significance level of 95%.
Results: The postoperative pain levels measured during the clinical tests and functions were significantly higher than the pain levels at rest ($P < 0.05$). The pain levels after percussion tests were significantly higher than that during the function and chewing tests ($P < 0.05$). Pain intensity during the function was simulated with a higher correlation when using the chewing strip method rather than the percussion method.

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Conclusion: The bite test using the chewing strips as a pain intensity assessment can mimic the actual postoperative pain experience, whereas the percussion test fails to provide the accuracy of this pain experience.

Introduction

Pain is a subjective, distressing experience. Subjectivity is driven by sensory, emotional, and cognitive components in the presence of actual or potential damage.[1] Various factors play important roles in endodontic pain, such as host-dependent, chemical or mechanical injury, or bacterial infection.[2] In particular, apical extrusion of infected debris and mechanical vibration and/or noise created by different handpieces during root canal instrumentation have also been shown to affect postoperative pain.[3–5] Several studies have investigated the effect of procedural methodology on postoperative pain, such as the number of visits,[6] endodontic files with different kinematics,[7,8] and irrigation[9] or filling protocols,[10] proving that these factors affect postoperative pain. However, there are conflicting results among these studies that may be associated with the subjectivity of the data on postoperative pain.[7,11]

The subjectivity of pain combined with fear of pain, avoidance, and escape behavior[12] may affect the chewing habits of individuals in the short or long term, resulting in decreased chewing action and forces on painful teeth. Even the mention of a painful movement before the actual movement itself was shown to cause a conditioned fear response.[13] When left unattended, fear, avoidance, and behavioral change may affect the results of the pain intensity evaluation.

A quantifiable method using a diagnostic device such as a bite fork has been reported to provide reliable and repeatable results.[14] Although the use of such devices is efficient for diagnostic purposes, it is inherently unfeasible to assess a postoperative pain during consecutive days. Assessment of postoperative pain due to chewing may sound like a convenient methodology; however, the accuracy of such an assessment should be verified to eliminate the shortcomings mentioned above.[12,13]

Therefore, this study aimed to evaluate the pain intensity levels while the relevant tooth was at rest and in function, as well as via clinical percussion and chewing tests, and then to compare the difference between clinical test data and unattended pain (pain in function) intensity. The null hypothesis was that there is no difference in the measured pain intensity between the clinical percussion and chewing tests and unattended functional pain.

Materials and methods

The ethics committee of the university approved this clinical trial (file number: E−10840098-772.02-2677, decision number: 592). Consent was obtained from all participants before enrollment into the study.

Inclusion and exclusion criteria

This study aimed to compare the pain intensity levels while the relevant tooth was at rest and in function, as well as via percussion and chewing tests, and to evaluate the difference in the pain intensity data between clinical tests (percussion and chewing) and function.

This study included patients with asymptomatic teeth which required root canal treatment. Thorough clinical and radiological examinations (Kodak RVG 5100; Carestream Health, Inc. Rochester, NY, USA) were performed to confirm the diagnosis.

The following patients were excluded from the study: patients under 18 years old, those with contraindications for root canal treatment due to their medical conditions, those who used analgesics one week and/or antibiotics one month before the procedure, those who failed to comply with the follow-up, and those with bruxism. Additionally, patients with symptomatic teeth with spontaneous or provoked pain, previous root canal treated teeth, teeth with present or suspected vertical root fracture, periodontal pocket depth $\geq$4 mm, periapical lesions $\geq$5 mm, root resorption, history of trauma, teeth in need of apical surgery, and teeth with no antagonist teeth in the opposite arch were excluded from the study. Thus, all the teeth were painless (pain score = 0 on the visual analog scale) before root canal treatment.

A power analysis was performed using the G* Power (v3.1.9) program to determine the sample size. A total of 36 patients with one tooth per patient were finally included in this study.

Treatment procedure

All treatment steps, including the commencement of the procedure, were explained in detail to the patients, and it was ensured that they understood and were comfortable with the process. Verbal and written informed consent for the treatment procedure was obtained from all patients before commencing the study. The entire treatment procedure, from access cavity preparation to coronal restoration, was performed in a single visit by an endodontist with over 15 years of experience.

A dental loupe with a magnification of 4.5X (EyeMag Pro F; Carl Zeiss, Jena, Germany) was used throughout the procedure. After administering local anesthesia (articaine hydrochloride and epinephrine hydrochloride 0.006 mg/mL; Ultracaine DS Forte; Aventis Pharma, Bridgewater, NJ, USA),

a rubber dam (Hygenic Dental Dam Kit; Coltene/Whaledent Gmbh, Langenau, Germany) was placed for tooth isolation.

Access cavity preparation was followed by scouting of the root canals with a #10 C-file (MMC file; Coltene-MicroMéga, Besançon, France). Coronal pre-flaring of the root canals was performed using a OneFlare (Coltene-MicroMéga) NiTi file with an endodontic motor (Dual Move, Coltene-MicroMéga). After determining the working length using a #10 C-file (MMC file, Coltene-MicroMéga), glide path preparation was completed using a #15 K-File (Mani, Tochigi, Japan). Canal shaping was performed using 2Shape (Coltene-MicroMéga) TS1 (#25/.04) and TS2 (#25/.06) files of the working length. Further apical shaping was performed using a 2Shape F35 (#35/.06) file, according to the apical canal lumen. The manufacturer's instructions were followed during the application of all the rotary files.

After instrumentation with each file, irrigation was performed using a 5.25% NaOCl solution (Wizard; Rehber Chemistry, Istanbul, Turkey). Following the completion of root canal shaping, a final irrigation protocol was performed using 5% ethylenediamine tetraacetic acid (Wizard) for 1 min, 5.25% NaOCl for 30 s, and saline solution for 30 s.

Corresponding gutta-percha (GP) points (TS2 or F35; 2Shape GP points, Coltene-MicroMéga) were used to fill the root canals using a sealer-based hydraulic technique. The root canals were partially filled into the root canal using a premixed syringe loaded with a calcium silicate-based sealer (Well-Root ST; Vericom, Chuncheon, Korea) before GP insertion, which was also loaded with a small amount of sealer. GP was severed at the root canal orifice level using a heated plugger (Dentsply Sirona, Johnson City, TN, USA). The coronal restoration was performed using the total-etch technique and composite material (Filtek Supreme Ultra Universal; 3 M ESPE).

Evaluation of postoperative pain

Postoperative pain was evaluated 24 h after root canal treatment using an electronic pain-rating scale program (ETZ Pain Assessment and Rating Scales ver. 2.1). Patients were asked to mark their pain levels on a vertical visual analog scale (vVAS) while the relevant tooth was at rest and in function (Fig. 1). Postoperative pain after percussion and pain at rest in the relevant teeth was also recorded for comparison.

During the 24 h follow-up, the patients were asked to mark their pain level at rest. Afterwards, three different tests were performed during clinical evaluation. First, a percussion test was performed by applying a light-tapping force to the relevant tooth using the blunt end of the dental probe. Tapping was applied from a ~1 cm distance as gently as possible. Second, the patients were asked to bite on a 2-mm thick chewing strip (Bausch Fleximeter Strips, Köln, Germany). After each test, patients were asked to mark their pain levels using the same vVAS. All tests were performed by the same operator.

Statistical evaluation

The pain intensity levels measured in vVAS pain intensity scores by percussion and bite tests were compared with the pain intensity at rest and during function. Pearson's correlation coefficient was used to evaluate the reliability of the test methods. In addition, the effects of patient- and tooth-related parameters, such as sex, jaw (maxillary and mandibular), and tooth location (anterior, premolar, and molar), were evaluated. The significance levels were set at 95%. The analysis was conducted using SPSS software (version 22.0; IBM, Armonk, NY, USA).

Results

The vVAS data of the 36 patients are shown in Fig. 2. The postoperative pain intensity levels measured during the tests and function (unattended) were significantly higher than those at rest ($P < 0.05$). In addition, the pain intensity level in the percussion test was significantly higher than that during the function and chewing tests ($P < 0.05$).

The case distribution and Pearson correlations between the vVAS scores obtained using different test methods are presented in Table 1. The postoperative pain intensity during function (unattended) or pain at rest was simulated with a higher correlation using the chewing strip method (Pearson's correlation coefficient = 0.916) than the percussion method (Pearson correlation coefficient = 0.667).

Female patients showed much higher Pearson correlation coefficients than male patients for both test methods. The maxillary teeth had higher Pearson's correlation coefficients than the mandibular teeth. The percussion test did not show reliable pain intensity for the anterior teeth and premolars, whereas pain intensity during the chewing strip test had a higher correlation with pain at rest.

Discussion

In this study, the effect of different types of stimulation on postoperative pain intensity levels in teeth treated with single-visit nonsurgical root canal treatment was evaluated. There was no significant difference between the pain intensity levels after the bite test and pain during function, whereas the pain intensity levels were significantly lower in the resting position than during the function or tests. Based on these findings, the null hypothesis was partially rejected.

Previous studies comparing postoperative pain intensity between different variables during root canal treatment have shown contradictory results.[7–9,15,16] The contradictions were attributed to different study setups, varying pain rating scales, and differences in study groups.[17] However, the type of stimulation that induces postoperative pain during data collection remains elusive and has not been included in a recent study that focuses on an extensive analysis of postoperative pain.[17] Therefore, it can be speculated that different stimulation types during data collection may further increase the subjectivity of the collected data on an already subjective phenomenon, postoperative pain. Although an objective test with precision and validation is required for diagnostic purposes,[14] a repeatable test to mimic the postoperative pain experience would be sufficient for its assessment.

Percussion and bite tests, along with mechanical sensory testing, have been used by dentists for both diagnostic and

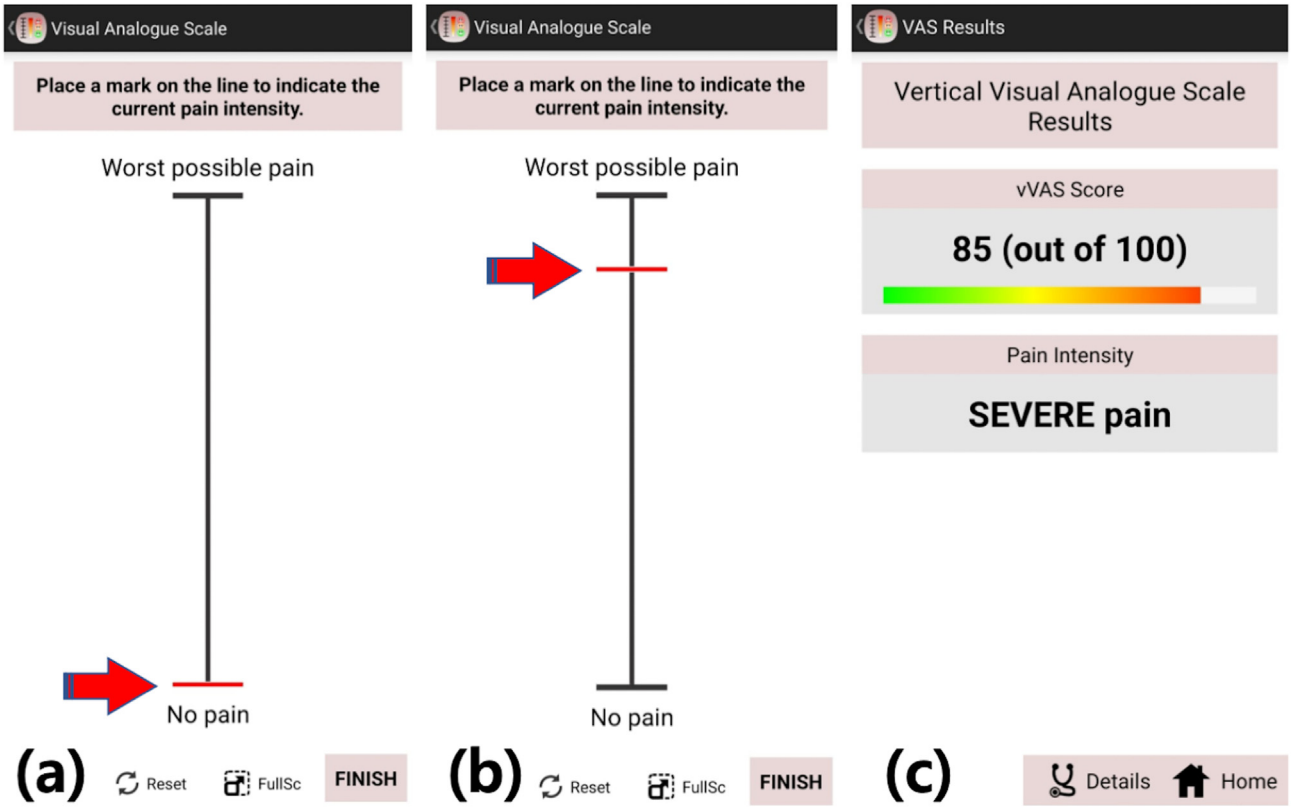

Figure 1 The vertical visual analogue scale (vVAS) and the vVAS scores of pain intensity.

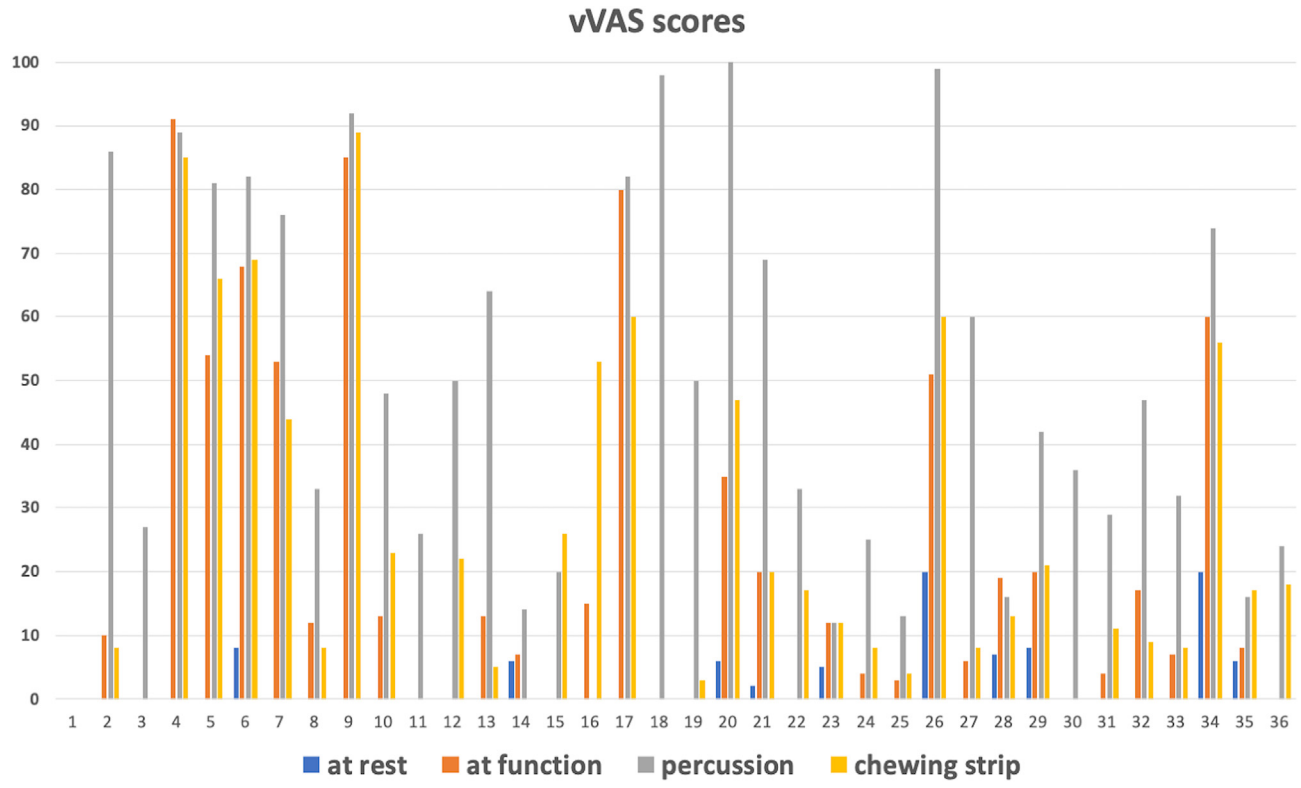

Figure 2 The data of pain intensity scores of all patients at rest and during function as well as from clinical tests of percussion and chewing strip.

Table 1 Case distribution and Pearson correlations between the vVAS scores by different test methods.

	Pain at function and on percussion	Pain at function and on chewing strip	Pain on percussion and on chewing strip
Sex			
Male (n = 19)	0.586**	0.892**	0.449*
Female (n = 17)	0.760**	0.946**	0 .778**
Arch			
Maxilla (n = 17)	0.771**	0.921**	0.682**
Mandible (n = 19)	0.370	0.751**	0.243
Tooth type			
Anterior (n = 3)	0.694	0.888	0.947
Premolar (n = 9)	0.538	0.830**	0.163
Molar (n = 24)	0.697**	0.962**	0.718**
Total (n = 36)	0.667**	0.916**	0.585*

*: $P < 0.05$, **: $P < 0.01$ vVAS: Vertical visual analogue scale

postoperative assessments. Although both tests have unknown levels of specificity and sensitivity and are not quantitative or imprecise, they are easily applicable and confirmatory in nature, according to various studies.[14,18] The response to mechanical sensory testing was suspected to be due to mechanical allodynia originating from hypersensitive neural endings in teeth with no apical pathology.[19] Although this may create a plausible approach for the use of these testing techniques for diagnostic purposes, such data would have no impact on the recognition and evaluation of postoperative pain, which focuses solely on the intensity of pain rather than its relevance to periodontal disease. Therefore, the focus should remain on applicable and reproducible testing techniques that can truly mimic patients' pain experiences while neutralizing the influence of avoidance and escape behavior during postoperative pain assessments. However, the main disadvantage of the percussion test is that the vertical or lateral forces applied by each dentist differ substantially, creating heterogeneity in the stimuli. Differences in bite forces among age, sex, craniofacial deformities, and TMJ disorders further complicate and diminish the objectivity of this test.[20]

The highest results observed during percussion may result from mechanical allodynia, a symptom of central sensitization which may have no correlation with periapical status.[21] Moreover, painful percussion results are associated with increased overall pain, further complicating postoperative pain results.[22] Such circumstances would render percussion tests unsatisfactory for postoperative pain studies to mimic patients' pain experiences.

Chewing strips were used to mimic postoperative pain intensity in function because of the ambiguity of long-distance pain assessments. In addition, patients may have refrained from properly placing the relevant tooth in function for reasons previously described.[12] Therefore, strips were used to mimic chewing habits and forces particular to each patient while avoiding the disadvantages of the test at home.

Although the chewing strip test showed slightly increased pain intensity results compared to pain results while the tooth was in function, there was no significant difference between the groups, indicating the interchangeability of both tests. These results suggest that distance assessment of postoperative pain is feasible under the implicit utilization of the "pain in function" test methodology without the risk of avoidance.

According to the results of this study, chewing tests using strip bands as a pain assessment method after nonsurgical root canal treatment can mimic patients' actual postoperative pain experience, whereas the percussion test fails to provide the accuracy of the experience.

Declaration of competing interest

The authors have no conflict of interest relevant to this article.

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References

1. Williams ACC, Craig KD. Updating the definition of pain. *Pain* 2016;157:2420—3.
2. Glennon JP, Ng YL, Setchell DJ, Gulabivala K. Prevalence of and factors affecting postpreparation pain in patients undergoing two-visit root canal treatment. *Int Endod J* 2004;37:29—37.
3. Siqueira Jr JF, Rôças IN, Favieri A, et al. Incidence of postoperative pain after intracanal procedures based on an antimicrobial strategy. *J Endod* 2002;28:457—60.
4. Eyuboglu TF, Kim HC. When to install the endodontic post? First visit with root canal filling versus a separate second visit for post-restoration: a randomized controlled trial. *J Oral Rehabil* 2020;47:1247—53.
5. Choi DM, Kim JW, Park SH, Cho KM, Kwak SW, Kim HC. Vibrations generated by several nickel-titanium endodontic file systems during canal shaping in an ex vivo model. *J Endod* 2017;43:1197—200.
6. Erdem Hepsenoglu Y, Eyuboglu TF, Özcan M. Postoperative pain intensity after single- versus two-visit nonsurgical endodontic retreatment: a randomized clinical trial. *J Endod* 2018;44:1339—46.
7. Eyuboglu TF, Özcan M. Postoperative pain intensity associated with the use of different nickel-titanium shaping systems

during single-appointment endodontic retreatment: a randomized clinical trial. *Quintessence Int* 2019;50:624—34.
8. Comparin D, Moreira EJL, Souza EM, De-Deus G, Arias A, Silva EJNL. Postoperative pain after endodontic retreatment using rotary or reciprocating instruments: a randomized clinical trial. *J Endod* 2017;43:1084—8.
9. Mostafa Mehaa Mostafa, El-Shrief YAI, Anous WIO, et al. Postoperative pain following endodontic irrigation using 1.3% versus 5.25% sodium hypochlorite in mandibular molars with necrotic pulps: a randomized double-blind clinical trial. *Int Endod J* 2020;53:154—66.
10. Graunaite I, Skucaite N, Lodiene G, Agentiene I, Machiulskiene V. Effect of resin-based and bioceramic root canal sealers on postoperative pain: a split-mouth randomized controlled trial. *J Endod* 2018;44:689—93.
11. Nair PN. On the causes of persistent apical periodontitis: a review. *Int Endod J* 2006;39:249—81.
12. Karos K, Meulders A, Gatzounis R, Seelen HAM, Geers RPG, Vlaeyen JWS. Fear of pain changes movement: motor behaviour following the acquisition of pain-related fear. *Eur J Pain* 2017;21:1432—42.
13. Meulders A, Vlaeyen JW. Mere intention to perform painful movements elicits fear of movement-related pain: an experimental study on fear acquisition beyond actual movements. *J Pain* 2013;14:412—23.
14. Khan AA, McCreary B, Owatz CB, et al. The development of a diagnostic instrument for the measurement of mechanical allodynia. *J Endod* 2007;33:663—6.
15. Walters SJ. Sample size and power estimation for studies with health related quality of life outcomes: a comparison of four methods using the SF-36. *Health Qual Life Outcome* 2004;2:26.
16. Su Y, Wang C, Ye L. Healing rate and post-obturation pain of single- versus multiple-visit endodontic treatment for infected root canals: a systematic review. *J Endod* 2011;37:125—32.
17. Sathorn C, Parashos P, Messer H. The prevalence of postoperative pain and flare-up in single- and multiple-visit endodontic treatment: a systematic review. *Int Endod J* 2008;41:91—9.
18. Klausen B, Helbo M, Dabelsteen E. A differential diagnostic approach to the symptomatology of acute dental pain. *Oral Surg Oral Med Oral Pathol* 1985;59:297—301.
19. Kayaoglu G, Ekici M, Altunkaynak B. Mechanical allodynia in healthy teeth adjacent and contralateral to endodontically diseased teeth: a clinical study. *J Endod* 2020;46:611—8.
20. Takaki P, Vieira M, Bommarito S. Maximum bite force analysis in different age groups. *Int Arch Otorhinolaryngol* 2014;18:272—6.
21. Latremoliere A, Woolf CJ. Central sensitization: a generator of pain hypersensitivity by central neural plasticity. *J Pain* 2009;10:895—926.
22. Erdogan O, Malek M, Janal MN, Gibbs JL. Sensory testing associates with pain quality descriptors during acute dental pain. *Eur J Pain* 2019;23:1701—11.