PRELIMINARY INVESTIGATION OF A NOVEL ENDODONTIC OBTURATOR

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ABSTRACT

Conventional endodontic treatment requires the removal of the pulp and dentin by shaping the inside of the tooth. The shaping occurs with the use of drills to a geometry that is directly related to a predetermined form of material that will obturate the tooth's interior.The aim of this study was to investigate a novel device that applies sonic energy during the obturation of the tooth's interior. Extracted human teeth underwent endodontic treatment. Half of the group were conventionally obturated and the other half were obturated with the novel device. Post-treatment radiographs were evaluated utilizing Schulich dental school endodontic marking criteria.No statistical significance ($\alpha = 0.05$) was determined between each group. A higher incidence of filled space (60%) occurred with sonic obturation when compared to conventional obturation (33%). Micro-computer tomography (CT) images were obtained of one sample from each group to assess the three-dimensional obturation. The novel device facilitated easy handling and demonstrated potential for effective obturation. Further tests are required for device refinement, larger sample sizes and clinical validation to assess the attitude and practice of dental professionals towards using of advance Radiographic technique.

KEYWORDS: endodontics, device, sonic, obturation
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INTRODUCTION

Endodontics is a branch of dentistry concerned with maintaining the health of the root canal system with the objective of enabling the endodontically-treated tooth to continue performing its normal functions without compromise[1-2]. The major steps in endodontic therapy involve accessing the pulp chamber, removing coronal and radicular pulp, cleaning and shaping the root canals and then obturating these canals[3]. Conventional endodontics often requires a generous access and a continuous taper to facilitate the introduction of the obturating material. Over-preparation can result in the considerable loss of the tooth and compromised structure[3-4]. Longevity of an endodontically-treated tooth may be questionable and the tooth could be at an increased risk of root fracture[1]. Moreover, torsional stresses may be generated from rotary or reciprocating instrumentation[2]. Lastly, incompletely obturated spaces are a frequent dilemma in which debris and pathogens remain and increase the possibility for re-infection[5].

Minimally invasive endodontics (MIE) is an emerging concept directed at lessening structural changes during endodontic treatment[1-2,4]and this philosophy aims to address the shortcomings of conventional endodontics. MIE aims to preserve structural integrity by removing only the infected pulp and the infected dentine lining the walls of the canals. That is,

excavating the minimum amount of tissue required for healing. The prepared size of the canals remains conservative and minimal. Currently, sonic devices are being developed in research to facilitate cleaning and shaping through MIE. In other dental disciplines, sonic devices are employed to facilitate the dispersion of materials. The same philosophy has been applied to this investigation, with the impression that sonic energy will disperse the endodontic sealer and guttapercha to micro voids within the interior of the tooth to provide a hermetic seal. The aim of this preliminary investigation was to: develop a sonic endodontic obturator, assess the handling and utility of the novel device in vitro, and compare the device's performance to conventional obturation in human extracted teeth.

MATERIAL AND METHODS

DEVICE DEVELOPMENT

Following multiple design iterations, a prototype sonic endodontic obturator was designed and fabricated utilizing a wireless ultrasonic motor (24-48K movements/minutes; 200-400 Hz), ergonomic intra-oral delivery extension and a resilient file receptor. Design specifics will be kept confidential, pending intellectual property protection.

TEETH

Extracted human teeth, (incisors, premolars and molars) that were not previously endodontically treated, appeared to have patent canals and estimated working lengths of 16 mm to 23 mm, were collected. The teeth were randomized into two groups.

WAVEONE ROTARY FILES

The WaveOne rotary file (Dentsply Tulsa Dental Specialties, Tulsa, USA) was used for conventional shaping of the root canal system. WaveOne files are made of M-wire, a special type of heat treated nickel-titanium (Ni-Ti) alloy which retains the same elastic properties of a regular NiTi file but provides four times more strength to better withstand instrument separation[6-7].Instead of rotating continuously in one direction, the WaveOne rotary file uses an uneven reciprocal motion which mimics the balanced force clinicians use for hand files[7-8].The wider counterclockwise motion cuts, while the clockwise motion disengages tooth structure[8].This prevents taper lock and provides relief from the torsional stresses, which result in cyclic failure[8]. Studies demonstrated a decreased incidence of dentinal cracks when using reciprocal motion for root canal shaping[9].WaveOne files also maintain canal anatomy with less modification to canal curvatures[10]. Since theWaveOne file is exclusively used to shape the entire root canal system, there will be a reduction in the number of files used and less time spent on shaping[10]. These files are single-use, cannot be sterilized and serve to enforce a new standard of care in eliminating the risk of cross-contamination[7,10].

GUTTACORE OBTURATORS

The GuttaCore Obturator from Dentsply(Dentsply Tulsa Dental Specialties, Tulsa, USA) were used to obturatethe canals. The carrier system features a cross-linked guttapercha core, which resolves many issues encountered by previous carrier systems[5]that utilized silver cones[11]or files as carriers[12].The guttapercha core permits easier and faster removal for re-treatment and post space formation[5]. The cross-links provide sufficient strength for the obturator to be placed into severely curved canals without breaking[13]. Although gaps and voids are inevitable with any currently known obturation technique, GuttaCore demonstrates the lowest incidence of interfacial gaps and voids when compared with warm vertical and cold lateral compaction techniques[5].To ensure a three-dimensional adaptation to the canal walls, the thermoplastic guttapercha flows when heated and during placement into the canal, and is forced by hydraulic pressure into all directions, rather than apically or laterally as compared to warm vertical compaction and cold lateral compaction[13-14]. Other benefits of GuttaCore obturation are its predictability and simplicity[13]. The handle can be separated from the obturator through a side-to-side bending motion without affecting the seal[14].

FILLAPEX

Mineral trioxide aggregate, a mixture of refined Portland cement and bismuth oxide, is widely used in endodontics for pulp capping, pulpotomy of primary teeth, and apexification[15-16]. The MTA Fillapex sealer (Angelus, Londrina, Brazil) was used for all obturations in this project. This sealer includes beneficial properties of MTA, such as biocompatibility, bioactivity, hydrophilicity, and low solubility[16-17-18]. The bioactivity of MTA Fillapex is important for the healing of a tooth[16]and has been shown to induce differentiation of human osteoblasts and cementoblasts[15], and stimulate nucleation of hydroxyapatite crystals to promote mineralization[15]. The hydrophilic particles of the MTA sealer enable it to harden in the presence of blood and moisture[18], and when set MTA maintains a seal by expanding and having low solubility and water absorption[18-19].Unlike current epoxy-resin-based sealers, the set MTA sealer constantly releases calcium ions to create

a long-lasting, alkaline, anti-microbial environment[20].Bismuth oxide in the sealer provides its radio-opacity and the absence of eugenol permits the use of resin composites as a restoration[18].The sealer is dimensionally stable[20], has a comparable sealing ability to other proprietary sealer cements[15], and exhibits ideal physical properties making it an effective endodontic sealer[19].

CLEANING AND SHAPING TECHNIQUE

Pre-operative radiographs of all teeth were taken. Both groups of teeth were accessed, cleaned, shaped and obturated. Standard endodontic accesses, with respect to tooth morphology were made. Hand files (Lexicon K File; Dentsply Tulsa Dental Specialties, Tulsa, USA) and single-use WaveOne reciprocating nickel-titanium files (Dentsply Tulsa Dental Specialties, Tulsa, USA) were used for shaping canals to working length following standard protocols. Irrigation, recapitulation, and irrigation (IRI) was performed with 5% sodium hypochlorite and a size 010 Lexicon K File after the use of each file. The EndoActivator (Dentsply Tulsa Dental Specialties, Tulsa, USA, and EndoActivator Tips; Dentsply Tulsa Dental Specialties, Tulsa, USA) was used per manufacturer's instructions for 30 seconds with 5% sodium hypochlorite at the end of the shaping and cleaning procedure for all canals. All canals were dried with ProTaper Universal paper points (Dentsply Tulsa Dental Specialties, Tulsa, USA).

OBTURATION TECHNIQUE

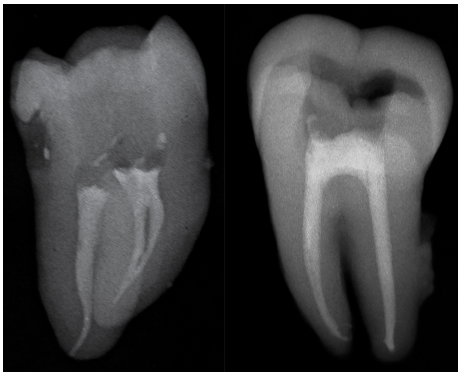
For obturation, MTA Fillapex sealer (Angelus, Londrina, Brazil) was used for both groups. Conventional obturation utilized anSV file (Size Verifier File; Dentsply Tulsa Dental Specialties, Tulsa, USA) for each canal followed by placement of GuttaCore Obturators. The GuttaCore Obturators were sterilized in 5% sodium hypochlorite for one minute, and were heated at the F1-F2 setting in the GuttaCore oven (Dentsply Tulsa Dental Specialties, Tulsa, USA) before being inserted into the tooth to working length as per manufacturer's instructions. Sonic obturation utilized the same technique as above, with placement of the GuttaCore obturator into the device receptor, insertion of the obturator to length and then activation of the sonic device for 10 seconds with a very gentle up and down motion. For both groups, the obturator handle was then broken off. Final post-operative radiographs were taken for all teeth.

RESULTS

IMAGING

Periapical radiographs were exposed for each tooth post-obturation to identify the outcome of endodontic treatment without sonic obturation (Figure 1a) compared to sonic obturation with the novel device (Figure 1b). Radiographs were exposed in both the mesial-distal and buccal-lingual aspect. There was evidence of micro void obturation utilizing the sonic device, as illustrated by the accessory canal in the apical region in Figure 1b.

Figure 1. Periapical radiographs following endodontic treatment. Figure 1a (left): Conventional obturation. Figure 1b (right): Sonic obturation.



Micro-computed tomography (CT) scans were performed on only one sample from each group (Figures 2 and 3). The CT scans provided an accurate three-dimensional assessment of the endodontic treatment. Figure 2 demonstrates a lack of obturation between the two canals, an incomplete fill on the larger single canal and a short obturation. Figure 3 demonstrates micro void obturation between the two canals and complete obturation of the larger canal.

Figure 2. Micro CT image of endodontic treatment with conventional obturation.

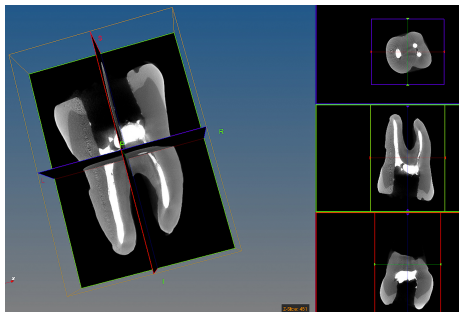
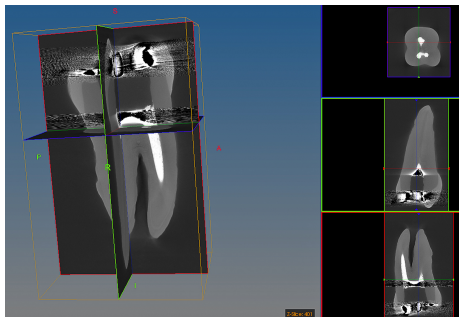


Figure 3. Micro CT image of endodontic treatment with sonic obturation.



SCORING & STATISTICAL ANALYSIS

To evaluate for differences between the groups, final periapical radiographs were placed in random order and attached to a score sheet for objective blind assessment by a university faculty endodontist. The quality of the obturation was evaluated on a 1-4 scale (1-poor; 4-excellent). Scoring was consistent with the marking criteria of patient-based endodontic treatment delivered by students at the Schulich dental clinic.

Scores were averaged. Two-tailed t-tests were performed with the statistical significance set at $\alpha = 0.05$. There were no statistically significant differences ($\alpha = 0.05$) between conventional and sonic obturation between the two treatment groups. The t-values between the groups were 1.238 and -0.918 respectively. The difference in frequency of filled spaces between conventional obturation group was 33% and sonic obturation group was 60%, and was not statistically significant ($\alpha = 0.05$).

DISCUSSION

This preliminary laboratory investigation indicated a lack of statistically significant difference between conventional and sonic obturation. The evaluation of results was based on the post-obturation radiograph score, which is limiting, as the two-dimensional image was not an accurate representation of the true three-dimensional obturation. Micro CT scans depict a true 3D representation, but are costly, challenging and may encounter distortion. Based on the extremely limited micro CT scan, one may hypothesize that sonic obturation seems to disperse the endodontic sealer into micro voids more effectively than conventional obturation. However, further studies would be required to expand upon this. The prototype device offered a simple and effective approach for the delivery and obturation for endodontics. Although the device was utilized with commercially available obturators, the sonic application requires an extension to the cleaning and shaping instrumentation to maximize on the MIE philosophy.

CONCLUSIONS

A novel dental endodontic sonic obturator had been developed and demonstrated functionality in vitro. The utility was assessed on human extracted teeth and compared to conventional obturation. The results from the preliminary investigation warrant further research with a larger sample size and a more objective evaluation of performance. Clinical evaluation would require substantial advancement with MIE and significant device testing and approval.

As imaging technologies evolve, it becomes clear that the internal geometry of a tooth is a complex three-dimensional space. The utility of a sonic obturator may have a clinical benefit in effectively eliminating the internal space, providing a predictable and successful hermetic seal and ultimately prolonging the life of the tooth.

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CONFLICT OF INTEREST

The principal author has a financial affiliation with the subject material. Dr. Kalman is the inventor of the device and president of the company, Research Driven, that maintains the intellectual property.

REFERENCES

1. Gutmann JL. Minimally invasive dentistry (Endodontics). JCD 2013;16:282-283.

2. Gluskin AH, Peters CI, Peters OA. Minimally invasive endodontics: challenging prevailing paradigms. BDJ 2014;216:347-353.

3. Clark D, Khademi J. Modern molar endodontic accesses and directed dentin conservation. Dent Clin North Am 2010;54:249-273.

4. Clark D, Khademi J, Herbranson E. The new science of strong endo teeth. Dent Today 2013;32:112-117.

5. Li GH, Niu LN, Selem LC, Eid AA, et al. Quality of obturation achieved by an endodontic core- carrier system with cross linked gutta-percha carrier in single root canals. J Dent 2014;42:1124-1134.

6. Johnson E, Lloyd A, Kuttler S, et al. Comparison between a novel nickel titanium alloy and 508 Nitinol on the cyclic fatigue life of Profile 25/.04 rotary instruments. JOE 2008;34:1406-1409.

7. Webber J, Machtou P, Pertot W, et al. The WaveOne single file reciprocating system. Roots: International Magazine of Endodontology 2011;7:28-33.

8. Castello-Escriva R, Alegre-Domingo T, Faus-Matoses V, et al. In vitro comparison of cyclic fatigue resistance of ProTaper, WaveOne, and Twisted Files. JOE 2011;38:1521-1523.

9. Kansal R, Rajput A, Talwar S, et al. Assessment of dentinal damage during canal preparation using reciprocating and rotary files. JOE 2014;40:1443-1446.

10. Berutti E, Chiandussi G, Paolino DS, et al. Canal shaping with WaveOne Primary reciprocating files and ProTaper system: A comparative study. JOE 2012;38:505-508.

11. Welch SE. Guttapercha coated silver cones as root canal filling material. Ill Dent J 1978;47:604-610.

12. Johnson WB. A new gutta-percha technique. JOE 1978;4:184-188.

13. Beasley RT, Williamson AE, Justman BC, Qian F. Time required to remove obturation materials from moderately curved root canals. JOE 2013;39:125-128.

14. Delivering warm guttapercha throughout the canal (2013). BDJ 2013;214:477.

15. Camilleri J, Gnadolfi MG, Siboni F, et al. Dynamic sealing ability of MTA root canal sealer. IntEndod J 2010;44:9-20.

16. Naik RM, Pudakalkatti, PS, Hattarki SA. Can MTA be: Miracle trioxide aggregate? J Indian SocPeriodontol 2014;18:5-8.

17. Glassman G. Bioactive endodontic obturation: combining the new with the tried and true, MTA Fillapex and continuous wave of condensation. ROOTS 2013;4:16-24.

18. Glassman, G. Mineral trioxide aggregate revisited: a cement for all seasons. ROOTS 2013;4:6-9.

19. Vitti RP, Prati C, Silva EJNL, et al. Physical properties of MTA Fillapex sealer. JOE 2013;39:915-918.

20. Zhou H, Shen Y, Zheng W, et al. Physical properties of 5 root canal sealers. JOE 2013;39:1281-1286.