STUDY OF RHEOLOGICAL PROPERTIES OF ENDODONTIC SEALERS USED IN PEDIATRIC DENTISTRY

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Abstract

The success of root canal treatment depends on effective cleaning of the root canal, eradication of pathogens and proper root canal filling. The present study aimed at comparing the flow, film thickness and radiopacity of three endodontic sealers; Roeko Seal Automix (RSA), Bioseal (BS) and Real Seal (RS). The sealers were tested according to the standard procedures which included flow test using glass plates, film thickness test under the applied load and radiographic test for radiopacity. The results showed the differences between the sealers' performances; RS had the highest flow value of 38.2mm, film thickness of 25.7 microns and the radiopacity of 4.8mm Al which is equivalent or even better than the required ANSI/ADA standards. RSA formed a thin film of 8. 9 microns and had a reasonable radiopacity of 4.0mm Al while having a low flow of 33.1mm. BS had the highest flow value of 39. 5 mm but it did not meet the radiopacity requirement of 2.9 mm Al. Oneway analysis of variance gave a significant ($p < 0.05$) difference indicating RS as the most suitable sealer. The results indicate that Radiopacity, flow and film thickness of RS are adequate for the clinical use and thus it can be considered as a potential substitute for endodontic procedures. It is recommended that future research be conducted to assess the effectiveness of sealers in terms of long term sealing ability and bacterial leakage.

Introduction

Currently, the standard technique of root canal filling includes the use of an endodontic sealer and gutta-percha. Gutta-percha being one of the most commonly used material is preferred for its desirable physical and biological properties although it has a major flaw. [1,2] The lack of adhesion of gutta-percha to the canal walls and sealer is a major disadvantage.[3] Due to the fact that gutta-percha does not bond to the dentine walls, the seal that is obtained is not the most optimal one and therefore the use of a sealer is required.[4] An ideal endodontic sealer should have good flow along the walls of the canal, should fill the gaps between the gutta percha and the dentine and should have good adhesion to both the surfaces.[5] However, researches have shown that the bond between endodontic sealers and gutta percha may not be very strong. Also, all the modern filling techniques used in the root canal are not impermeable to bacteria over a long period thus affecting the success of the root canal treatment. [6]

This has created the need to develop new and improved sealer and core obturation products and techniques in order to address this limitation. Among these advancements, the Real Seal (RS) system, developed by Sybron Endo, is a new concept in root canal filling.[6,7] RS is a dual-cured resin based sealant which is claimed to have bonding capability with RS obturating points which are soft resin core filling material, similar to gutta percha and root canal wall.[6] This bond is expected to form what is called a monoblock structure which is believed to prevent bacterial leakage and provide better coronal and apical seals.[8] The manufacturer has stated that this system is a better option as compared to the existing filling materials. The findings of the study also support these claims, it revealed that RS provided better seal than the conventional materials. [7,8]

In order to be considered clinically effective, endodontic filling materials must fulfil certain criteria which include biocompatibility non-toxicity and possession of appropriate chemical and physical properties for endodontic use. [9,10] Despite the nice design of the RS sealer, no in vitro study has evaluated its physical properties of the RS sealer. It is important to know these properties in order to assess the possible benefits and risks of its use in the clinical practice. [11] The current research therefore seeks to fill this gap by assessing and comparing the radiographic, flow and film thickness properties of the RS sealer with that of the currently used endodontic sealers. It is from this investigation that a comprehensive view of the physical characteristics of RS and its possible effect on enhancing the standard of root canal treatment can be made.

Material and Methods

Of the three endodontic sealers used in this study, there were RSA: Roeko Seal Automix (RSA; Roeko, Langenau, Germany), BS: Bioseal (BS; Ogna, Milan, Italy) and RS: Real Seal (RS; Sybron Endo, Orange, CA). All the sealers were mixed as recommended by the manufacturers to make sure that the test results were reliable. The assessment of these sealers was made in a way that was described in the guidelines of the American National Standards Institute/American Dental Association (ANSI/ADA) Specification No. 57.[12] This standard provides the test methods and sets the minimum requirements for the physical properties of endodontic sealers such as flow, film thickness and radiopacity.

The flow test was conducted in order to determine the material's capacity to spread under certain conditions as stated by the guidelines while the film thickness test was to measure the thinnest film that could be formed between two flat surfaces with a certain load. Radiopacity of sealer was assessed under radiographic examination in order to check suitability for the clinical use. All the tests were done in the laboratory, and the experiments were carried out in a controlled ANSI/ADA guidelines in accordance to ensure with that the results obtained were accurate. The use of this methodical process ensures that a comparison of the physical properties of the selected sealers is fair of and concludes their effectiveness in the clinical practice.

Flow

In line with ANSI/ADA Specification No. 57, a volume of 0.5 mL of each endodontic sealer was mixed as detailed in the package insert. At 180 seconds after the start of mixing, the sealer was placed in the centre of a glass plate (40 mm × 40 mm × 5 mm) using a graduated hypodermic syringe. It was then placed under an identical glass plate and a load of 100 g was carefully placed in the middle of the top plate.

At ten minutes after the beginning of the mixing, the load was taken off and the largest and the smallest diameters of the compressed sealer disc were measured. In cases where the difference in the measured diameters was not more than 1mm, the average of the two was reported. If the difference was greater than 1mm, then the test was done again to eliminate any chances of errors.

The flow tests were conducted in a manner that each sealer was subjected to six different tests and the mean value of the diameters for each sample was computed to the nearest millimeter. The results were analyzed statistically using one-way Analysis of Variance (ANOVA) and Student-Newman-Keuls (SNK) test to compare the flow properties of the various sealers. This way, the method used in this study provided a sound basis for assessing the flow characteristics of the materials tested.

Film thickness

A certain quantity of each endodontic sealer was made as detailed in the manufacturer's instructions. The unhardened sealer was sandwiched between two glass slides of equal size with a surface area of 200mm^2 with more than 5mm of sealer between the two glass slides. At 180 seconds after the initiation of the mixing process, a load of 150 N was exerted perpendicularly on the top glass slide, with a lot of attention given to the application of equal pressure and ensuring that the area between the two plates is completely covered.

Thereafter, the thickness of the resulting sealer film was assessed using a micrometre fitted on a stereomicroscope (Lomo MBC-10) at 10 minutes after the start of mixing. The study was repeated four times for each sealer to increase the reliability of the results.

The obtained data were analyzed statistically with one-way analysis of variance (ANOVA) and Student-Newman-Keuls (SNK) test to compare the film thickness properties of the used sealers. This standardised approach enabled a systematic assessment of the film thickness properties of the materials in question.

Radiopacity

The sealers were mixed according to the manufacturer's recommendations and placed in 20 stainless steel ring -molds with the dimensions of 10 ± 0.01 mm in diameter and 1 ± 0.01 mm in height. In order to investigate five specimens were kept for each sealer. An X-ray machine working at 70kV and 10mA was employed in conjunction with radiographic films (31mm X 41mm) of the speed group D (Ultra Speed, Kodak, Rochester, USA) to expose the test specimens and an aluminium step wedge radiographs. filtration as well as the aluminium step wedge was an 1100 alloy which contains 98 % aluminium, conforming to the ASTM Specification B209. Thus, the aluminium step wedge was placed in the center of the film and around it there were four specimens of the sealer for each radiograph. For each sealer three radiographs were taken. The focal length was kept at 300 mm during the whole process.

According to ANSI/ADA Specification No. 57, the radiopacity of endodontic sealers shall not be less than the radiopacity of 3 mm of aluminium. Thereafter, the radiographs were converted into digital images and analyzed with the help of an imaging software (Image Pro Plus 4. 1, Media Cybernetics, Silver Spring, USA). The data obtained were analyzed statistically using one-way analysis of variance (ANOVA) and Student-Newman-Keuls (SNK) test to determine the difference between the radiopacity of the sealers. This approach made it possible to implement a rigorous and systematic analysis of the radiopacity characteristics of the materials.

Results

The table aimed at assessing the flow characteristics of the three sealants which are RSA, BS and RS:

Mean Flow (mm): The flow value of BS was the highest at 39.5mm while RS was close to it at 38.2mm and RSA had the lowest flow of 33.1mm. Standard deviation (mm): In flow measurements BS showed highest variability of 2.5mm, pointing out the possibility of variation as against RS 1.1 and RSA (SD = 1.2). Conformity with ANSI/ADA Standards: All the sealers fulfilled the requirement of the minimum flow as stated in ANSI/ADA standard and hence are suitable for clinical use taking into consideration this characteristic.

The table 2 examines the film thickness of the sealers: Mean Thickness (microns): The present study revealed that RSA had the least film thickness that is 8.9 microns which shows that it has better fit in small gaps and irregularities. BS on the other hand had the thickest film (42.3 microns) which could possibly have an impact on its sealing capability. RS showed moderate range (25.7 microns). Standard Deviation (SD): This was also evident in BS as it had a higher standard deviation of 3.0, whereas RSA had a standard deviation of 1.0 and RS 0.9. Fulfillment of the ANSI/ADA Standards: All the sealers met the standard since the standard allows for a maximum thickness of 50 microns.

The table 3 illustrates the radiopacity of the sealers tested against the ANSI/ADA standard of having 3 mm of aluminium equivalent: This is the result of the mean radiopacity (mm Al): RS has the highest radiopacity which is 4.8mm Al, RSA is 4.0mm Al and both of them meet or even exceed the required standard. Only RSA and RS meet the ANSI/ADA radiopacity standard as shown in the table: BS on the other hand did not meet this standard thus casting a doubt as to its usefulness in the clinical practice.

Table 1: Flow test results of endodontic sealers

	sealer	Mean flow	Standard deviation	Compliance with ANS
1	RSA	33.1	1.2	yes
2	BS	39.5	2.5	yes
3	RS	38.2	1.1	yes

Table 2: Film thickness of endodontic sealers

	sealer	Mean thickness	Standard deviation	Compliance with ANS
1	RSA	8.9	1.0	Yes
2	BS	42.3	3.0	Yes
3	RS	25.7	0.9	yes

Table 3: Radiopacity of endodontic sealers

	sealer	Mean radiopacity	Compliance with ANS
1	RSA	4.0	Yes
2	BS	2.9	No
3	RS	4.8	yes

Discussion

The outcomes of this research offer important findings on the physical characteristics of three endodontic sealers namely RSA, BS and RS to determine their conformity with ANSI/ADA Specification No. 57 on flow, film thickness and radiopacity. These properties are very important in order to assess the effectiveness of root canal obturation and the potential for clinical success in the future.

Flow

Flow is one of the most important characteristics of endodontic sealers because it enables the material to cover the walls of the canal and fill the gaps and irregularities.[8,12] In this study, BS had the highest flow rate of 39.5mm, RS had a flow rate of 38.2mm while RSA had the lowest flow rate of 33.1mm. Despite this, all the three sealers met the ANSI/ADA minimum flow requirement. The better flow of BS and RS could possibly improve their performance in negotiating complicated root canal systems and thus improve sealing potential. However, the high standard deviation for BS indicates that the flow of the material may not be constant and could require more careful management during clinical procedures.

Film thickness

The thickness of the film affects the ability of the canal sealer system.[13] RSA showed lowest film thickness of 8.9 microns, and this is beneficial for providing a good seal and reducing any differences. RS had moderate thickness of 25.7 microns while BS had the thickest film of 42.3 microns which was closer to the ANSI/ADA maximum of 50 microns. All the sealers fulfilled the requirement but since RSA is the thinnest, it reduces the chances of microleakage to a large extent.[14] This is the parameter where RS performs moderately, and this indicates that it has a reasonable compromise between its flexibility and the ease of application.

Radiopacity

Radiopacity is very important because it helps in the identification of root canal fillings during the radiographic examination [15,16]. RS was more radiopaque (4.8 mm Al), while Al value according to ANSI/ADA. Is 3mm. while BS only provided (2.9 mm Al), RSA is in line with the calibre (4.0mm AI) which may pose a question regarding its clinical applicability. Radiopacity to an adequate level is crucial in order to discern any gaps or gaps in filling, especially in complicated areas. This provides RS with a clear radiographic detection which is a major advantage over the other two.

Clinical implications

RS was identified as the most balanced sealer as it had the best flow, sufficient film thickness and the best radiopacity. These characteristics are indicative of RS as a suitable sealer for clinical application with the best of both worlds – high adaptability and detectability. RSA on the other hand provided the best results in film thickness and radiopacity but had lower flow properties which may be an issue in some clinical situations. BS although it had the best flow, had the least radiopacity and this may not be advisable for use in normal endodontic practice.

Conclusion

The results emphasize the need to choose an endodontic sealer wisely after analyzing all the physical properties. RS has the best combination of properties, and it is considered as a potential sealer for future practice. More research should be conducted on the results of these properties on the sealing effectiveness and the antimicrobial resistance.

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