

# Accuracy of Apex ID Electronic Apex Locator using Stainless Steel and Nickel Titanium Hand Files: In Vitro Study

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## ABSTRACT

**Introduction:** Accurate determination of working length (WL) of root canal system is needed to eliminate infection and protect same tooth from future microbial invasion. For this, electronic apex locator (EAL) has been widely used to increase the accuracy of actual length (AL) determination in comparison to traditional methods leading to successful endodontic treatment.

**Objective:** To evaluate the accuracy of sixth generation EAL (Apex ID) in determining WL of root canal using Stainless Steel (SS) and Nickel Titanium (NiTi) hand files in both dry canals and three simulated wet conditions: human blood plasma, 3% sodium hypochlorite, and 2% chlorhexidine.

**Materials and Method:** Sixty single-rooted teeth with closed apex were selected by convenience sampling for this analytical cross-sectional study conducted at Kantipur Dental College from July 1, 2021 to September 1, 2021 after ethical approval. After determination of actual length, Apex ID was used to determine WL of root canal using SS and NiTi hand files in both dry canals and all three simulated conditions. Recorded AL was compared with values obtained with EALs using SS and NiTi files in different simulated conditions and statistically analysed using SPSS v.21.

**Result:** Findings of this study showed that accuracy in WL measurement by sixth generation EAL (Apex ID) using NiTi and SS file was almost similar in different simulated conditions.

**Conclusion:** Hence, during root canal treatment, both SS hand K-file and NiTi file can be used interchangeably without compromising the WL while using with Apex ID EAL as the results show almost equal accuracy.

**Keywords:** Electronic apex locator (Apex ID); nickel titanium hand file; stainless steel hand file; wet canal; working length.

## INTRODUCTION

Endodontic treatment is treatment sequence for infected tooth pulp intended to result in elimination of infection and protection of decontaminated tooth from future microbial invasion. It includes cleaning, shaping, disinfection, and three-dimensional obturation of entire accurate length of root canal. So accurate working length determination of root canal plays vital role for clinical success of endodontic treatment.<sup>1</sup>

Electronic apex locators (EAL) have gained popularity for correct working length determination and eliminated many shortcomings associated with

### Citation

Rajbhandari SM, Khanal S, Karmacharya A. Accuracy of apex id electronic apex locator using stainless steel and nickel titanium hand files: in vitro study. *J Nepal Dent Assoc.* 2022 Jan-Jun;22(34):45-50

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radiographic techniques. According to previous studies, fourth generation EAL performed relatively well in dry canals but it became inapplicable in exudate and blood.<sup>2</sup> The fifth generation EAL whereas performed very well in presence of blood and exudates but was inaccurate in dry canal.<sup>2</sup>

In order to overcome these problems, method and devices of sixth generation EAL are expected to ensure accuracy of determining length of root canal regardless of moisture like- blood, exudates, irrigants, non-extirpated pulp in root canal and dry canal as well.<sup>2</sup>

This study aimed to evaluate the accuracy of sixth generation EAL (Apex ID) using stainless steel (SS) and nickel titanium (NiTi) hand files in both dry canal and three simulated wet environments- 3% sodium hypochlorite, 2% chlorhexidine, and blood plasma.

## MATERIALS AND METHOD

Single-rooted teeth with closed apex, non-carious mandibular premolars were collected by convenience sampling for this analytical cross-sectional in vitro study. The study was done for three months from July 1, 2021 to September 1, 2021 in the Department of Conservative Dentistry and Endodontics, Kantipur Dental College, Basundhara, Kathmandu, Nepal. The study proposal was approved by institution's research committee (KDC-IRC, Ref. 09/021, dated June 30, 2021). Sample size was calculated using the formula for comparison of means:  $n = 2 * (Z\alpha + Z\beta)^2 * SD^2 / d^2$ ; Where,  $m_1 = 16.62$ ,  $m_2 = 18.62$ ,  $sd_1 = 1.38$ ,  $sd_2 = 1.30$ .<sup>3</sup> Taking Power = 90%:  $Z\alpha = 1.96$ ;  $Z\beta = 1.282$ . The calculated size,  $n = 9.44 \approx 10$ . Hence, total sample size =  $10 * 4 = 40$ . Due to availability of premolars, 15 in each group resulting in a total of 60 ( $15 * 4$ ) sample teeth were taken for study purpose.

All collected samples were immersed in 3% sodium hypochlorite solution (Septodont) for 24 hours to remove adhered tissues. Calculus and surface deposits were removed by ultrasonic scaler (DTE). All collected samples were examined under 5X magnification using a magnifying glass. Samples with root resorption and fractures were excluded. For each sample, two radiographs were taken in buccolingual and mesiodistal projection to view

root canal anatomy and radiographic apex. Teeth with more than one canal were excluded.

Finally, sixty teeth were selected for the study. Then, access opening and occlusal reduction of cusp tips of the samples were performed. Before, electronic measurement of root canal length, SS number 15 K-file (MANI) was inserted into each canal until the tip became visible through the foramen. Then the file was withdrawn until a magnification glass 5X showed its tip to lie tangential to apical foramen. The silicone stop was adjusted to the level of chosen as reference for root canal measurement and a millimeter ruler was used to measure the distance from silicone stop to the file tip. These measurements were recorded as reference length (actual length, AL). Barbed broaches (MANI) were used to extirpate the pulp but no root canal instrument was used to avoid enlargement of root canal. Then, samples were rooted up to cemento-enamel junction in a plastic container containing freshly mixed alginate (Coltene). Adequate care was taken to keep the alginate models moist.

Then, samples were randomly divided into four groups with 15 samples each. Group I ( $n = 15$ ): In this group, root canals of samples were kept dry by using absorbent paper (META Biomed). Group II ( $n = 15$ ): In this group, root canals of samples were filled with 3% sodium hypochlorite (NaOCl) (Septodont). Group III ( $n = 15$ ): In this group, root canals of samples were filled with 2% chlorhexidine (CHX) (PREVEST DenPro). Group IV ( $n = 15$ ): In this group, root canal of samples were filled with human blood plasma mixed with Ethylene Diamine Tetra acetic Acid (EDTA) (META Biomed) as an anticoagulant.

The size 15 or 20 SS hand K-file (MANI) was attached to the file holder and circuit was completed by inserting the lip electrode into the alginate model. Then, SS hand file was introduced apically within the root canal of sample until the Apex ID electronic apex locator (Sybron) displayed '0.0' reading. The file was then, gently retracted until the display showed stable '0.5' reading on the Apex ID electronic apex locator (Sybron). Two silicone stoppers on the file were adjusted to a coronal reference point and file was withdrawn to measure the distance between the silicone stopper and file tip with an endodontic scale (Densply Maillefer).

This was recorded as electronically measured canal length (EL). The same measurement techniques were repeated with NiTi hand files (K-File NiTi Flex Densply Maillefer) in dry canals and three different simulated wet conditions- 3% NaOCl (Septodont), 2% CHX (PREVEST DenPro) and Blood plasma.

The recorded AL was compared with the value obtained with the EALs using SS and NiTi hand files in dry canal and three different simulated wet conditions and their differences were tabulated and  $\pm 0.5$  mm was used to evaluate the accuracy of EALs in dry canals and three different simulated wet conditions. Then, obtained values were subjected to statistical analysis using IBM SPSS Statistics for Windows, version 21 (IBM Corp., Armonk, N.Y., USA).

## RESULT

The findings of this study showed that the accuracy in working length measurement by sixth generation

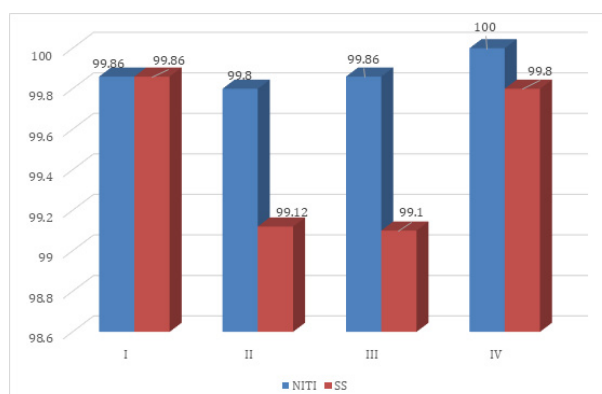
EAL (Apex ID) using NiTi files and SS file was 99.86% and 99.86% in Group I, 99.8% and 99.12 % in Group II, 99.86 % and 99.1% in Group III, 100% and 99.8% in Group IV respectively (Figure 1). The mean differences between actual working length measurements and electronic working length (EWL) for Apex ID with SS file was  $0.033\pm 0.13$  mm in Group I,  $0.167\pm 0.45$  mm in Group II,  $0.20\pm 0.367$  mm in Group III,  $0.03\pm 0.13$  mm in Group IV. The accuracy of Apex ID using NiTi files in different groups show in decreasing order of Group I, Group II, Group III, then Group IV, while SS file shows in decreasing order of Group I, Group IV, II, and then Group III. In dry canals, both files showed similar accuracy while in other simulated condition NiTi files shows higher accuracy than that with SS file. Hence, there was no statistically significant difference between working length measurement using both SS file and NiTi file using electronic apex locator .

**Table 1: Mean difference between actual length and length obtained by Apex ID electronic apex locator using nickel titanium and stainless steel files.**

Type of file	Group I	Group II	Group III	Group IV
Stainless steel	$0.033\pm 0.13$	$0.167\pm 0.45$	$0.20\pm 0.367$	$0.03\pm 0.13$
Nickel titanium	$0.033\pm 0.13$	$0.033\pm 0.13$	$0.03\pm 0.29$	$0.00\pm 0.00$

**Table 2: Mean value of actual length obtained by Apex ID electronic apex locator using nickel titanium and stainless steel files.**

Group	Actual length (Mean $\pm$ SD)	Length using SS file	Length using NiTi files	Total number of teeth in each group
Group I (dry canal)	22.63	22.60	22.63	15
Group II (canal filled with NaOCl)	20.67	20.57	20.67	15
Group III (canal filled with CHX)	22.63	22.50	22.67	15
Group IV (canal filled with blood)	21.00	20.97	20.97	15
Total				60



**Figure 1: Accuracy of nickel titanium and stainless steel files in working length measurement in different media.**

## DISCUSSION

Accurate working length has been defined as “ the distance from a coronal reference-point to the point at which canal preparation and obturation should terminate.<sup>4</sup> Inaccurate estimation of root canal working length may result endodontic procedural errors such as over-instrumentation and under-instrumentation, which may lead to the failure of endodontic treatment.<sup>5</sup> Over instrumentation during endodontic treatment may cause periradicular inflammation, post-operative pain, and injuries to the periapical tissues which may result in preventing or delaying the healing process.<sup>6</sup> Whereas, under-instrumentation may causes inappropriate cleaning, shaping, and disinfection of the root canal which may result to under-filling of root canal and failure to prevent future microbial invasion.<sup>7</sup> So, root canal preparation and filling should not extend beyond the tooth root, nor should leave any under-instrumented areas inside the root canals to obtain favourable endodontic outcome.<sup>8,9</sup>

Various methods of determining working length includes: radiographs, tactile sense, anatomical knowledge, anatomical average, absorbent point, and electronic apex locator. However, all the above-mentioned methods have limitations.<sup>10,11</sup> Among them in clinical practice, radiographic technique is the most commonly used method for determination of the working length of root canal.<sup>12</sup> But, radiographs cannot determine the accurate length of root canal because, it gives a two-dimensional image of a three-dimensional object. The accuracy of the radiographic method also depends on the quality of radiography and X-ray films.<sup>13</sup> It is also associated with limitation of radiation exposure to patient and dental practitioner.

In the authors' previous comparative study of electronic apex locators, sixth generation Apex ID EAL showed the highest accuracy in working length determination of root canal using stainless-steel hand files in both dry canal and three different simulated moist environments- Blood plasma, 3% NaOCl and 2% CHX but, did not reveal 100% accuracy in 3% NaOCl, and 2% CHX. It may be due to role of properties of material of stainless steel hand file as testing purposed.<sup>14</sup>

There are very limited studies on evaluation of accuracy on electronic apex locators using stainless steel and nickel titanium and also fail to reveal conclusive result on it. The purpose of this in vitro study was to evaluate the accuracy of sixth generation electronic apex locator (Apex ID) using stainless steel and nickel titanium hand file in both dry canal and three simulated wet environments- 3% NaOCl, 2% CHX, and blood plasma for determining correct working length.

In clinical practice, various working length determination methods like- radiograph technique, tactile sense, anatomical knowledge, anatomical average, absorbent point can be used but among them, radiographic method is the most commonly used technique to determine working length.<sup>12</sup> Many studies have stated that, all above mentioned methods have limitations and electronic apex locators are more accurate and superior to radiographic technique.<sup>10,11,15,16</sup> So, in recent endodontics, the use of electronic apex locators for working length determination has increased in popularity due to introduction of the latest generation EALs with improvement in their features and drawbacks to obtain accuracy of working length in different aspects of endodontic practices.<sup>10,17</sup> Because of these reasons, in this in vitro study, the authors have used sixth generation EAL Apex ID to evaluate its efficiency to determine accurate working length using two different alloys: stainless steel and nickel titanium hand files in different simulated environments, we encountered usually during procedure of endodontic therapy.

Many studies have been designed in vivo and in vitro to evaluate various aspects that associated with the different EALs. In vitro studies, different authors have been suggested different materials as electro-conductive in nature such as: alginate, agar, gelatin, and saline solution.<sup>18-21</sup> Among these, Alginate model and extracted human teeth are one of the most common in vitro models to allow testing of the EALs.<sup>10,22</sup> The firm consistency of an alginate prevents tooth mobility and are stable for hours. Many previous studies stated that, alginate model present various advantages like good electro-conductive properties, ease of model preparation, stability, and firm consistency.<sup>23</sup> So,

in this present study, we also used alginate as the embedding medium to stimulate periodontium as it has appropriate physical properties.

Briseno-Marroquin et al. studied the accuracy of four different EALs with three different instruments size of hand files and found that, size 08, 10, and 15 had no influence on the accuracy of working length determination.<sup>24</sup> Cianconi et al. also found, no significant difference between different instrument sizes of K-files and concluded that performance of EALs were not influenced by instrument sizes of hand files.<sup>15</sup> So, in this in vitro study, the authors used sized 15 stainless steel and nickel titanium hand K-file.

Various types of hand files can be used interchangeably without any compromise during procedure of endodontic treatment. Nickel titanium files are also commonly used in endodontic treatment because of its increased flexibility and resistance to torsional fracture during preparation of curve canals. Hence, NiTi hand files were compared to SS hand files in this in vitro study, to evaluate the accuracy of the sixth generation EAL Apex ID. Various studies have stated that, the accuracy using

SS files ranges from 70% to 100% and with NiTi, it has been found to range from 39% to 94%.<sup>10,25-29</sup>

The present study shows accuracy with SS files ranging from 99.1% to 99.86% while that of NiTi files shows accuracy of 99.8% to 100% which is almost similar stating that both files can be used interchangeably during working length determination. This result is similar with study by Geloth PM et al.<sup>29</sup> and Chaudhary S et.al.<sup>30</sup> where they found no significance differences in accuracy of working length determination with EAL using stainless steel and NiTi files.

Limitations of this study was the small sample size.

## CONCLUSION

Apex ID EAL showed almost similar accuracy using NiTi file SS hand files. Hence the authors recommend that during root canal treatment, both SS hand K-file and NiTi file can be used interchangeably without compromising the WL.

**Conflict of interest:** None.



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