Teaching Model for Artificial Teeth and Endodontic Apex Locators


Abstract: Artificial teeth are a useful teaching aid during endodontic education. This article describes the development of a simple and inexpensive model that can be equipped with artificial teeth. It shows that working length determination in artificial root canals using electronic apex locators is possible and that the embedding media has no influence on measurements. The model supports the application of current endodontic techniques and facilitates a validated evaluation of the treatments between students. Artificial teeth can be removed for visualization and replaced for further endodontic exercises.

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Endodontic topics have become an important part of predoctoral and continuing education during the past years, due to the ongoing development of endodontic materials and techniques. Several innovations such as electronic apex locators (EALs) and nickel-titanium rotary instruments have strongly influenced endodontic practice. Both students and dentists require intensive practical exercises before performing new techniques on patients for the first time. Nonetheless, there is no consensus on the strategy, content, and quantity of endodontic education so far.\(^1,2\) To comply with the quality guidelines for endodontic treatments, the education should cover the following practical procedures: radiographic imaging, isolation, access cavity preparation, electronic and radiographic working length determination, preparation of the root canal system, irrigation, medication, and root canal filling.\(^3\) A number of educational models have been introduced in this respect, including the use of human skulls and animal jaws.\(^4,6\) Nowadays, it is common practice to use a mixture of simulated root canals for introductory techniques followed by extracted human teeth.\(^5\) Resin blocks with simulated canals were produced primarily for research purposes.\(^7\) Since then, they have been used in several studies, particularly for testing root canal instruments.\(^6,9\) Spenst and Kahn recognized their benefits and promoted their application in endodontic education.\(^10\) A further development was recently introduced in form of an entire artificial tooth made of clear resin with multiple roots and colored root canals (VDW, Munich, Germany).

A teaching model should permit the application of all these endodontic techniques. Although most of the described models enable radiographic imaging, they do not allow multiple approaches for working length determination that are often recommended.\(^11,12\) The possible use of EALs in combination with artificial teeth has not been tested so far. Thus, the aim of this article is to describe the development of an inexpensive endodontic teaching model that can be repeatedly equipped with artificial teeth and enables the use of EALs.

Methods

The individual steps of the fabrication process are shown in Figure 1. To begin with, a mounting for the artificial tooth (VDW, Munich, Germany) was constructed (C). For this purpose, dental modeling wax (Pinnacle standard, Dentsply DeTrey, Konstanz, Germany) was applied circumferentially around the original tooth (D). The mounting was made subsequently by injecting a silicon impression material (Aquasil Ultra XLV, Dentsply DeTrey, Konstanz, Germany) into the mold leaving the apices uncovered (E). Following this, a plaster duplicate (Snow White Plaster No. 2, Kerr, Romulus, MI, USA) of the original tooth
steel wire (Dentaurum, Ispringen, Germany) was used to build a loop with angled ends reaching into the previously constructed cavity (H). Afterwards, the model was placed in a resin filled base former (I).

In a final step, the marginal edges were trimmed, and an aperture with an approximate diameter of 5 mm was drilled in the distal end of the arch. The tip of a plastic tube (ThermoTube PCR Tube 0.2 mL, Peqlab, Erlangen, Germany) was cut off, and the tube was attached to the opening, serving as a valve for the enclosure (J). To improve the stability of the artificial tooth in the model, a conventional bolt was integrated behind the tooth using acrylic resin (K-L). Any type of base plate can be attached afterwards to enable the application in a phantom head.

A mixture of dental adhesive (OptiBond FL, Kerr, Orange, CA, USA) and bismuth oxide (Sigma-Aldrich, Steinheim, Germany) was produced with an approximate ratio of 5:1 by volume. The adhesive was applied to all root surfaces facing the furcation to intensify the radiopacity.
The influence of two different embedding media on root canal length measurements was evaluated using the Raypex 5 (VDW, Munich, Germany). Five artificial teeth were inserted in the model with 0.9 percent saline or embedded in alginate respectively. A total of fifteen root canals were measured in each group. A #10 stainless steel K-file was inserted until the red bar on the display of the Raypex 5 indicated that the file tip reached the apical foramen. The teeth were removed from the model and a radiograph was taken. The distance between the radiographic apex and the file tip was measured and recorded. Mean values and standard deviations were calculated using SPSS 16.0 (SPSS Inc., Chicago, IL, USA).

Results

A simple and inexpensive technique for fabricating a mounting model for artificial resin teeth has been developed. The model is reusable since the artificial teeth can be replaced. The bolt secures the tooth in the model additionally to prevent loosening during the usage of rotary instruments. The observational results derived from the working length determination using the Raypex 5 were as follows: mean distances and corresponding standard deviations between the apex and the file tip were 0.089 ±0.105 mm for saline and 0.087 ±0.084 mm for alginate respectively. The cost of the materials was approximately US$10 for the reusable duplicating forms and US$10 for the model.

Discussion

The main objective of this study was the development of an improved teaching model that can be equipped with artificial teeth and allows the application of modern endodontic techniques in undergraduate and continuing education. The design of an introductory educational program is of major importance. Hands-on training and correct guidance are especially necessary to prevent procedural errors and reach a high acceptance rate.\textsuperscript{13,14} The application of simulated root canals for endodontic courses is widely spread in this respect.\textsuperscript{1,2} Nassri et al. evaluated entire artificial resin teeth with multiple roots and root canals and observed a large acceptance among professors of endodontics.\textsuperscript{15} Artificial teeth have many favorable properties. Compared to extracted human teeth, they are standardized and easy to obtain in quantity. A particular advantage of artificial teeth is the opportunity of visualization. The teeth can be removed to review any endodontic procedure step-by-step in three dimensions. In this way, they improve the understanding of biomechanical root canal preparation, for example.\textsuperscript{16} The varieties of errors that can occur throughout endodontic treatment remain, but they can easily be understood. Students can practice under identical conditions and the visual feedback may enhance the learning effect. Also for dentists they are a valuable aid for self-assessments.

The observational results show that working length determination using EALs is also possible in artificial teeth with common embedding media.\textsuperscript{17} Following the guidelines for infection control, extracted teeth should be heat-sterilized before being used in an educational setting.\textsuperscript{18} Since endodontic treatment is one of the most technically sensitive procedures, the teaching approaches should simulate the clinical situations as realistically as possible. Root canal models and artificial teeth do not meet this requirement entirely because they are usually held in the hand during usage. Teaching models that can be mounted in a phantom head are more suitable in this respect. An ideal simulation model should enable the use of all available modern endodontic techniques to comply with the requirements demanded for endodontic treatment on patients.\textsuperscript{3}

The model presented in this article is a further development of a previously published teaching model.\textsuperscript{19} It benefits from the cavity around the roots in two ways. The conductive media and the steel wire enable the use of EALs, whereas differences in radiographic translucency around the root apices, associated with the lower resin thickness in the transverse section, allow radiographic WL verification. Nonetheless, a critical analysis of the original radiopacity (Figure 2, panel B) shows that a visual evaluation of the artificial roots is not yet acceptable. In this respect, an acrylic resin with a higher radiopacity would be favorable. To overcome this disadvantage, a mixture of bismuth oxide and a dental adhesive was applied on the inner root surfaces (Figure 2, panel C). This has only minimal effects on the translucency of the root.

The observational results show that working length determination using EALs is also possible in artificial teeth with common embedding media.\textsuperscript{20} In contrast to a study using human teeth, the conductive media had no evident influence on the measure-
ments. However, distances between the file tip and the apex were small. To maintain a safety distance during endodontic treatment, 0.5 mm should be subtracted from the working length determined by EALs (Figure 2).

Conclusion

An inexpensive model can be manufactured that uses artificial teeth and enables working length determination using EALs. Consistent measuring results can be obtained with alginate and 0.9 percent saline as embedding media.

REFERENCES