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Original Article

Model to Aid Teaching of Electronic Apex Locator Use for Endodontics in Dental Pre-Clinical Training – A Uitm Experience Pilot Study

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ABSTRACT

Background: *Electronic Apex Locators (EAL) has been increasingly used to facilitate working length determination in endodontics. This instrument is becoming more important to be used in addition to radiographs. A steep learning curve has existed between EAL use in the clinical, from the pre-clinical settings.* **Objectives:** *To fabricate a model that will facilitate dental students to use Electronic Apex Locator (EAL) in the dental simulation clinic and to conduct a questionnaire-based survey to investigate Electronic Apex Locator Model (EALM) effectiveness.* **Materials and Methods:** *Construction of model master jaw, EALM, using materials available in the prosthetic laboratory. The model can be mounted on the phantom head which when connected to an EAL will simulate its clinical use. A validated questionnaire was distributed to a group of n=10 pre-clinical students before and after demonstration conducted at the simulation clinic.* **Results:** *A prototype EALM was successfully fabricated at Universiti Teknologi MARA Dental Prosthetic Laboratory. with features incorporating conductive-media-chamber, with attached anatomically-correct fabricated model teeth. The teeth were constructed incorporating continuous access cavity, root canal, through to a patent apex. When attached to the jaw model, the electrical circuit was connected allowing EAL to function.* **Conclusion:** *EALM can be conveniently constructed at the Dental Prosthetic Laboratory by using materials readily available here. Furthermore, a steep learning curve exist between pre-clinical and clinical studies was bridged by the use this EALM and this allowed familiarity of clinical handling EAL. However, this study was limited by the small number of students exposed to this new method. Further prospective study is required by increasing the sample size to provide more significant results.*

Keywords: *Dental education, Apex locators, Dental simulation, Apex locator model*

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INTRODUCTION

Root canal treatment (RCT) is a multi-stage procedure and working length determination is one of many crucial stages. Failure to determine the correct working length will lead to inadequate canal preparations which may lead to reduced RCT success.

The use of Electronic Apex Locators (EAL) as an adjunctive tool has been increasing, so it is becoming more important to teach students in addition to the use of radiographs (Chen et al., 2011). Their study aimed to develop a simple and inexpensive ex vivo model, using extracted human teeth, to teach students the use of electronic apex locators in a preclinical setting. Furthermore, the advantage and the precision of electronic working length measurement depends on the device used and the type of irrigation and is not influenced by the status of the pulp tissue (Tsesis et al., 2015)

In a recent study, (Suksudaj et al., 2015)showed that their students' admitted that their learning experiences (such as using additional training aids) are one of the key components to understand new skills in an educational setting. The role of the laboratory tutors was also found to be important in creating an effective learning environment by providing demonstrable techniques in pre-clinical setting (Suksudaj et al., 2015).

A study illustrated the need for an improved evidence based on dental simulations to inform curriculum designs and psychomotor skill learning in dentistry (Perry et al., 2017)

Presently, artificial models to aid EAL (EAL-model) are already commercially available as well as those non-commercially types and they are already made accessible by various authors sharing their expertise to guide fabrication. Nissin Dental Products Inc, Japan is selling the models which cost around RM700.00 (Figure 1).

(Tchorz et al., 2012), has outlined a detailed description to fabricate their version of EAL-model incorporating natural teeth. They developed a simple model, where extracted teeth were placed in a mould and embedded in acrylic resin. The resin was applied in two consecutive steps to form a cavity around the root apices. A closable plastic tube served as a valve, and a steel wire connects to the EAL (Tchorz et al., 2012).

Recently also Hanafi et al., 2020 showed that a 3D print training dental model with embedded human teeth and electronic working length determination was used and the vast majority of students rated the modular 3D print training model positively. The model allowed a more realistic simulation of the clinical situation with a simultaneous use of EALs and led to reduced stress levels in endodontic treatment in the subsequent clinical courses**.** (Hanafi et al., 2020).

However, the use of these natural teeth presented problems due to cross-infection issues (Nawrocka & Łukomska-Szymańska, 2019), ethics (Holden & Dracopoulos, 2017) and more importantly variations in canal anatomy leading to unsuitability for undergraduate pre-clinical training (Decurcio et al., 2020) (see Figure 2).

PROBLEM STATEMENTS

There exists a steep learning curve for students to use EAL in patients. Currently there is a relative lack of bridging the skills gap between pre-clinical and clinical settings particularly in handling EAL. Commercially available EALMs are costly particularly for equipping large number of students. This does not include the added cost of repair and maintenance. Nevertheless, there have been articles which guided us to fabricate EALMs and some suggested to use extracted teeth which led to difficulties outlined above.

So to fabricate EALMs from available dental laboratory materials and adapt them to the available training equipment would be very flexible and indeed, feasable. This will facilitate customizing to the current curriculum and allow low cost maintenance and repair.

Furthermore the need to test the acceptance of this prototype by students, based on the current curriculum has developed.

Research questions include whether we can fabricate a totally artificial model with artificial teeth thus eliminating the problems outlined above. Also whether the students may find it useful when they are trained handling this pre-clinical tool.

OBJECTIVES

1. To fabricate a model (EAL-model) using materials available in a dental prosthetic laboratory.

2. To test students' feedback via questionnaires on the effectiveness of this adjunctive tool.

MATERIALS AND METHODS

Ethics Approval

Ethics Approval: UiTM Research Ethics Committee, Institute of Research Management & Innovation Universiti Teknologi MARA, 600-IRMI (5/1/6) REC/387/19 dated 25 July 2019.

Evolution of EAL- Model (EALM) Fabrication – UiTM Experience

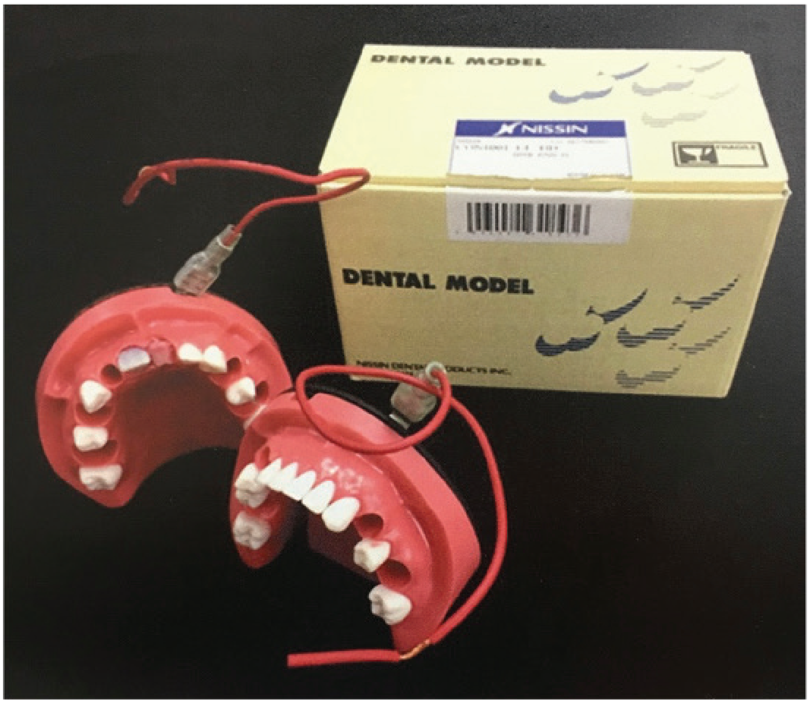

Figure 1: Nissin ® Apex Locator Models

Figure 2: UiTM 1st prototype model incorporating natural teeth. It is fabricated incorporating a compartment which can be filled with contact media and sealed posteriorly with a rubber stopper.

In Figure 2, natural teeth were used and the model was constructed following instructions by (Tchorz et al., 2012). Their method was to use extracted teet, placed in a mould and embedded in acrylic resin. The resin was then applied in two consecutive steps to form a cavity around the root apices. A closable plastic tube serves as a valve, and a steel wire connects to the EAL.

This base portion was used as a template to fabricate the 2nd prototype his and artificial teeth were used for reasons explained previously and are shown in figures 3-7. The detail step-by-step instructions will not be outlined in this article until copyright and patent issues are settled.

This pilot study, involved constructing EAL-model with anatomically-correct fabricated teeth (Figure 3). All teeth from incisors to molars were individually fabricated in the dental laboratory.

The latest models are shown in Figures 3 and 4. The fabricated tooth (Figure 5 and 6) is made with the root canal extending continuously from the access cavity to the apex. The tooth is made up of transparent material to let the students see the advancing file in the canal. Figure 7 shows the tooth having sufficient contrast to show up in the radiograph despite it being transparent.

Pre-clinical Exercise and Data Gathering

This EAL-model can be mounted on the phantom head so that the EAL can be correctly handled in a pre-clinical setting (Figure 8). A small survey is conducted with supervisor-student input collected via questionnaire. The questionnaire was first validated among 70 students and consent was acquired.

Groups of ten (n=10) students were supervised by the same lecturer over two weeks. The feedback from student-supervisor grouping, comparing the pre- and post- demonstration via the validated questionnaire (Table 1), is collected and analyzed. Figures 8 and 9 show how the EAL-model is attached to the phantom head and the EAL is connected to demonstrate its use.

No	Part 1 Questions
Students' Perspective*	
1.	I love Endodontics
2.	I enjoy learning Endodontics with the current method of teaching
3.	I know the importance of Endodontics in my undergraduate studies
4.	I have the required knowledge on working length determination
5.	I think working length determination's lecture is important
6.	I think working length determination's demonstration is important
7.	I think working length determination lecture and demonstration is equally important

*Likert Scale 1-5 (Strongly disagree – Strongly agree)

No	Part 2 Questions
Students' Practices on Electronic Apex Locator (EAL) **	
1.	I already had working length determination lecture previously
2.	I already had working length determination demonstration previously
3.	U understand about working length determination
4.	I had experience using EAL this year
5.	I am confident using EAL in clinic
6.	I am competent using EAL on patients

**Likert Scale 1-5 (Never – Always)

RESULTS

Electronic Apex Locator Artificial Model (EALM, with artificial teeth) Fabrication at UiTM

Figure 3: UiTM 2nd prototype model with removable artificial teeth. It is also fabricated incorporating a compartment which can be filled with contact media and sealed posteriorly with a rubber stopper.

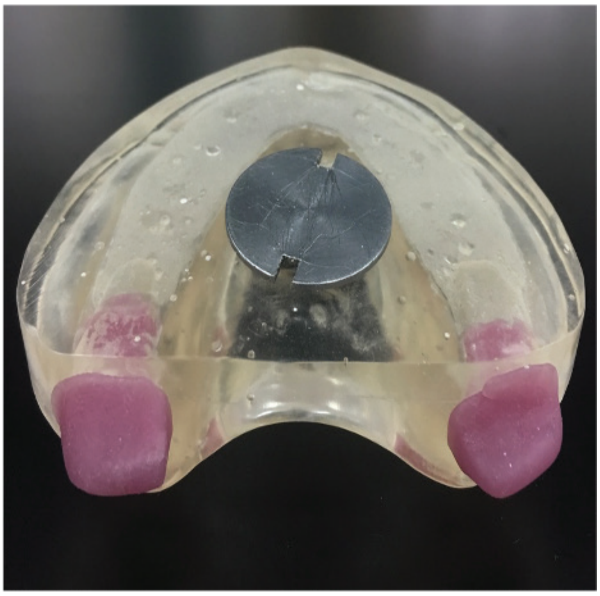

Figure 4: View from the underside showing the metal disc and posterior placed chamber plugs sealing the compartment filled with contact media.

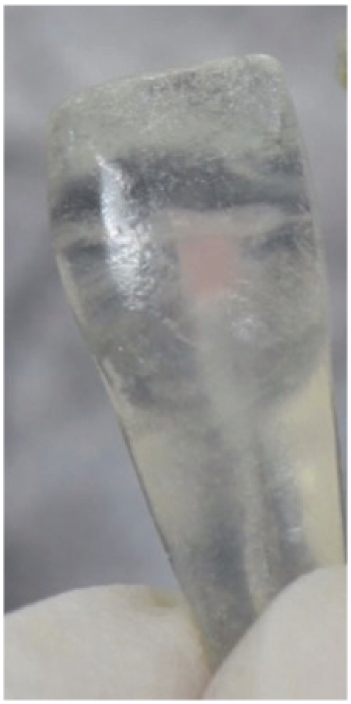

Figure 5: Labial view of artificial tooth (21) showing the access cavity and canal outline.

Figure 6: Distal view of artificial tooth (23) showing the continuous outline from access cavity to the apex.

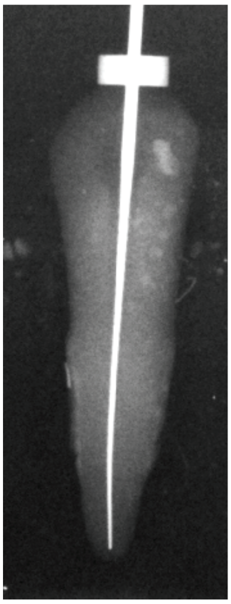

Figure 7: Periapical radiograph of artificial tooth 23 with an endodontic file inserted.

A 2nd prototype EAL-model was successfully fabricated in the dental prosthetic laboratory, see figures 3-7). The artificial teeth were made to replace the natural teeth. Radiographic comparison will still be possible for comparison with the EAL.

There are special features incorporated by the artificial models (EALM) namely:

1. The jaw part (the base) contained a sealed hollow chamber.

2. The roots of artificial teeth are inserted and are in contact within the chamber (for file clip).

3. Anteriorly, a lip electrode is also fabricated to be in contact within the chamber (for lip clip).

4. The sealed chamber** is filled with a liquid contact media, like glycerine or washing liquid and is sealed or plugged posteriorly.

5. The removable fabricated tooth has a simulated root canal that is continuous from access cavity to patent apex.

6. The artificial tooth is placed and sealed with plumber's tape within the jaw socket. The jaw sockets are continuous with the sealed chamber** and allowed the apices of the teeth to be connected with the contact media.

7. The base also incorporates a metal plate and is compatible for mounting to Kavo ® Phantom Head.

The model once mounted will allow the attachment of file clip and lip clip of the EAL to complete the circuit when an endodontic file is inserted into the into the artificial root canal.

Supervision

Figure 8: Demonstration conducted at Simulation Clinic, by a supervising lecturer to students.

Figure 9: The pre-clinical students handling the mounted artificial model with EAL.

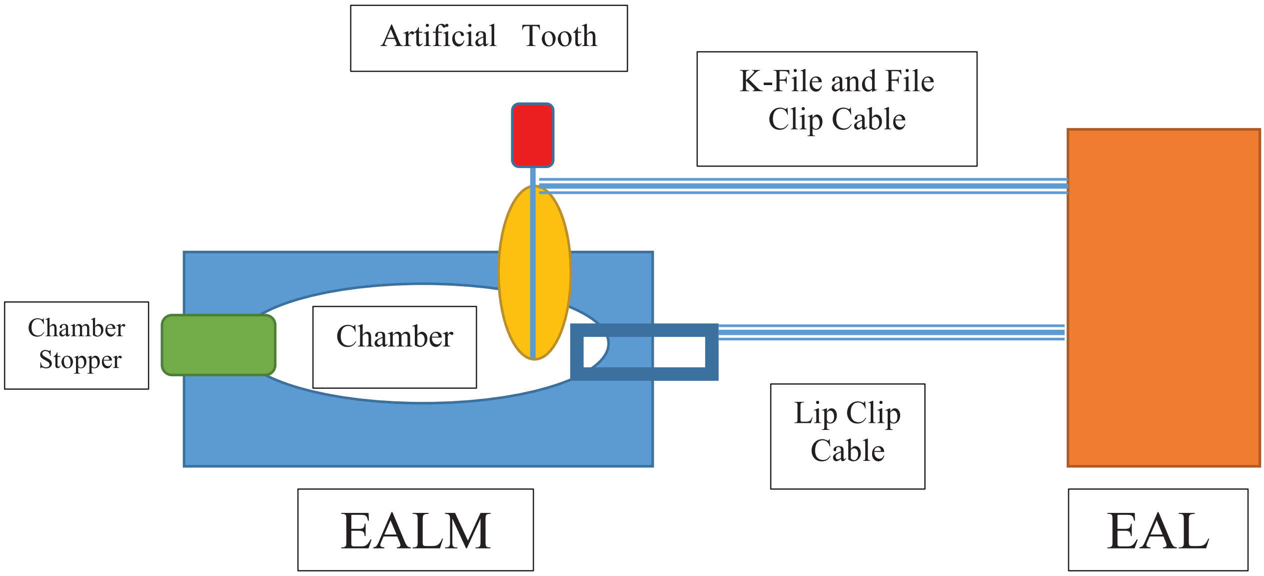

Figure 10: Connection between EALM and EAL.

Data Gathering

Data were entered onto a spreadsheet (Microsoft Office Excel 2010) and transferred to a data analysis and statistical software programme (SPSS version 24). The result is shown in Table 2. Score of pre-demonstration is 46.50 and post-demonstration is 59.50. A Wilcoxon Signed-Rank Test indicated that the median and interquartile range post total score in students' perspective and practical, is significantly higher than the median and interquartile range pre- total score, with the *p-value=0.036* (Table 2).

Table 2: Result of Pre-Demonstration and Post-Demonstration.

Variable	Pre-Demonstration Median (IQR)	Post-Demonstration Median (IQR)	Z statistic[a]	p-value
Total Score	46.50 (5)	59.50 (12.5)	-2.095[b]	.036

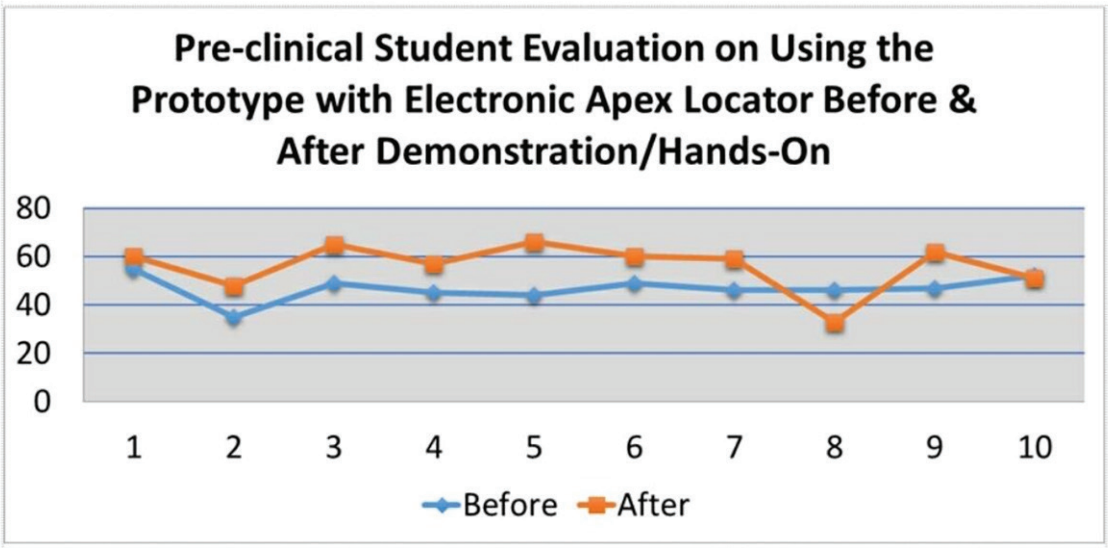

Figure 11: Students' evaluation before and after EALM demonstration/hands-on.

DISCUSSION

The EALM was fabricated manually which was different from that fabricated by Hanafi et al., 2020, where they used 3D printing plus natural teeth. Another difference was that we fabricated our artificial teeth using the same method as for the base, not natural teeth. Furthermore, our EALM was adapted to be used to our phantom-head which proved that ease of customizing, can be achieved when fabrication is concurrently being conducted.

The was significantly better acceptance by the students on training with the help of EAL-model. Since the EAL-model can be mounted on the phantom head this provided a better learning experience for competent clinical practice.

Based on another questionnaire-based study, the phantom head simulator was found to produce the best motor skills compared with those who had traditionally trained on bench-tops (Clancy et al., 2002).

Further questionnaire-based study conducted by Mirza, 2015, aimed to evaluate the short comings in preclinical endodontic training and to find out key areas to stress upon for better student understanding and treatment outcome. He showed that, locating the apical constriction has the highest percentage of difficulty among all the groups and concluded that the training for students in future needs to be amended so that they are better able to manage such difficulties (Mirza, 2015). So using this EAL-model, the students were able to detect their own errors in their own performance and they noted that this has helped them to improve. This is similar to the study concluded by Suksudaj *et al,* 2014 and Hanafi et al., 2020.

The EAL-model used in this pilot study is tested showing, positive and significant results. The use of artificial teeth fabricated avoided the variation of canal anatomy as well as cross-infection issues. To date there are no studies done to test the students' response on EAL-model effectiveness.

CONCLUSION

The EAL-model mimics the RCT procedure of working length determination carried out in patients. Although, the students will still be able to compare their EAL readings with radiographs. The reliance of visual feedback can supplement the instrument-feedback of EAL. This is due to the transparent material used.

This pilot study showed that students' feedback after using this EALM is significantly better than the before using the artificial model.

SUGGESTION

Further to this we can conduct the study for a large-scale number of students. We may compare the EAL-model with a commercially available EAL-model.

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