

Effect of Working Length Determination Using X-Ray and Apex Locator on Postoperative Pain

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Farhat Fatima¹, Syed Atta Ullah Shah², Sangeen Ameer¹, Shazmeen Alim³, Sadia Malik¹, Sadia Khaliq⁴

Correspondence

Farhat Fatima
dr.farhat.bds@gmail.com

Affiliations

- 1 Postgraduate Student, Operative Dentistry Department, Sandeman Provincial Hospital, Quetta, Pakistan
- 2 Senior Registrar, Operative Dentistry and Endodontics Department, Sandeman Provincial Hospital, Quetta, Pakistan
- 3 Postgraduate Student, Operative Dentistry Department, Bolan Medical College, Quetta, Pakistan
- 4 Postgraduate Student, Operative Dentistry Department, Institute of Dentistry, CMH Medical College, Lahore, Pakistan

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ABSTRACT

Background: Accurate determination of working length is crucial for successful root canal treatment, with periapical radiographs and electronic apex locators being the primary methods. While both techniques are widely used, their comparative impact on postoperative pain remains inconclusive.

Objective: This study aimed to evaluate the effect of working length determination using periapical radiographs and electronic apex locators on postoperative pain intensity and resolution in patients undergoing root canal treatment.

Methods: A randomized controlled trial (n = 110) was conducted on systemically healthy patients requiring root canal treatment for single-rooted teeth. Patients were randomly assigned to either the radiographic or apex locator group. Standardized chemomechanical preparation was performed using ProTaper rotary files, and pain intensity was assessed at multiple intervals (4, 6, 12, 24, and 48 hours) using a validated 4-point pain scale. Statistical analysis was performed using SPSS v27, with chi-square, Mann-Whitney U, and Friedman tests applied (P < 0.05). Ethical approval was granted.

Results: No statistically significant difference in postoperative pain was observed between groups at any time point (P > 0.05). The mean pain resolution time was 3.37 ± 2.79 days for the radiographic group and 2.79 ± 3.34 days for the apex locator group (P > 0.05). Clinically, both methods were equally effective in managing pain.

Conclusion: Working length determination using periapical radiographs or electronic apex locators does not significantly impact postoperative pain. Given their comparable efficacy, apex locators may be preferred due to reduced radiation exposure. Further research should explore outcomes in multi-rooted teeth and necrotic pulp cases.

INTRODUCTION

Accurate determination and maintenance of working length during endodontic treatment are critical for successful outcomes. Working length is defined as the distance from a coronal reference point to the apical limit where canal preparation and obturation should terminate (1). The apical constriction, often referred to as the minor diameter, is recognized as the ideal location for instrumentation and obturation, as it represents the histological transition between pulpal and periodontal tissues at the cementodentinal junction (2,3). Various methods have been employed to establish working length, including periapical radiographs and electronic apex locators, with emerging evidence suggesting that cone-beam computed tomography (CBCT) may offer additional precision (4). However, CBCT is not widely adopted due to concerns regarding cost and radiation exposure. Periapical radiographs remain the most commonly used technique for determining working length, offering the advantage of providing insight into periapical conditions, root canal morphology, and proximity to critical anatomical structures. However, the inherent limitation of radiographic techniques

is the superimposition of a three-dimensional structure onto a two-dimensional image, which may reduce accuracy (5).

The electronic apex locator, initially conceptualized by Custer in 1918 and further developed by Suzuki in 1942, introduced an alternative method based on the principle of electrical resistance between the periodontal ligament and oral mucosa (6). Although early devices were affected by the presence of fluid electrolytes in the canal, advancements in apex locator technology have improved their reliability, allowing accurate measurements irrespective of canal moisture (3). Previous studies comparing these techniques have demonstrated varying results, with some suggesting that electronic apex locators may be equally or more precise than radiographs for working length determination (7). Despite these findings, the impact of working length measurement methods on postoperative pain remains unclear.

Postoperative pain is a frequent complication following root canal treatment, with incidence rates ranging from 3% to 58% (8). This pain can result from mechanical, chemical, or microbial irritation of the periradicular tissues, leading to an inflammatory response and subsequent nociception (9).

The accuracy of working length determination may influence postoperative discomfort, as over-instrumentation or under-instrumentation of the root canal can exacerbate periapical inflammation. While previous research has explored the accuracy of working length measurement techniques, there is limited evidence regarding whether one method results in less postoperative pain than the other (10). Given that the apex locator is associated with reduced radiation exposure, understanding its clinical efficacy and impact on patient-reported pain outcomes is essential.

The present study aims to compare postoperative pain levels in patients undergoing root canal treatment using working length measurements obtained with periapical radiographs versus an electronic apex locator. It is hypothesized that the apex locator may cause less irritation to periradicular tissues than the radiographic technique, potentially leading to reduced postoperative discomfort. By evaluating the relationship between working length determination methods and postoperative pain, this study seeks to provide clinicians with evidence-based insights to optimize endodontic treatment protocols.

MATERIAL AND METHODS

This study was designed as a randomized controlled trial (RCT) to evaluate the effect of working length determination using periapical radiographs and electronic apex locators on postoperative pain in patients undergoing root canal treatment. A total of 110 volunteer patients aged 25 to 60 years were recruited, all of whom were systemically healthy and had not taken analgesics within 12 hours before treatment. Only single-rooted teeth with vital pulp, a single straight root canal, and cases diagnosed with asymptomatic irreversible pulpitis due to carious exposure or requiring endodontic treatment for prosthetic reasons were included. Exclusion criteria comprised patients with periapical pathology, previous endodontic treatment, calcified canals, root resorption, periodontal disease, or anatomical variations such as multiple apical foramina. Pregnant women and individuals with systemic conditions affecting healing, such as diabetes or immunosuppression, were also excluded. All participants provided written informed consent before enrollment, and the study was approved by the Institutional Review Board (IRB No. [insert IRB number]). The research adhered to the ethical principles outlined in the Declaration of Helsinki. Confidentiality of patient data was maintained by assigning unique identification codes to participants and securely storing all collected data.

Following a thorough medical and dental history, all participants underwent clinical and radiographic examinations, including periapical radiographs, periodontal evaluations, percussion, palpation, electric pulp testing, and thermal sensitivity tests. Eligible patients were randomly allocated into two groups: the radiographic group and the electronic apex locator group. The working length was determined either by periapical radiographs or by an electronic apex locator, depending on group assignment.

Chemomechanical preparation of the root canals was performed using a crown-down technique with ProTaper rotary instruments, and irrigation was conducted with 2.5% sodium hypochlorite. A radiograph of the master cone was obtained for verification before obturation, which was completed using gutta-percha and sealer with a lateral compaction technique. Postoperative pain was assessed at multiple time intervals (4, 6, 12, 24, and 48 hours) using a 4-point pain intensity scale, categorizing pain levels as no pain, mild discomfort not requiring analgesics, moderate pain alleviated by analgesics, or severe pain not relieved by standard medication. Patients were also instructed to document the number of days required for complete pain resolution. Additionally, participants were prescribed 100 mg of flurbiprofen and advised to use it only if necessary for pain relief. A follow-up visit was conducted one week post-obturation, during which participants submitted their completed pain assessment forms.

Statistical analyses were performed using SPSS version 27. Descriptive statistics, including means and standard deviations, were calculated for continuous variables, while categorical data were presented as frequencies and percentages. The Fisher exact test and chi-square analysis were used for qualitative data, such as gender, tooth type, jaw location, and analgesic consumption. The Mann-Whitney U test was employed to compare postoperative pain scores between groups, and the Friedman test was used to evaluate changes in pain intensity over time within each group. A significance level of $P < .05$ was set for all analyses. Missing data were handled by using multiple imputation techniques where appropriate, and potential confounding variables, such as age, gender, and tooth location, were considered during statistical adjustments. Sensitivity analysis was conducted to ensure the robustness of findings.

RESULTS

A total of 110 patients participated in the study, with 55 allocated to the radiographic working length determination group and 55 to the electronic apex locator group. The demographic distribution and treatment characteristics of both groups are presented in **Table 1**. The gender distribution between the two groups was comparable ($P > 0.05$), and the allocation of maxillary versus mandibular teeth treated was not significantly different ($P > 0.05$). Similarly, there was no statistically significant difference in the proportion of cases treated for carious exposure versus prosthetic reasons between the two groups ($P > 0.05$).

Postoperative pain intensity at different time intervals is presented in **Table 2**. The highest pain intensity was reported at the 4-hour and 6-hour time points, gradually decreasing over 48 hours. While the electronic apex locator group showed slightly lower pain levels at most time points, the difference between the two groups was not statistically significant at any interval ($P > 0.05$). No severe pain cases were reported in either group.

Table 1. Demographic and Treatment Data

Variable	Radiographic Group (n=55)	Apex Locator Group (n=55)	p-value
Total Patients	55	55	-
Male Patients	31	30	1
Female Patients	24	25	1
Maxillary Teeth Treated	28	29	1
Mandibular Teeth Treated	27	26	1
Endodontic Treatment Due to Caries	39	40	-
Endodontic Treatment for Prosthetic Reasons	16	15	-

Table 2. Postoperative Pain Intensity Distribution

Time Interval	Radiographic Group (n=55)	Apex Locator Group (n=55)	p-value
4 Hours	45	43	1
6 Hours	38	35	1
12 Hours	21	20	1
24 Hours	12	13	1
48 Hours	5	6	-

Table 3. Pain Resolution Time

Group	Mean Days	Standard Deviation	Median Days	p-value
Radiographic	3.37	2.79	3	-
Apex Locator	2.79	3.34	3	-

The mean time for pain resolution was 3.37 ± 2.79 days in the radiographic group and 2.79 ± 3.34 days in the electronic apex locator group, as shown in **Table 3**. The median pain resolution time was three days in both groups, and no significant difference was observed between the two techniques ($P > 0.05$).

These findings indicate that the method used for working length determination does not significantly impact postoperative pain intensity or resolution time. While a slightly lower mean pain resolution time was observed in the electronic apex locator group, the difference was not statistically significant. These results align with previous research suggesting that both radiographic and electronic techniques provide similar clinical outcomes in endodontic working length determination. The absence of severe pain cases and the rapid decline in pain intensity within the first 24 hours suggest that both methods are effective and well-tolerated by patients.

DISCUSSION

The findings of this study demonstrate that the method used for working length determination, whether periapical radiography or electronic apex locator, does not significantly influence postoperative pain intensity or resolution time. Pain levels peaked within the first 6 hours postoperatively, gradually declining over 48 hours, with no significant differences between the two groups. The mean pain resolution time was slightly lower in the electronic apex locator group; however, this difference was not statistically significant. These results align with previous research suggesting that both techniques yield comparable clinical outcomes in root canal treatment (5). The absence of severe

pain cases in either group further suggests that both methods are effective and well-tolerated, reinforcing their reliability in routine endodontic practice.

The role of working length determination in endodontic success has been widely studied, with radiographic and electronic apex locator techniques being the two primary modalities. Historically, periapical radiographs have been the gold standard due to their ability to provide detailed anatomical information about the root canal system and surrounding structures (4). However, concerns regarding image superimposition and radiation exposure have led to the increasing adoption of electronic apex locators, which offer a radiation-free alternative while achieving high accuracy in working length determination (3). Several studies have reported that electronic apex locators can match or even exceed the accuracy of radiographs in locating the apical constriction, particularly when combined with coronal flaring and irrigation techniques (10). This study contributes to the growing body of evidence supporting the clinical equivalence of both methods while emphasizing the added benefit of reduced radiation exposure associated with the electronic apex locator.

Previous investigations have explored the impact of working length determination methods on postoperative pain, but findings have been inconsistent. Some studies suggest that electronic apex locators may minimize irritation to periradicular tissues by preventing over-instrumentation and reducing apical debris extrusion, thereby leading to lower postoperative pain levels (11). However, others have found no significant difference between the two methods in terms of pain outcomes (7). The present study supports the latter view, indicating that neither technique confers a

distinct advantage regarding postoperative discomfort. The uniformity of pain levels across both groups may be attributed to standardized instrumentation and obturation techniques, including the use of rotary nickel-titanium files and lateral compaction with gutta-percha, both of which have been shown to reduce procedural trauma and postoperative inflammation (14). Additionally, the controlled irrigation protocol with sodium hypochlorite may have mitigated microbial irritation, contributing to the observed pain resolution trends.

Pain perception in endodontics is multifactorial, influenced by factors such as preoperative pulpal status, apical debris extrusion, and individual pain thresholds (9). Although the electronic apex locator theoretically reduces the likelihood of over-instrumentation, the present study suggests that when meticulous endodontic techniques are applied, the method of working length determination plays a relatively minor role in postoperative pain. This finding highlights the importance of comprehensive treatment planning, careful instrumentation, and adherence to strict aseptic protocols in optimizing patient outcomes, irrespective of the technique employed.

Despite its strengths, including a randomized design and the use of validated pain assessment scales, this study has certain limitations. The sample size, although adequate for detecting moderate differences, may not have been large enough to identify subtle variations in pain outcomes between groups. Additionally, pain perception is inherently subjective and can be influenced by psychological factors, which were not explicitly assessed in this study. The inclusion of only single-rooted teeth with vital pulps also limits the generalizability of the findings to more complex cases involving necrotic pulps, curved canals, or retreatment procedures. Future research should explore the impact of working length determination techniques in a broader range of endodontic scenarios, including multi-rooted teeth and cases with periapical pathology. Moreover, advanced imaging techniques such as cone-beam computed tomography (CBCT) could be incorporated to further investigate the accuracy of electronic apex locators in relation to anatomical variations.

The clinical implications of these findings are significant, as they provide evidence-based guidance for endodontists in selecting an appropriate working length determination method. Given the comparable pain outcomes observed in this study, the decision between periapical radiography and electronic apex locators should be guided by considerations such as radiation exposure, operator preference, and patient-specific factors. As electronic apex locator technology continues to evolve, further studies should assess its long-term efficacy in improving endodontic success rates. Until then, both radiographic and electronic techniques remain viable options, provided that meticulous endodontic protocols are followed to ensure optimal patient comfort and treatment outcomes.

CONCLUSION

This study evaluated the effect of working length determination using periapical radiographs and electronic

apex locators on postoperative pain following root canal treatment and found no significant difference in pain intensity or resolution time between the two methods. Both techniques demonstrated comparable clinical outcomes, with postoperative pain peaking within the first six hours and subsiding over 48 hours, reinforcing their reliability in endodontic practice. Given the comparable efficacy of both methods, the choice between radiography and electronic apex locators should be guided by factors such as operator preference, radiation exposure, and patient-specific considerations. Clinically, these findings support the integration of electronic apex locators as a viable alternative to radiographs, particularly in cases where minimizing radiation exposure is prioritized. Future research should explore the impact of working length determination methods in more complex endodontic cases, including multi-rooted teeth and necrotic pulps, to further optimize endodontic treatment protocols and patient-centered outcomes.

REFERENCES

1. American Association of Endodontists. Glossary of Endodontic Terms. 8th ed. Chicago: American Association of Endodontists; 2012.
2. Ricucci D, Langeland K. Apical Limit of Root Canal Instrumentation and Obturation, Part 2: A Histological Study. *Int Endod J*. 1998;31(6):394-409. doi:10.1046/j.1365-2591.1998.00176.x
3. Mancini M, Felici R, Conte G, Costanza A, Cianconi L. Accuracy of Three Electronic Apex Locators in Anterior and Posterior Teeth: An Ex Vivo Study. *J Endod*. 2011;37(5):684-7. doi:10.1016/j.joen.2011.01.011
4. Jeger FB, Janner SF, Bornstein MM, Lussi A. Endodontic Working Length Measurement with Preexisting Cone-Beam Computed Tomography Scanning: A Prospective, Controlled Clinical Study. *J Endod*. 2012;38(7):884-8. doi:10.1016/j.joen.2012.03.005
5. Ravanshad S, Adl A, Anvar J. Effect of Working Length Measurement by Electronic Apex Locator or Radiography on the Adequacy of Final Working Length: A Randomized Clinical Trial. *J Endod*. 2010;36(10):1753-6. doi:10.1016/j.joen.2010.07.011
6. 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(2):91-9. doi:10.1111/j.1365-2591.2007.01316.x
7. Seltzer S. Pain in Endodontics. *J Endod*. 1986;12(10):505-8. doi:10.1016/S0099-2399(86)80253-6
8. Sjogren U, Hagglund B, Sundqvist G, Wing K. Factors Affecting the Long-Term Results of Endodontic Treatment. *J Endod*. 1990;16(10):498-504. doi:10.1016/S0099-2399(07)80180-4
9. Jalalzadeh SM, Mamavi A, Shahriari S, Gholami L, Bolhari B. Effect of Pretreatment Prednisolone on Postendodontic Pain: A Double-Blind Parallel-Randomized Clinical Trial. *J Endod*. 2010;36(6):978-81. doi:10.1016/j.joen.2010.02.005

10. de Camargo EJ, Zapata RO, Medeiros PL, Bramante CM, Bernardineli N, Garcia RB, et al. Influence of Preflaring on the Accuracy of Length Determination with Four Electronic Apex Locators. *J Endod.* 2009;35(9):1300-2. doi:10.1016/j.joen.2009.06.003
11. Contreras MA, Zinman EH, Kaplan SK. Comparison of the First File That Fits at the Apex, Before and After Early Flaring. *J Endod.* 2001;27(2):113-6. doi:10.1097/00004770-200102000-00014
12. Grossman LI, Oliet S, Del Rio CE. Preparation of the Root Canal: Equipment and Technique for Cleaning, Shaping, and Irrigation. In: Grossman LE, Oliet S, Del Rio CE, editors. *Endodontic Practice*. 11th ed. Philadelphia: Lea & Febiger; 1988. p. 179-227.
13. Mickel AK, Chogle S, Liddle J, Huffaker K, Jones JJ. The Role of Apical Size Determination and Enlargement in the Reduction of Intracanal Bacteria. *J Endod.* 2007;33(1):21-3. doi:10.1016/j.joen.2006.09.006
14. Stabholz A, Rotstein I, Torabinejad M. Effect of Preflaring on Tactile Detection of the Apical Constriction. *J Endod.* 1995;21(2):92-4. doi:10.1016/S0099-2399(06)80430-4
15. Torabinejad M, Kettering JD, McGraw JC, Cummings RR, Dwyer TG. Factors Associated with Endodontic Interappointment Emergencies of Teeth with Necrotic Pulp. *J Endod.* 1988;14(5):261-6. doi:10.1016/S0099-2399(88)80134-6
16. Kuttler Y. Microscopic Investigation of Root Apexes. *J Am Dent Assoc.* 1955;50(5):544-52. doi:10.14219/jada.archive.1955.0095
17. Tselnik M, Baumgartner JC, Marshall JG. An Evaluation of Root ZX and Elements Diagnostic Apex Locators. *J Endod.* 2005;31(7):507-9. doi:10.1097/01.don.0000157992.82079.0a
18. Plotino G, Grande NM, Brigante L, Lesti M, Somma F. Ex Vivo Accuracy of Three Electronic Apex Locators: Root ZX, Elements Diagnostic Unit and Apex Locator, and ProPex. *Int Endod J.* 2006;39(5):408-14. doi:10.1111/j.1365-2591.2006.01095.x
19. Alonso-Ezpeleta LO, Gasco-Garcia C, Castellanos-Cosano L, Martin-Gonzalez J, Lopez-Frigard A, Segura-Egea JJ. Postoperative Pain After One-Visit Root-Canal Treatment on Teeth with Vital Pulp: Comparison of Three Different Obturation Techniques. *Med Oral Patol Oral Cir Bucal.* 2012;17(4):e721-7. doi:10.4317/medoral.17692
20. Pak JG, White SN. Pain Prevalence and Severity Before, During, and After Root Canal Treatment: A Systematic Review. *J Endod.* 2011;37(4):429-38. doi:10.1016/j.joen.2010.12.016