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Assessing the radiopacity of new root end filling materials using digital radiography technique

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Abstract

Background: Radiographic discrimination of root end filling materials from surrounding tooth structure is clinically relevant for assessing the quality of retrograde treatment. The present study aimed at evaluating the radiopacity of Biodentine™ and Pro Root MTA as root end filling materials using a digital radiography technique.

Materials and Methods: Specimens of Biodentine™ and Pro Root MTA test materials with 1mm thick and 10 mm internal diameter were prepared for digital radiographic analysis using an aluminum washer. The radiopacity of the Biodentine™ and Pro Root MTA was assessed using dental radiography equipment in combination with a phosphor plate digital system and a grey scale value aluminum step wedge with thicknesses varying from 1 mm to 10 mm in steps of 1 mm each. The degree of radiopacity of the test materials were radiographed and compared together with the aluminum step wedge on a computer screen using image J software. Radiopacity was expressed in mm of equivalent aluminum step wedge. The radiopacity values of Biodentine™ and Pro Root MTA were statistically analyzed using the one way analysis of variance (ANOVA) and post-hoc test (Bonferroni test), the level of significance was set at 0.05 ($P<0.05$). **Results:** The radiographic data showed that the degree of radiopacity of Pro root MTA is significantly higher than that of Biodentine™ ($P<0.001$). The current study reported that the ProRoot MTA showed requisite radiopacity around 5.86 mm when compared with aluminum step wedge steps, whereas the radiopacity of Biodentine™ determined around 2.46 mm of equivalent aluminum.

Conclusion: The radiopacity of Pro Root MTA is clinically relevant that allows for clear distinction between the material and the surrounding tooth structure enabling it to be used as root end filling material. However, Biodentine showed reduced radiopacity that needs further improvement.

Key words: Digital imaging, Biodentine™, root end materials, ProRoot MTA, radiopacity

Introduction

Apical surgery is an important endodontic treatment modality intended to cure persistent apical periodontitis (AP) after orthograde root canal treatment [1]. Persistent infection of periradicular area occurs when root canal treatment of apical periodontitis has not adequately eliminated intraradicular infection. Inadequate seal of radicular canal is one of the causes that lead to persistent of apical periodontitis [(2)]. Following apical surgery, a root end filling material is required to adequately seal and isolate the root canal system from the adjacent tissues [(3, 4, 5)]. Ideal root end filling material must provide favorable merits such as good biocompatibility, superior sealing ability, low cytotoxicity and lack of dissolution in tissue fluids to promote healing of periapical lesion [(5)]. Sufficient radiopacity is another important prerequisite of root end filling material that allows for a clear distinction between the materials and surrounding anatomic structures [(6, 7, 8)] and to facilitate the evaluation of the quality of the root fillings, which can be undertaken only through radiographic examination [(9)].

A variety of materials have been reported as retrograde filling material such as amalgam, composite resins, cavit and glass ionomer cement [(10)]. Mineral trioxide aggregate was first introduced in dentistry in 1993 by Torabinejad [(11)] and approved for endodontic use in 1998. It has been considered as the ideal root end filling material due to its low cytotoxicity and tissue biocompatibility with ability to induce mineralized tissue formation [(12)]. ProRoot MTA (Dentsply Tulsa Dental Products, Tulsa, OK) is one of the MTA based products and has the potential for being used as a promising root end filling material [(13)]. The main composition of MTA is 75% wt Portland cement with 20% wt bismuth oxide and 5% calcium sulfate. Recently, attempts were made to replace MTA with tricalcium silicate based cements such as Biodentine [(14)] (Septodont, Saint Maur des Foss´es, France). Biodentine[TM] is a new material introduced as a dentine replacement and is primarily composed of tricalcium silicate and calcium carbonate with zirconium oxide as powder while the liquid consists of calcium chloride, and a hydrosoluble polymer with water. It has been reported that Biodentine has comparable physical and chemical properties to MTA [(15, 16)].

The radiopacity of a root end filling material is considered one of the essential requirements contributing in the evaluation of root filled teeth, thereby a relevant technique for measuring the radiopacity of a root filling material was developed through obtaining radiographic images of a material alongside an aluminum step-wedge [(1)]. This technique includes digitalization of radiographic images and the use of specific software to discriminate different grey-scale value. The aim of the current study was to assess the radiopacity of two retro grade filling materials (Biodentine™ and ProoRoot MTA) by comparing the test materials with aluminum step wedge according to the (ANSI/ADA 2000) standards [(17)]. The null hypothesis tested in the present study was that Biodentine™ has a comparable radiopacity to ProRoot MTA on a radiograph.

Materials and methods

Six specimens of Biodentine[TM] and ProRoot MTA root end filling materials were prepared and manipulated according to their manufacturer's instructions. The radiopacity of the test materials was assessed using dental radiography equipment (Planmeca Qy, Helsiniki, Finland) in combination with a storage phosphor plate digital system and grey-scale value aluminum step wedge with thicknesses varying from 1mm to 10mm in steps of 1mm each (ANSI/ADA 2000). After manipulation, the test materials were placed into aluminum washer measuring 10mm internal diameter and

1mm thick according ISO 6876 specifications [18]. The filled aluminum washer with the test materials stored at 37C and 100% humidity until they completely set. All set materials were removed from the washer and the uniformity of the thicknesses was precisely calculated by a digital caliper (Maplin Electronics, Rotherham, UK). The specimens were then placed on a periapical film supplied with storage phosphor plate (Digora, Soredex, Helsinki, Finland) and radiographed together with graduated aluminum step wedge using radiography unit. The exposure parameters were set up at 70KV, 8mA and 0.2s. The object to-focus distance was 30cm. Storage phosphor plates were then scanned using Digora Scanner and digital images were obtained and converted to the computer using Digora for Windows software. The optical densities of the test materials were characterized on computer screen using specific image J software (Image J processing and analysis in Java, version 1.47g) and the grey-scale values (density measurements) converted into mm equivalents of aluminum and recorded. Statistical analysis was performed using (SPSS) software for Windows version 19. The radiopacity data were submitted to one-way analysis of variance (ANOVA) and post-hoc Bonferroni test for multiple comparisons.

Results

The means and standard deviations for the radiographic densities in (mm Al) of Biodentine TM and ProRoot MTA are reported in Table (1). The finding data obtained from the x-ray contrast analysis showed that the radiopacity value of ProRoot MTA is significantly higher than Biodentine TM at around 5.86 mm ($P<0.001$) , whereas Biodentine TM displayed a radiopacity determined around 2.46 mm as shown in Figure (1). It is apparent from the results that the radiopacity value of Biodentine TM is lower than the standards level established by ANSI/ADA (2000) specification no. 57, which should be not less than 3 mm Al equivalent.

Discussion

Root-end filling surgical procedure is urgently needed to save the tooth with apical periodontitis when the conventional ortho-grade treatment is failed or contraindicated. The root end filling material must fulfill characteristic features to seal the root end cavities successfully [19]. Radiopacity of an endodontic material is one of the significant properties that provide a contrast between adjacent anatomical structures and filling material, improving the radiographic diagnosis of voids and improper contours [20, 21]. Some materials provide a sufficient natural radiopacity, whilst others require radiopacifiers such as bismuth oxide and barium sulphate to optimize their radiopaque properties [22]. In the current study, the null hypothesis was rejected because the ProRoot MTA showed a radiopacity value significantly higher than Biodentine™.

The methodology used to measure radiopacity value in the present study is based on measurement of the pixel grey scale (image J) value using specific software after digitization of conventional film. The digital radiographic system has been used effectively in a few studies for radiopacity measurements of root canal filling materials [23, 24]. The main benefit of digital imaging technique is its ability to process and analyze radiographs on computer based image effectively [24].

Six aluminum washers of 1 mm thick and 10 mm height filled with each material were radiographed along with an aluminum step wedge that was used for reference. For every radiograph, the average grayscale value of the material was converted into absorbance and compared with that of the reference step wedge using image J software in order to determine the equivalent radiopacity in terms of millimeters of Al per millimeter of material. The radiopacity values of a material are related to the relative atomic mass of constituent elements. ProRoot MTA exhibited high radiopacity values because it contains bismuth oxide possessing a high relative atomic mass. However, Biodentine™ unveiled low radiopacity values due to the presence of elements with low radiopacity values in the powder of Biodentie™.

During manipulation of the tested material, Powder/liquid ratio is of significant relevance that may affect the radiopacity value because more fluid cement could be susceptible to wash out, particularly in the periradicular tissue making it difficult to view the material. Therefore, the manufacturer instructions of the material should be strictly followed during the manipulation procedure in order not to compromise the quality of retro-grade filling. Bismuth oxide (Bi_2O_3) in the ProRoot MTA acts as a radiopacifier to impart the requisite radiopacity of the material showing a radiopacity value around 5.86 mm Al, whereas Zirconium oxide incorporated in the powder of Biodentine™ resulting in a reduced radiopacity. This may be attributed to the relatively lower atomic mass of Zirconium oxide. According to the standards established by ANSI/ADA specification number 57, the radiopacity value of the endodontic material should be not less than 3 mm of Al equivalent. Hence, Biodentine™ showed an inferior radiopacity determined around 2.46 mm Al which is lower than the standards making it questionable to be performed in retro grade Interestingly, the lower radiopacity data of Biodentine suggested that this material is not clinically relevant to be used as root end filling material because it is not easily distinguishable from adjacent structures on radiograph. It has been reported that the endodontic material is being considered radiopaque when it exhibits a radiopacity value of 3 mm Al equivalent. Hence further improvement in the radiopacity value of Biodentine™ is highly recommended to be employed in surgical root canal treatment. The present findings of this study are in agreement with recent study done by many researchers wherein they reported that the radiopacity of Biodentine™ is less than 3 mm Al equivalent [(5)]. Further research on the biological properties and sealing ability of Biodentine™ and ProRoot MTA to be used as root end filling materials is highly recommended

Conclusion

Within the limitation of the present study, it could be concluded that the radiopacity of ProRoot MTA is sufficient enough to be clinically relevant for evaluation of the quality of retro grade fillings as it showed higher radiopacity value compared with Biodentine™. On the other hand, the Biodentine™ exhibited radiopacity values lower than the ISO standards making it not relevant for retrograde filling procedure. Further improvement in the radiopacity value of Biodentine™ is required.

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Table (1) Mean and standard deviation (SD) of the radiopacity values in mm Al for each material (N=6).

Product	Radiopacity values in mm (mean ± SD)
ProRoot MTA (Tulsa, OK)	5.86 ± 0.54
Biodentine™ (Septodont, France)	2.46 ± 0.34

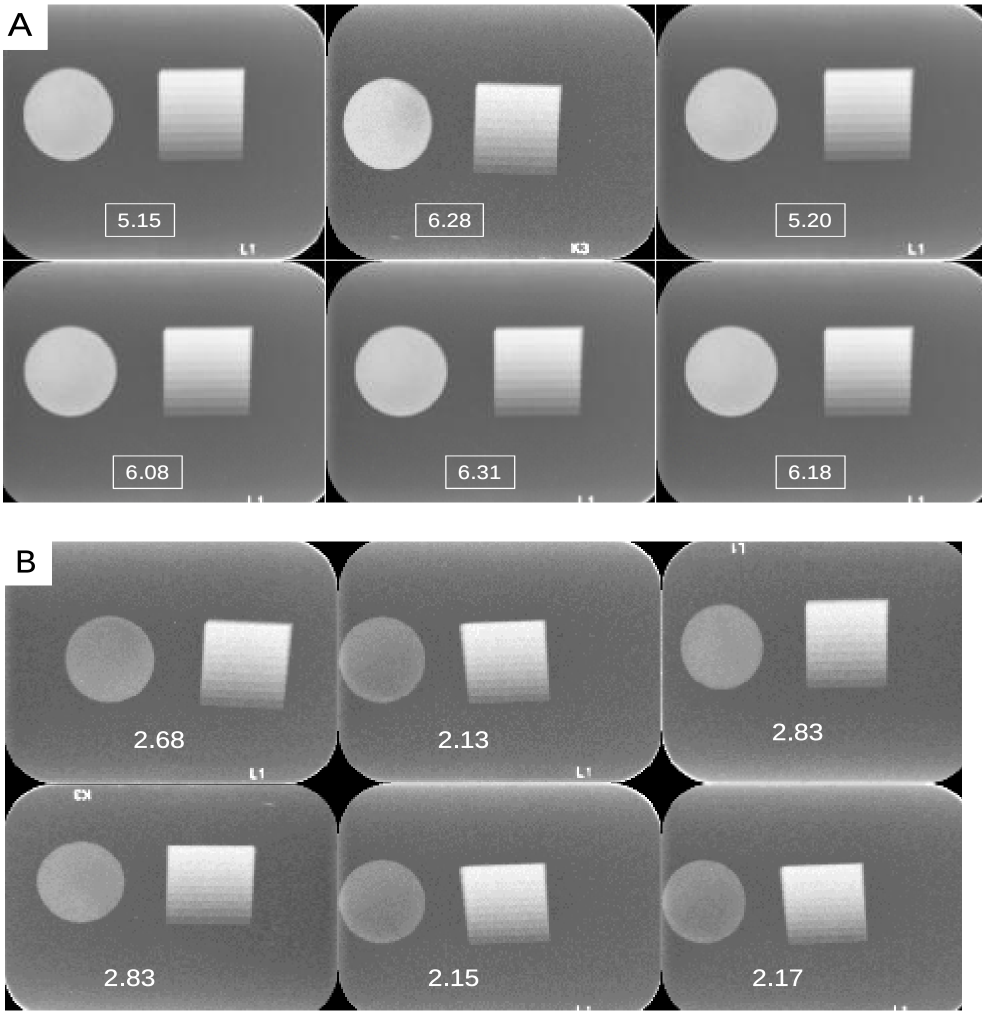

Figure (1) Radiographs showing the radiopacity values of A) ProRoot MTA and B) Biodentine™ in aluminum washer estimated in relation to the density of the aluminum step wedge.