ABSTRACT

Temperature Change in the Apical 2 mm of Gutta-percha During the Continuous Wave Technique

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Purpose

The purpose of this study was to record the average temperature rise in the apical 2 mm of gutta-percha during the continuous wave technique and compare it with published data on the traditional warm vertical technique.

Background

The final objective in root canal therapy is total obturation of the prepared canal space and development of a hermetic apical seal. There are several reasons adequate obturation is a necessary step to successful root canal therapy.

Filling the canal space seals any viable bacteria in the dental tubules or against the canal wall, isolating them from a nutritional supply. A hermetic apical seal also inhibits apical percolation, which by itself is not detrimental, but could act as a nutritional source for residual bacteria and as a reservoir for protein breakdown and perpetuation of a periapical inflammatory response. Finally, obturation helps retard coronal microleakage.

Gutta-percha is the most widely used and accepted root canal filling material. It is compactible, inert and tissue tolerant and easily can be removed if re-treatment becomes necessary. One drawback is that it does not adhere to dentin and must be used with a sealer.

A variety of techniques have been devised to compact gutta-percha into the radicular space. Lateral condensation and warm vertical condensation are the two most widely accepted methods. Lateral condensation calls for auxiliary cones to be inserted and condensed around a primary cone placed in the canal. In 1967, Schilder introduced the concept of warm vertical condensation, which involves heating gutta-percha within the canal space and condensing it apically with pluggers.

Some practitioners prefer the cold lateral technique and others prefer the warm vertical technique. However, the relative difficulty in skillfully performing either has led to the development of many new or hybrid techniques. The popularity of most new methods is short lived because dentists find them no easier or more effective than traditional methods.

Although gutta-percha was thought to be compressed with force that reduced volume, studies have shown it actually is compacted, not compressed. A recent technique that is enjoying wide popularity is the so-called “continuous wave of condensation” root canal obturation technique.

Buchanan introduced the technique, which conceptually is similar to warm vertical compaction, in 1994. The continuous wave of compaction involves compacting gutta-percha cones, warmed by an electrically heated plugger, to obturate the root canal system. The pluggers specifically are designed for use in combination with an electric heat plugger (System B Heat Source, Analytic Endodontics, Orange, Calif.) to provide simultaneous heating and compaction of gutta-percha within the root canal.

Despite its wide popularity, there is little research on this technique. What research there is mainly focuses on root surface temperature changes. There has been no research addressing the thermal profile of gutta-percha within the canal. In particular, the apical temperature change of gutta-percha has a significant impact on obturation quality.

The temperature of the apical gutta-percha affects length control and dimensional stability. Some authors recognized this when they published their series of papers addressing gutta-percha's thermomechanical properties. Temperature elevations should be high enough to allow adequate molding of the apical extent of gutta-percha, but not high enough to thermoplastize the apical gutta-percha. This would result in loss of length control and the apical seal.

Another factor affecting the apical seal is the volume change upon cooling of the gutta-percha. Schilder states that if the apical segment is not elevated above 45°C, molecular transformation is avoided and the ultimate volume changes are small, predictable and controllable. He also advocated applying vertical pressure to compensate for volume changes because of cooling.

One may speculate that, when using warm gutta-percha techniques, practitioners walk a fine line between too much and not enough heat. The purpose of this study was to record the average temperature rise in the apical 2 mm of gutta-percha during the continuous wave root canal obturation technique and compare it with published data on the traditional warm vertical technique.

Methods and Material

Twenty single-rooted extracted teeth were selected for this experiment. The crowns were removed at the level of the cementoenamel junction and root lengths were established between 12 mm and 14 mm. The root canals were prepared with Gates-Glidden burs #2 and #3 and Profile .04 taper (Dentsply Tulsa Dental, Tulsa, Okla.) rotary instruments. The apical preparation was enlarged to a size 40 file to facilitate inserting the thermal probe into the apical gutta-percha.

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A System B plunger was pre-fitted to its binding point in the canal ~5 mm short of working length. A non-standardized gutta-percha size fine-medium master cone was fit to working length with tug back. The cone was removed and dipped in chloroform for two seconds. Upon replacing the cone, the thermal probe was inserted into the apical gutta-percha through the foramen to a depth of 2 mm. This assembly was allowed to stand for five minutes to allow the chloroform to evaporate and the gutta-percha to re-solidify.

The temperature reading on the digital thermometer was recorded in tenths of a degree Celsius immediately before compaction was initiated. At the manufacturers recommended setting of 200°C, the heat-activated System B plunger was driven through the gutta-percha point in the canal to a point 2 mm to 3 mm short of its binding point. The heat-activation spring then was released and the plunger was driven the rest of the way to its predetermined length. As Buchanan suggested, vertical pressure was applied for 10 seconds with the System B plunger to compensate for shrinkage from cooling.

After 10 seconds, the temperature of the apical 2 mm of gutta-percha was recorded. The maximum temperature before the gutta-percha began to cool also was recorded. The average temperature change at 10 seconds and the average maximal temperature change were calculated.

Results

The mean temperature rise at the end of the 10-second downpack was 99°C. The mean maximum temperature increase was 2.6°C. The increase was reached at an average of 34.35 seconds after the downpack was terminated.

Discussion

Using the traditional warm vertical technique, Goodman et al. reported temperature elevations of more than 2°C in the apical gutta-percha were infrequently observed. Marlin and Schilder reported increases of 4°C when obturating simulated canals in Teflon rods. More recently, Blum et al. using the Touch n' Heat, recorded apical temperatures as high as 7°C above the base temperature.

Schilder et al. in the thermomechanical properties of gutta-percha measured thermal expansion from 37°C to 45°C. Schilder considered 45°C the maximum temperature the apical 2 mm of gutta-percha could reach. This experiment showed volume reduction of about 37°C accompanied cooling of the gutta-percha back to body temperature.

Even the maximal temperature increases Blum reported fail to reach the beta to alpha transformation temperature and are well below those required for an amorphous change. This lack of apical temperature transfer, however, benefits warm gutta-percha compaction techniques. When apical segments are not elevated above 45°C, molecular transformation of the material does not take place and minimum volume changes occur.

Techniques that use thermoplastics or subject apical gutta-percha to temperatures above the beta to alpha transformation temperature predispose to shrinkage and/or loss of length control. Two recent experiments at the University of Florida illustrate the importance of preventing phase transformation of the apical gutta-percha.

Vakani et al. evaluated apical dye penetration at 3 mm, 5 mm and 7 mm downpacking lengths for the System B. Downpacking at 5 mm from the apex allowed the least apical dye leakage. Presumably, the downpack to 3 mm heated the apical gutta-percha too much, predisposing to shrinkage and the 7 mm downpack did not heat the gutta-percha enough to allow adequate molding at its apical extent.

Frenchman et al. compared apical dye leakage in canals obturated by Thermafil Plus or lateral compaction. Statistical analysis revealed less dye penetration in canals filled by lateral compaction. Thermafil's amorphous nature upon insertion lends itself to significant volume loss upon cooling. Control of apical extrusion also has been reported as a major problem with the thermoplasticated injectable and Thermafil obturation techniques.

The temperature increases reported in this experiment are similar to those previous authors reported using the Schilder's technique. This experiment does not support concerns of significant volume reduction or extrusion caused by overheating the gutta-percha. With proper compaction force, the continuous wave of compaction technique should produce temperatures high enough to allow adequate molding of apical gutta-percha.

Interestingly, the maximum temperatures in the apical 2 mm are achieved roughly 35 seconds after the downpack is completed. The continuous wave technique advocates applying pressure only for 10 seconds, at which time the apical gutta-percha only has increased an average of 1°C. One should assume longer application of compaction forces to be beneficial to this new technique.

References