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Research Article

Comparing Gutta Percha Backfill Leakage Over Multiple Heating Cycles

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Abstract

Introduction: Warm vertical compaction of gutta-percha is a commonly used obturation technique due to the material's thermoplastic properties. However, gutta-percha in backfill systems is often heated, cooled, and reheated multiple times before use, potentially altering its physical properties. This study investigated whether repeated heat cycling affects the sealing ability of gutta-percha, as measured by coronal dye leakage.

Methods: Forty extracted single-rooted human teeth were cleaned, shaped, and randomly divided into four groups (n = 10) based on the number of heating cycles the gutta-percha underwent prior to obturation: Group A (1 cycle), Group B (3 cycles), Group C (5 cycles), and Group D (7 cycles). All teeth were obturated using the B&L Beta Mini backfill system set to 200°C. After obturation, roots were sealed with nail polish (excluding the orifice), submerged in India ink for 7 days, then cleared using a standard decalcification and dehydration protocol. Dye penetration was measured from the orifice to the deepest apical extent using ImageJ. Statistical analysis was performed using two-tailed Student's t-tests ($P < 0.05$).

Results: Group A showed the least dye leakage (2.29 ± 1.07 mm). Leakage increased significantly in Groups B (4.10 ± 1.82 mm), C (5.62 ± 1.91 mm), and D (3.88 ± 1.27 mm) compared to Group A ($P < 0.05$). No significant differences were observed among Groups B, C, and D ($P > 0.05$).

Conclusion: Repeated heating of gutta-percha was associated with increased coronal dye leakage. Clinicians should use caution when reusing gutta-percha subjected to multiple heat cycles to avoid compromising obturation quality.

Keywords: *Dye Leakage, Gutta Percha, Heating Cycles, Backfill*

Introduction

A root canal procedure is typically preformed to eliminate bacterial infection and prevent re-contamination of the canal space (1, 2). Once the cleaning and shaping of the canal system is completed, clinicians must attempt to fill the prepared space in three dimensions. There are several clinically accepted obturation techniques used in today's endodontic offices to try and achieve a hermetic seal of the canal system. One of the most popular techniques is warm vertical compaction of gutta percha and sealer. (3). Two other popular techniques used to fill an instrumented canal are single cone technique and cold lateral condensation technique (4). Both of these techniques do not require the operator to back fill the coronal portion of the canal.

There are several benefits to using gutta percha for the bulk of a root canal fill. "Gutta percha is thermoplastic – a term denoting its extreme sensitivity to temperature" (5). The material exists in two phases, alpha and beta. The phase where the material is a solid compactible mass is the beta phase. When heated, the material moves into the alpha phase, in which the material is pliable and tacky (6). One advantage to this material is that it has a melting interval, meaning there is a temperature range the material becomes moldable allowing for the clinician to mechanically compact it (7). In 1899, Obach discusses the physical properties of guta percha in its different forms, stating that gutta percha at approximately 40-49°C is soft. As the temperature increases to approximately 61-78°C the material is more flexible and moldable (8). Although the softening point of gutta percha is a range, the malleability of gutta percha is only dependable at a temperature of 65°C or higher (9). Based on the statement above one could assume using gutta percha in a warm vertical compaction technique may provide the best 3-dimensionally dense fill. One obstacle clinicians must overcome with the warm vertical technique is the quick and extensive shrinkage of the root canal filling seen upon cooling (10). Previous studies have proven that gutta percha expands slightly during heating and shrinks upon cooling (11). When gutta percha is in its beta phase the shrinkage is around 1-2% upon cooling (3). When the material is in its alpha phase, the phase it's in when obturating a canal, the shrinkage is approximately 4-7% (9). The increase in shrinkage in alpha phase is due to the material being more flowable when heated and undergoing greater contraction when cooling (12). The shrinkage of the material must be taken into consideration when trying to fill a canal in three dimensions to avoid leakage. Endodontic sealer is used in adjunct to warmed gutta percha to help compensate for any gaps that may occur during shrinkage.

The warm vertical technique was previously accomplished by the heating of metal condensers to soften the gutta percha enough to condense the material into the irregular shape of the canal (3). Various modifications and advances in the field have allowed for the warm vertical technique to evolve: these include thermoplasticised injectable gutta percha from an electrical heating unit (13) and thermocompaction (14), to warm and dispense the material directly into the canal, eliminating the need for an open flame and allowing more control over the temperature that the gutta percha is being warmed to. The gutta percha within the unit has the potential to be heated, cooled, and reheated several times before it is used to fill a root canal that has been cleaned and shaped. The purpose of this investigation is to determine if number of heat cycles has a correlation with the amount of coronal dye leakage measured when using a modified warm vertical technique.

Materials and Methods

A total of 42 extracted human teeth with a straight, single root canal were selected and decoronated at the CEJ.

Cleaning and Shaping: Each tooth was accessed with #10 K-file that was be placed into canal until visible at the apical foramen and 1mm was subtracted from that measurement to determine a WL. Each root canal was cleaned and shaped to a final size of 35/.04 Vortex Blue rotary file system. Canals were irrigated with 2 mL of 6% NaOCl initially, through a 30-G side-venting needle. In addition, 1 mL of 6% NaOCl was used after each introduction of a new rotary file. For the final irrigation, all teeth were soaked in 6% NaOCl for 24 hours then saline for 24 hours followed by 17% EDTA for 10 minutes and another saline soak for 24 hours. The canals were dried using sterile, absorbent paper points matching the diameter of final file (35/.04).

Teeth were then divided into 4 groups of 10 teeth each according to the treatment: number of heat cycles were chosen based on how long a single gutta percha pellet lasts for a certain amount of treatments.

Group A: gutta percha that has undergone 1 heat cycle.

Group B: gutta percha that has undergone 3 heat cycles.

Group C: gutta percha that has undergone 5 heat cycles

Group D: gutta percha that has undergone 7 heat cycles.

Obturation: Each tooth was obturated using the B&L beta mini backfill gun loaded with B&L Gutta Percha Pellets (Regular) using a warm vertical technique. The heated gun was set to 200°C and the tip was placed 7mm into the canal. Gutta percha was dispensed in a single continuous push then condensed down using cold pluggers.

Sample Storage: Roots were coated in 3 layers of nail polish leaving the orifice exposed and then submerged in India ink for 7 days. After rinsing in tap water, the nail polish was then gently removed with cotton tips and acetone.

Demineralization/Dehydration/Clearing process: The following process is a clearing technique used by Robertson et al. Each tooth was decalcified by soaking in 5% nitric acid (Sigma) for 5 days, with daily changes of the acid, followed by 4 hours of submersion in running tap water. Decalcified teeth were dehydrated in ascending percentages of ethyl alcohol (Sigma). The samples were placed in 80% alcohol for 12 hours, replaced with 5 ml of 95% alcohol for 2 hours, and replaced with 100% alcohol for 2 more hours. To complete the clearing process, the roots were submerged in methyl salicylate for 24 hours (Sigma).

Using a Zumax operating microscope, an image was taken of each tooth. Images were then uploaded to ImageJ and measurements (in millimeters) of dye penetration were made starting from the orifice and extending apically (16). Measurements were averaged to determine the mean and standard deviation for each group.. Two-tail Student's T tests were used to determine significant differences between groups where P < 0.05 was significant.

Results

The percentage of dye leakage for the whole canal is represented in figure (1). Canals filled with gutta percha that were not pre-heated, Group A, had the lowest amount of dye leakage with an average of 2.29±1.07mm leakage from the orifice (16.7%). Group B, gutta percha pre-heated 2 times, had an average dye leakage of 4.10±1.82mm (26.8%). Group C, gutta percha pre-heated 4 times, had an average dye leakage of 5.62±1.91mm from the orifice (39.8%). Group D, teeth obturated with gutta percha pre-heated 6 times, had an average dye leakage of 3.88±1.27mm from the orifice (33.0%). For all the repeated cycles of heating, groups B, C, and D, the dye leakage was significantly greater that those not preheated in group A (P < 0.05). Additionally, there was no significant differences in leakage between the groups that were heated repeatedly (P > 0.05).

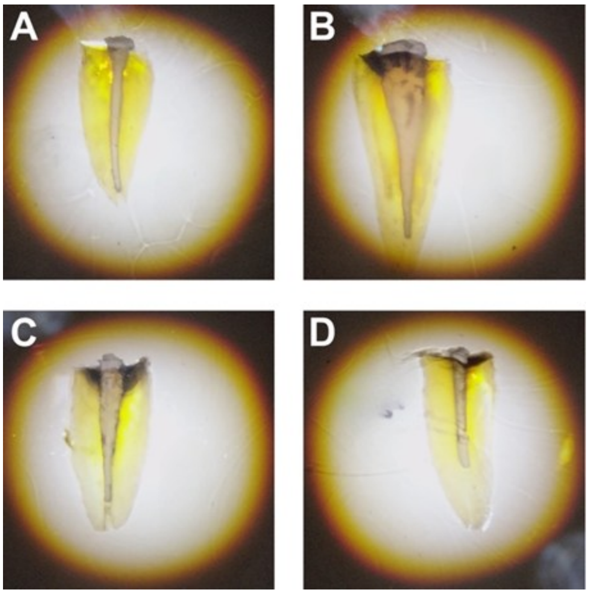

Figure 1. Images representing dye leakage in each group. *Obturated teeth were filled with gutta percha that had previously been heated and cooled in their respective groups. (A) represents gutta percha that has undergone 1 heat cycle, (B) represents gutta percha that has undergone 3 heat cycles, (C) represents gutta percha that has undergone 5 heat cycles, (D) represents gutta percha that has*

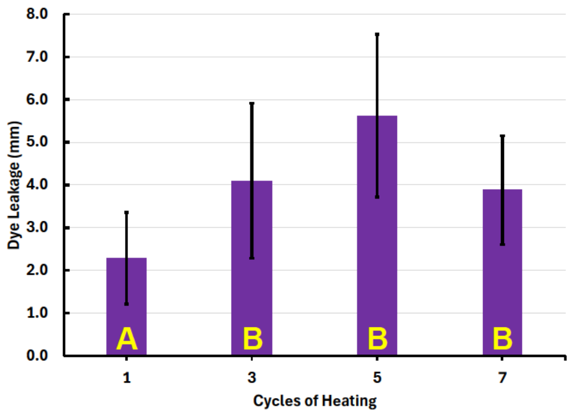

Figure 2. Quantitative comparison of dye leakage. *Obturated teeth were filled with gutta percha that had previously been heated and cooled several times. Bars represent the mean and standard deviation of 10 samples per group. Bars marked with the same letter are not significantly different.*

Discussions

The results observed in this study align with previous studies that report on the changes in gutta percha's physical properties from changes in temperature (10,11). Gutta percha undergoes thermal expansion when heated and contracts upon cooling, with greater shrinkage occurring when transitioning from the alpha phase back to the beta phase (9). This shrinkage can lead to space between the root canal walls and the gutta percha, allowing for potential coronal leakage.

While we hypothesized that increasing the number of heat cycles would result in an greater amount of dye leakage, the data collected did not demonstrate a linear relationship. Gutta percha that was reheated twice (Group B) and four times (Group C) exhibited increased leakage compared to Group A; the leakage in Group D (heated six times) was not significantly greater than that in Groups B or C. One potential explanation is that after an initial degradation in sealing ability, further heat exposure may not substantially alter the material's properties beyond a certain threshold. Alternatively, variations in condensation pressure applied during obturation or slight inconsistencies in gutta percha reflow between cycles may have contributed to this outcome.

These findings have clinical implications for endodontic practice. Given that gutta percha is often reused in clinical settings, either within the cartridge of a backfill system or through reloading of the obturation device, practitioners should be aware of the potential compromise in sealing ability with repeated heating. Although the impact of reheating was significant in this study, the lack of a consistent trend beyond the initial cycles suggests that further research is needed to determine the precise threshold at which gutta percha's sealing ability is irreversibly affected.

Further research is needed to assess whether different brands or formulations of gutta percha exhibit similar trends in leakage following multiple heat cycles. Additionally, investigating alternative sealing strategies, such as the incorporation of bioceramic sealers, may provide insights into mitigating the effects of gutta percha shrinkage. Future studies should also explore micro-CT analysis or bacterial penetration models to provide a more comprehensive evaluation of gutta percha's long-term sealing ability after repeated heating.

Conclusion

Canals filled with gutta percha that were not previously heated showed less dye leakage than groups filled with previously heated gutta percha. When obturating during a conventional root canal procedure, the operator must use caution when backfilling gutta percha pellets that have been previously heated. While no significant differences were observed between the groups subjected to multiple heat cycles, the trend of increased leakage with reheated gutta percha warrants further investigation to optimize obturation techniques in endodontic practice.

Conflict of Interest

The authors declare no conflict of interest.

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