Research Article

Comparative Evaluation of Preflaring Versus Non-Preflaring on the Accuracy of Electronic Apex Locators-a Systematic Review.

Dr. Ankita Nagrani*1, Dr. Anita Sanap1, Dr. Sourabh Mategaonkar2, Dr. Shruti Khade1, Dr. Karishma Krishnakumar1

1. Conservative Dentistry and Endodontics, Dr. D. Y Patil Dental College, D.Y Patil Vidyapeeth, Pimpri, Pune.

2. Daswani dental college and research center Kota

*__Corresponding Author__: Dr. Ankita Nagrani, M.D.S, Conservative Dentistry and Endodontics, Dr. D.Y Patil Dental College, D.Y Patil Vidyapeeth, Pimpri, Pune

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Abstract

INTRODUCTION: *Success of endodontic treatment relies on the accurate determination of the working length and adequate enlargement of the root canal. Coronal preparing offers substantial advantages for more accurate apical sizing, with clinical implications regarding the adequacy of apical enlargement and debridement. Cervical preparation plays a vital role in reducing the discrepancy between initial apical file diameter and apical canal diameter.*

Objective: *The present review aims to assess the literature regarding preparing versus non-flaring of the root canal on the accuracy of apex locators in vitro experimental study.*

MATERIALS AND METHODS: *MEDLINE, Google Scholar, and major journals were searched for studies from January 2007 to December 2017 to identify appropriate articles. A comprehensive search was designed, and the articles were independently screened for eligibility by two reviewers. In vitro studies done on human extracted teeth comparing preparing versus non-flaring on the accuracy of the apex, locators were considered.*

Results: *A total of 282 articles were searched out of which 19 articles were selected after reading the title and abstract. As a second step, full-text papers were obtained. Finally, a total of 9 articles were included after reading and evaluating full-text papers, out of which 1 article was excluded as it did not satisfy the inclusion criteria and 8 articles were selected for final synthesis.*

CONCLUSION: *Cervical preparation in root canals significantly increases the accuracy of apex locators.*

Keywords: *Cervical Preflaring, AccuracyResults: A total of 282 articles were searched out of which 19 articles were selected after reading the title and abstract. As a second step, full-text papers were obtained. Finally, a total of 9 articles were included after reading and evaluating full-text papers, out of which 1 article was excluded as it did not satisfy the inclusion criteria and 8 articles were selected for final synthesis.*

Introduction

The most important step in endodontic treatment is the correct determination of working length as it prevents over-instrumentation and potential harm to the periapical region. **(**1**)** The apical constriction also referred to as the minor constriction diameter is an important anatomic landmark that is located at 0.5-1 mm from the major foramen and should be the point where instrumentation and obturation must terminate. **(**2**)** Radiographs and electronic apex locators are the tools available to determine the working length. With the evolution of Electronic Apex locators, determining working length has become more accurate and predictable. **(**2**)** Apex locators, currently, represent an important tool for the endodontist, because it enables with more practicality and precision the determination of the root canal's working length, reducing the doubts regarding the exact location of the foramina ending. **(**3**)**

There are so many factors like the irregularity of walls /curvature of the root which affect initial working width determination. To minimize the influence of these affecting factors early coronal flaring is recommended. **(**4**)** Preflaring of the root canals is one of the important factors that may influence the accuracy of Electronic Apex Locators along with other factors like the size of the measuring file. **(**4**)** Flaring of the coronal third of root canals has been recommended by recent techniques. It has been suggested that coronal flaring contributes to successful performance in subsequent treatment processes, namely preparation, irrigation, and obturation.

Coronal flaring has also been shown to help determine the first file to bind at the WL and to establish the correct final diameter required for complete apical enlargement. **(**5,6**)** Files that are placed in pre-flared canals can easily reach the apical constriction and thus prevent a lower incidence of overextension than those placed in unflared canals. **(**8**)** The increase in file size after preparing can be explained by realizing that, within a canal, irregularities and curvature produced contacts with the file and interfere with its progression toward the apex. Early flaring, regardless of the method used, removes these contacts, opens the space, and reduces file contact; thus, a file progresses more easily towards the apex after flaring.

This was previously suggested by Leeb. **(**9**)** Moreover, cervical preparation enhances the range of action of irrigating solution by enabling the advancement of the irrigation needle and penetration of the ultrasonic tip during passive ultrasonic irrigation (PUI). **(**10**)** Also, opening the coronal part of the canal early in the preparation may increase instrumentation efficiency, reduce canal instrumentation time and operator fatigue. **(**11**)** Lack of patency and accumulation of debris in canals have been reported as impediments for the establishment of accurate working lengths. Stabholtz et al. analyzed the effect that preparing of canals might have on the tactile sensitivity of operators who attempted to manually locate the apical constriction, and the preparing of canals to significantly enhance the tactile sensitivity of the investigators.

They observed that the greatest binding of files occurred in the coronal third of canals and that by enlarging the canal orifices and eliminating cervical interferences, files could be passed more easily to the apices of teeth. **(**12**)**. Ibarrola et al. conducted a study to assess whether canal preparing would improve the efficacy of EALs and found statistical differences between the means obtained in the two groups, with more consistent results associated with the pre-flared group. **(**13**)** However, to the best of our knowledge, there is no systematic review comparing the effectiveness of preparing on the accuracy of electronic apex locators. So this systematic review aims to compare the effect of preparing versus non-flaring on the accuracy of electronic apex locators.

Focused Question

What is the effect of preflaring versus non-flaring on the accuracy of apex locators?

Objective

To assess the literature regarding preparing versus non-flaring of the root canal on the accuracy of apex locators in vitro experimental study.

METHODS

Inclusion criteria

1) Articles in English or those having detailed summary in English

2) studies that were published in between 1st January 2007 to 31st December 2017

3) in vitro studies done on human extracted teeth, studies comparing preflaring versus non flaring on the accuracy of apex locators.

Exclusion criteria

1)Case reports, abstracts, letters to editors, editorials and in vivo studies.

2)Studies not having a separate group for unflared teeth were also excluded.

The PICOS guidelines that were selected are

P-(PARTICIPANTS): Freshly extracted human teeth.

I-(INTERVENTION): Preflaring of root canals.

C-(COMPARISON): Unflared canals.

O-(OUTCOME): Accurate working length.

Information Sources

Two Internet sources of evidence were used in the search of appropriate papers satisfying the study purpose: the National Library of Medicine (MEDLINE PubMed), Google Scholar, EBSCO Host, and SCOPUS and manual search using DPU college library resources. All cross-reference lists of the selected studies were screened for additional papers that could meet the eligibility criteria of the study. The databases were searched up to and including December 2017 using the search strategy.

Search

The following databases were searched on PubMed (the limits were all full-text articles in English dated from 1st January 2007 to December 31st, 2017), EBSCO HOST, SCOPUS, and Google Scholar. For the

electronic search strategy, the following terms were used as keywords in several combinations.

Study Selection Process

Preliminary screening consisted of a total of 281 articles out of which 18 articles were selected. The papers were screened independently by two reviewers. At first, the papers were screened by title and abstract. As a second step, full-text papers were obtained when they fulfilled the criteria of the study aim. Any disagreement between the two reviewers was resolved after additional discussion. For full-text screening, the following criteria were taken into consideration: In-vitro studies done on human extracted teeth in which comparison between preparing and non-flaring on the accuracy of electronic apex locators was assessed. Finally, a total of 8 articles were included out of which 8 articles were finally synthesized in this systematic review.

Data Collection Process

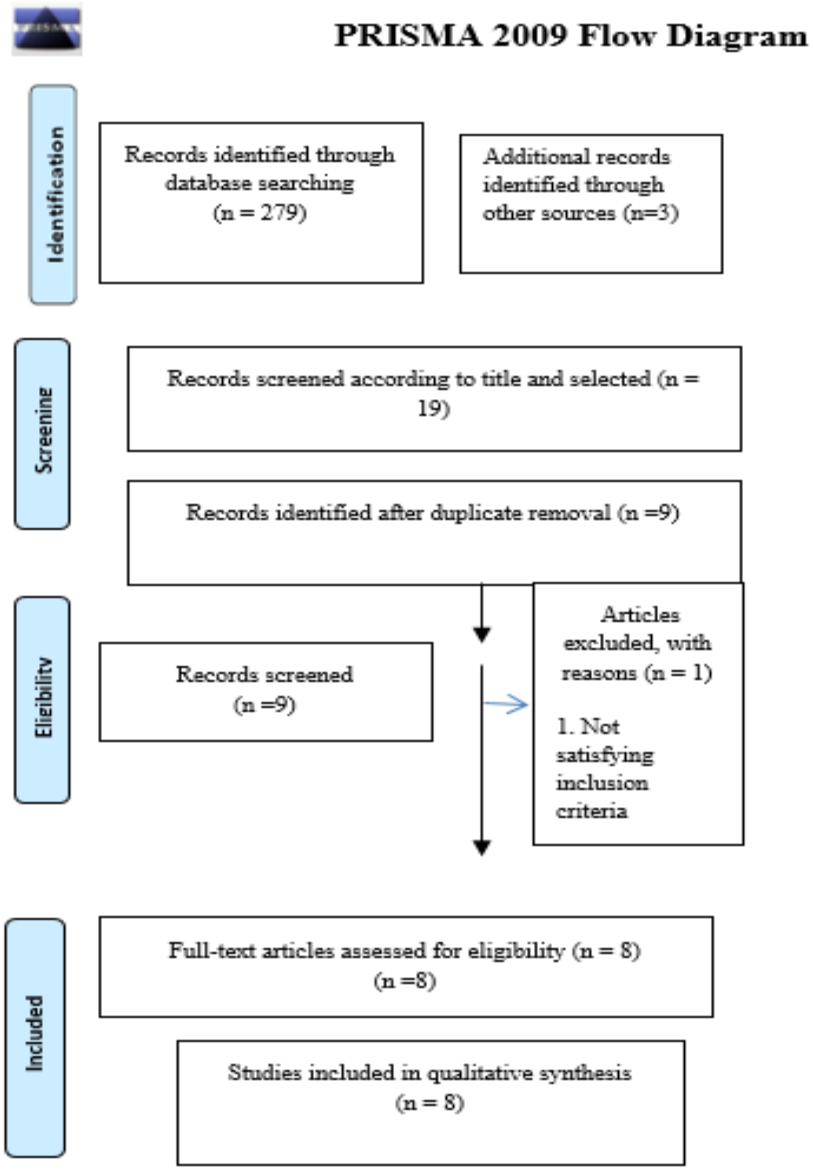
A standard pilot form in the excel sheet was initially used and then all those headings not applicable for review were removed. Data extraction was done for one article and this form was reviewed by an expert and finalized. This was followed by data extraction for all the articles.

Table-1: Detailed Search Strategy and Keywords

Sr no	SEARCH STRATEGY	NUMBER OF ARTICLES	NUMBER OF SELECTED ARTICLES	NUMBER OF ARTICLES AFTER DUPLICATE REMOVAL
1	Preflaring AND accuracy AND Electronic apex locators	3	2	2
2	Preflaring AND Electronic apex locators	5	2	0
3	Coronal flaring OR preflaring AND working length determination	28	3	1
4	Coronal flaring OR preflaring AND electronic apex locators	7	3	1
5	Coronal flaring OR preflaring AND working length determination OR electronic	237	4	1

Figure-1: Flowchart summarizing the article selection process

Study Selection



Results

The results of the search strategy are presented in table 1. Figure 1 represents a flow chart of the systematic review process. Total 282 articles were searched out of which 19 articles were selected after reading the title and abstract. As a second step, full-text papers were obtained. However, some studies

did not include a separate unflared group. Finally, a total of 9 articles were included out of which 1 article was excluded as it did not satisfy the inclusion criteria and 8 articles were selected for final synthesis. All included articles were summarized in table 2.

Discussion

Root canal treatment should be limited only to the root canal. The dentin-cementum junction is the terminal point of root canal preparation and obturation. The most common method used to measure the working length is radiography, but the level of precision depends on the recording technique. Several disadvantages of this technique include radiation exposure, a long work process, and it is less representative of the three dimensional tooth structure.

Therefore, an electronic root canal length measurement device (ERCLMD) was developed to overcome the deficiencies of radiographic techniques. Another advantage of this device is that it is applicable during pregnancy, however, its use should be carefully considered in patients with pacemakers. The ERCLMD, or so-called apex locator, works by electrical conductivity. The tissue surrounding the apex is larger than the inside of the root canal, both in dry and wet conditions, and is non-conductive.

Coronal preflaring provides many advantages during cleaning and shaping in root canal procedures. The study conducted by Stabholtz et al., showed that coronal preflaring increases the tactile sensitivity of the operator in determining the location of the apical constriction. It also showed that the largest resistance when inserting the file into the root canal is the first one-third of the coronal end of the canal. Coronal preflaring decreases file resistance, thus, it is easier to insert the file into the root canal toward the apex of the tooth.

Other advantages of performing root canal preparation with coronal preflaring include improved irrigation circulation within the root canal, reducing the risk of bacteria being pushed into the periapical tissue and decreasing the risk of debris and irrigation fluid extrusion during root canal preparation procedures, as well as reducing errors in determining the working length during root canal preparation. 4 Out of the 8 articles included in the study only 1 study concluded that cervical preflaring with Gates Glidden burs did not significantly influence the apical locator accuracy in determining the actual working length.

4 studies out of the 8 studies used Root ZX as their apex locator which is a third generation apex locator and they concluded Coronal pre-flaring improved the accuracy of electronic apex locators.

Studies conducted by Camargo E.J et al , Junior B.M et al ,BM Guimaraes, R Suryantoro and Fernanda Ullmann Lopez et al used S1 and SX Protapers for the coronal flaring and concluded that coronal preflaring significantly increased the accuracy of electronic apex locators.

Two of the studies used Gates-Glidden drills and the study by João Marcelo da Silva Teixeira et al concluded that cervical preflaring with Gates Glidden burs did not significantly influence the apical locator accuracy in determining the actual working length.

Morgental R.D et al (2011) 1 conducted a study to compare the accuracy of three electronic apex locators (Novapex, Mini Apex, and Propex II) and used LA Axxess burs for preparing and they concluded that the accuracy of electronic apex locators increased after coronal preparing.

LIMITATIONS

The limitation of this systematic review is that there is a lack of literature searched for systematic review and a lack in the literature searched other than electronic databases.

CONCLUSION

Root canal treatment should be limited only to the root canal. The dentin-cementum junction is the terminal point of root canal preparation and obturation. This systematic review presents the advantages of preparing for the accuracy of electronic apex locators. The coronal preparing procedure during endodontic treatment is important to remove cervical dentin interferences. It allows easier insertion of manual or rotary instruments into the apical portion of the root canals and avoids changes in the WL during the root canal preparation. Some studies evaluating the influence of the crown-down preparing of root canal through nickel-titanium rotary instruments verified that the readings did not seem to undergo the influence of the dentin layer reduction in the location of a point close to the apical constriction and resulted in more precise readings. However, the preparation performed by rotary files shows a more regular and uniform feature while the use of Gates Glidden burs may cause a greater flaring.

Table-2: Overview of Included Studies

Study ID	Technique for assessing accuracy
1 Camargo E.L et al	Actual working length measured with a 0.5 mm precision ruler. Electronic measurements determined before preflaring. After preflaring with S1 and SX rotary electronic working length determined.
2 Brito-Junior M et al	Actual working length determined.Electronic working length determined without preflaring. After preflaring with S1 and SX Protaper instruments, electronic measurements were again determined by a different examiner.
3 Morgental D. R et al	Actual working length determined by visual method until file tip observed at apical foramen measued by 0.5 mm precsision ruler.Electronic working length determined before preflaring. After preflaring with LA Axxess 20/0.6 bur electronic measurement again measured.
4 João Marcelo da Silva Teixeira et al	Twenty-five mesial roots of mandibular molars(50 roots) were used and had their crowns cut at the cemento-enamel junction. The actual measure of each root canal was performed and then the samples were embedded into a mixture of alginate, used as a conducting medium, where electronic measurements were taken with apex locator before and after preflaring of the canals with Gates-Glidden drills in descending order (#4, #3, #2). Measurements obtained by electronic method were then compared with the actual measurement of the root canal. The results were tabulated
5 Fernanda Ullmann Lopez et al	Thirty extracted human maxillary molars were radiographed in buccal-palatal direction. One stable reference point was marked on the cervical portion of each root to minimize measurement errorsR.oot canals were irrigated with 2.5% sodium hypochlorite. And accessed using a size 10 K file. Preflaring was performed with S1-SX-S1 with a size 10 K fle followed by irrigation with 1 ml of 2.5% sodium hypochlorite after each instrument change. Subsequently, roots were replaced in the alginate model, and new measurements were conducted. Preflaring was done by SX-S1-SX followed by recapitulation
6 Samadi Y et al	Actual root canal measurement using #10 or #15 K file which were placed into the root canal until the tip of the file exited from the apical foramen. This was examined under a 4x magnification. Actual working length was established by subtracting 0.5 mm from the actual length. Teeth were embedded in alginate and the primary electronic working length was established without preflaring. In the second phase preflaring was carried out for all the teeth with Gates glidden size 1-3. 10 teeth were used as control where as 30 teeth were obturated. The teeth were incubated at 37 degree celsius for 15 days.
7 R Suryantoro	Sixteen teeth with single root canals were cleared from the soft tissue and calculus with a scaler, rinsed under running water, then stored in a saline solution before treatment. The occlusal parts of the teeth were flattened to stabilize the stopper placement during the measurement process. The location of the apical foramen from the crown was visually measured by inserting a no. 08 file into the root canal until the file was visible in the apical foramen. The axial surface of the tooth was placed perpendicular to the line of view, then the file tip was positioned in contact with the apical foramen. After obtaining the location, the stopper was fixed and the file was removed from the root canal after which it was measured using a caliper. Before taking measurements using the apex locators, the prepared teeth were placed into tubes containing saline solution. Two types of apex locators were used to measure the location of the apical foramen from the crown. For each measurement a no. 08 file was placed into the root canal flooded with saline solution. The file was inserted until the number appearing on the screen showed 00 for 15 seconds, indicating that the file tip was located correctly in the apical foramen. Measurements were performed in triplicate until the stopper was in the right place. The file was fixed, then the distance between the stopper and file tip was measured using a caliper. After cavity access preparation and the straight path to the orifice was obtained, coronal preflaring was performed using an engine-driven Six Protaper file along two-thirds of the working length of the root canal, which had been determined visually
8 BM Guimaraes	Thirty mandibular incisors were accessed, and the root canal length (RCL) was determined with a K-file #15, with the aid of a stereo microscope. Afterwards, the specimens were divided into 2 groups (n = 15) referring to the cervical preflaring with LA-Axxess or ProTaper files. The teeth were embedded in alginate and the RCL was determined by the EALs before and after preflaring. Data were classified into: accurate, if the difference in RCL measurement were <0.05 mm; and inaccurate, if the difference were >0.5 mm or beyond the RCL.

Study ID	Intervention result	Comparison result	Result	Conclusion
1 Camargo E.L et al	75% measurements were precise with Root ZX and Mini apex locator.54% measurements were precise with elements apex locators.60% measurements were precise with Apex DSP	50% of the measurements were accurate with Root ZX and Mini apex locators. 47% of the measurements were accurate with Elements apex locator.45% of the measurements were accurate with Apex DSP apex locator	The preflared procedure increased the number of precise measurements for all the electronic apex locators	All the electronic apex locators showed an acceptable determination of working length after preflaring
2 Brito-Junior M et al	83% of the measurements were accurate with Root ZX apex locator. 80% of the measurements were precise with #10, 58% of the measurements were precise with the 15 # file and 71% with #20 file for No apex locator	67% of the measurements were precise with #10 file, 56% were precise for #15 file and 71% with 20# file for Root ZX apex locator. 76% of the meaurements were precise with #10 file, 74% with #15 and 80% with #20 file for No apex locator.	Preflaring procedure significantly increased the accuracy of the measurements for Root ZX.	Cervical preflaring significantly increased accuracy
3 Morgental D. R et al	After preflaring, mean differences are -0.03 mm; -0.13 mm and -0.23 mm for No apex, Mini Apex and Propex II respectively. (100%, 100% 90%)	Before preflaring, mean differences between electronic and visual working length were -0.06, -0.29 mm and -0.36 mm. (90% 87% 83%)	All Electronic apex locators presesnted high percentage of acceptable cases before preflaring and even higher after the procedure.	The electronic apex locators increased the accuracy after preflaring
4 João Marcelo da Silva Teixeira et al	25 samples demonstrated the exact reading after preflaring whereas 9 samples demonstrated reading at 0.5 mm short of the apex and 4 samples demonstrated reading at 1mm short of the apex	21 samples demonstrated the exact reading before preflaring whereas 9 samples demonstrated the reading at 0.5 mm short of the apex	The results revealed that there was no statistical significance ($p < 0.05$) between the readings before and after the root canal's preflaring.	Cervical preflaring with Gates Glidden burs did not significantly influence the apical locator accuracy in determining the actual working length.
5 Fernanda Ullmann Lopez et al	The mean length obtained in preflared canals was 15.42±1.33 mm	Mean length in unflared canals was 15.60±1.41 mm	. The Student's t test for paired samples did not reveal statistically significant differences in the measurements obtained for preflared and unflared canals ($P < 0.05$)	Electronic working length measurement can be carried out either before or after cervical flaring with nickel-titanium rotary files.

6 Samadi Y et al	After preflaring in the second phase of the study,greater accuracy was observed.Standard deviation in mm was (-0.09±0.24 for Raypex 6,-0.02±0.26 for Root ZX)	The standard deviation in mm was -0.24±0.18 for Raypex 6 and 0.15±0.19 for Root ZX	Preflaring significantly increased the accuracy of apex locators	Pre-flaring improves the accuracy of electronic apex locators..
7 R Suryantoro	Standard deviation using the multiple frequency apex locator after coronal preflaring was 0.3146 while it was 0.2562 for the dual frequency group	The standard deviation for the unflared group was -0.2813 mm.	There was a significant difference between measuring the location of the apical foramen using a multiple frequency apex locator before and after coronal preflaring ($p < 0.01$).	Coronal preflaring improves the accuracy of measurements for locating the apical foramen using apex locators. The accuracy level in determining the location of the apical foramen using a multiple frequency apex locator after coronal preflaring was better than before coronal preflaring.
8 BM Guimaraes	A significant increase in accuracy performed by Joypex 5 was observed after cervical preparation with drill LA-Axxes ($P = 0.01$). Both EALs presented accuracy concerning all canals that were measured after cervical preparation with the S1 and Sx by ProTaper system, without statistical difference between them.	When comparing the EALs evaluated under the same conditions, before and after the cervical preparation with the different instruments, there was no significant difference between them ($P > 0.05$).	Cervical preparation performed with the drill LAAxxes increased the accuracy of the Electronic Apex Locator Joypex 5.	

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