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RESEARCH ARTICLE

AN EX-VIVO EVALUATION OF THERMAL CHANGES IN PERIODONTAL LIGAMENT DURING THE USE OF THERMOPLASTICISED GUTTA PERCHA OBTURATING TECHNIQUES

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ABSTRACT

Gutta-percha is the most common obturation material used in root canal therapy. Heated thermo plasticised obturation techniques have shown to cause a temperature rise on the external root surface which may result in potential damage to the surrounding periodontium. Forty five human permanent incisors, with a single canal, were divided into 3 groups of 15 teeth each. Root canal preparation was done and the teeth were surrounded by alginate simulating the periodontal ligament in the clinical situation. A small window was cut into the test tube and through the alginate to allow access for the thermocouples for measuring the temperature. Canals were obturated using Warm vertical compaction(group I), Injectable thermo plasticized gutta percha techniques Obtura II(group II)and Elements obturating system(group III).Immediately before each experiment, the teeth were equilibrated at 30^0 C and all experiments were performed at a constant room temperature. Results showed that there was a significantly higher rise in temperature on the outer root surface of mandibular incisors in Elements group when compared to Obtura II and Warm vertical compaction groups. Out of 7 mandibular incisor teeth, 5 teeth exhibited temperature rise above 6^0c.So, the relatively higher temperature rises on the root surface suggest that caution should be exercised when using higher temperature thermo plasticized gutta percha technique to fill teeth with thin remaining root dentin.

INTRODUCTION

Root canal treatment can be predictably successful with careful cleaning and shaping of the canal system, three-dimensional obturation, and a well-fitting coronal resto-ration. Obturation of the root canal system is an integral part of the root canal therapy as it aims at sealing all portals of exit present in the concerned tooth(Marzius Lipski,2004).The objective of obturating the root canal is the substitution of an inert filling in the space previously occupied by the pulp tissue, to prevent recurrent infection by way of the circulation (anachoresis) or through a break in the integrity of the crown of the tooth.

Endodontic therapy aims for appropriate debridement of pulpal tissue and shaping of the root canal to receive an appropriate filling material resulting in an inflammatory free state. The root canal system is very complex and is well documented with fins, lateral and accessory canals, apical deltas and isthmuses. These can be cleaned may be with ultrasonics and recently available irrigating devices. For these reasons it is difficult to shape the canals to a form that can easily be filled in all dimensions (Marzius Lipski,2004). The material most commonly recommended for obturation techniques is gutta percha. Its physical properties have made several different root filling techniques possible. Lateral compaction of gutta percha has proven to be very popular and clinically effective obturation technique. However the final root canal filling in this technique lacks homogeneity and may also result in vertical root fractures if excessive condensation forces are used. To avoid such problems, different warm gutta percha techniques have been introduced. One of these is Warm vertical compaction technique described by Schilder in which gutta percha is heated and packed with a plugger within the root canal space. However the vertical compaction technique is also very time consuming and is difficult to use in small and curved canals. Additionally this technique employs the use of an instrument heated with an uncontrolled heat source (R.N. Weller *et al*, 1995).

The other thermoplasticised gutta percha techniques include Obtura II and Elements obturating system. Obtura II is a system which consists of a control unit,a hand held gun that contains a chamber surrounded by a heating element into which a pellet of gutta percha is loaded and heated to a temperature of a minimum 160^0C, When plasticized, the gutta percha extruding from the needle has got a temperature of 60^0C which is injected through silver needles into the prepared root canal(Marzius Lipski,2006; Marzius Lipski,2005;Villegas JC *et al*,2005).

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Elements obturating unit offers a modification of warm gutta percha technique. The main advantage of this technique is that downpack and backfill of gutta percha can be achieved in one equipment. The manuafacturer states that the ideal operating temperature is 200^0C.

These heated thermoplasticised obturation techniques have shown to cause a temperature rise on the external root surface which may result in potential damage to the periodontal tissues. However it has been accepted that 10^oC is permitted level of temperature augmentation on external root surface 47^oC (Mauro Venture *et al* 2004). The present study was designed to evaluate the temperature rise on the external root surface during the use of Warm vertical compaction, Injectable Thermoplasticized gutta percha technique- Obtura II and Elements Obturating System.

MATERIALS AND METHODS

Forty-five human permanent incisors (maxillary central incisors & mandibular central incisors), with a single canal, extracted for periodontal reasons, were used in this study. Teeth were divided into 3 groups of 15 teeth containing 8 maxillary central incisors and 7 mandibular central incisors. The roots were cleaned of soft tissue and calculus using hand instruments. All specimens were inspected under Dental operating microscope (CARL ZEISS, OPMI, PICO; GERMANY) at 2.5x magnification to disclose any defects or root fractures and to confirm complete formation of apices. For better access the crowns were sheared off at the level of cementoenamel junction.

Root canal preparation

After access cavities were prepared and the pulp extirpated, the working length was recorded and a mark was placed on the outside of the root 5mm coronal to the apex. The canals were enlarged apically to size #30 using K file (MANI Inc-JAPAN). The walls were flared with a step-back technique. The canals were irrigated with 2 ml of 1% Sodium hypochlorite solution (PRIME DENTAL PRODUCTS, INDIA)after each instrumentation. Finally the canals were flushed with saline and dried with paper points. Teeth were embedded in alginate impression material contained in test tubes stuffed with moist cotton to prevent dessication of water from alginate. As the roots were surrounded by alginate they simulated the periodontal ligament in the clinical situation. A small window was cut into the test tube and through the alginate to allow access for the temperature probes (Fig 1).

Figure 1 Tooth embedded in alginate contained in test tubes stuffed with moist cotton to prevent dessication of water from alginate. A marking was made at 5mm coronal to the root tip (shown with an arrow).

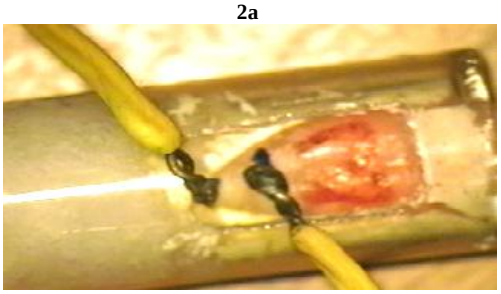
Immediately before each experiment, the teeth were equilibrated at 30^0C and all experiments were performed at a constant room temperature.

Experimental design and Grouping

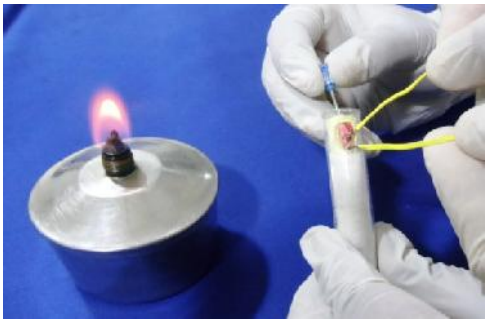
GROUP I: ***Warm vertical compaction***

Fifteen teeth were taken in this group. An appropriate finger plugger (MANI Inc-JAPAN) was selected by checking its fit in the canal 5mm short of working length. Master cone was selected. A thin coat of zinc oxide eugenol sealer was applied to the canal walls. The selected plugger was heated on a hot flame and is directed into the canal to its binding point and held in position for 10 secs. Simultaneously the two temperature probes were placed on the root surface one at the tip and one at 5mm above the root tip. The temperatures were recorded using digital thermometre connected to the temperature probes (Fig 2a, 2b, 2c).

2a



2b



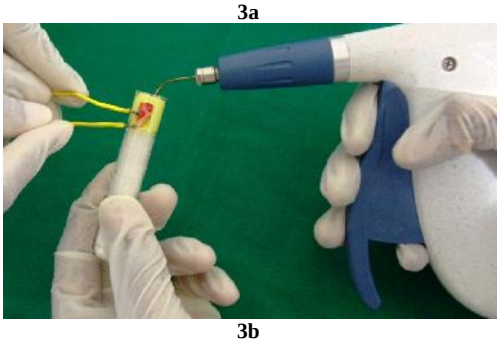
2c

Figure 2 a.)Thermocouple temperature indicators.b.) Thermocouples positioned on the root surface.
c.) Thermal changes being recorded during warm vertical compaction.

GROUP II: ***Obtura II***

The Obtura II gun was loaded with a gutta percha pellet and the fit of the silver needle at the tip of the gun was checked so that it was 5mm short of working length. Thin coat of sealer was applied and all the teeth in this group were obturated and increase in the temperatures were recorded (Fig 3a, 3b).

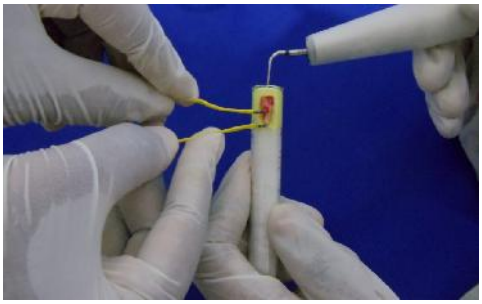
3a



3b

Figure 3a.) Obtura II unit, b.)Thermal changes being recorded with Obtura II

4a



4b

Figure 4 a.)Elements obturation system b.) Thermal changes being recorded with Elements obturation system

GROUP III: *Elements obturating system*

A Buchanan plugger that matched the taper of the gutta-percha was prefit to its binding point in the canal. 5 mm short of working length .The canals were coated with sealer. The heat source was adjusted to 200^0c and touch mode was activated. As the touch spring was pressed, initiating the softening prior to compaction. The plugger was driven through the gutta percha cone in the canal to within 3 to 4 mm of the binding point, touch spring was released, and then apical pressure was maintained on the plugger for seconds, allowing the apical segment cool under this force (downpack phase) activated for 1 second and the plugger is retrieved. The obturation of the remaining canal was not completed, since the first procedure was the focus of this study. The increase in temperatures was recorded (Fig:4a, 4b).

RESULTS

Statistical analysis

Data obtained were analysed using ANOVA test, p = 0.00 (Statistically highly significant)for the mean temperature rise on the outer root surface in all the groups (Table I).

Multiple comparision was done between groups using Scheff's Post Hoc analysis which showed significant difference between groups I&III and groups II & III. (Table II).

The highest mean temperature rise was recorded with the use of Elements obturating unit, intermediate rise in temperature with Obtura II and minimum rise in temperature with Warm vertical compaction.

Table I Temperature rise on the outer root surface in all groups.

Groups	Minimum ^{0}C	Maximum ^{0}C	Mean ^{0}C	Standard deviation
Warm vertical compaction.				
At root tip.	1.30	3.40	2.2600	0.6356
5mm above root tip.	1.00	3.40	2.2000	0.8384
Obtura II.				
At root tip.	1.0	4.30	2.3600	1.1394
5mm above root tip.	1.20	5.20	2.4933	1.2959
Elements obturating system.				
At root tip.	3.0	7.00	5.1867	1.2206
5mm above root tip.	4.60	7.30	5.7067	0.8189

Table II Multiple comparision done between groups using Scheff's Post Hoc Analysis.

Groups	Mean difference ^{0}C	Standard error	Significance
Warm vertical compaction & Obtura II:			
At the tip:	0.1000	0.3767	0.967
5mm above root tip:	0.2933	0.3683	0.730
Warm vertical compaction &Elements			
obturating system:	2.9267	0.3767	0.000 (significant)
At the tip:	3.5067	0.3683	0.000 (significant)
5mm above root tip:			
ObturaII & Elements obturating system:			
At the tip:	2.8267	0.3767	0.000 (significant)
5mm above root tip:	3.2133	0.3683	0.000 (significant)

DISCUSSION

The use of thermoplasticized gutta percha for the obturation of root canal systems has become popular during the last decade due to their excellent surface adaptation to the canal walls and homogeneity in the obturation. During softening of gutta-percha in these techniques, rise in temperature on the external root surface has been observed. The present ex-vivo study was designed to allow the assessment of the root surface temperature rise in the presence of a water containing medium similar to the periodontal ligament, which helps to dissipate heat and thereby may prevent tissue damage during the use of Warm vertical compaction, Obtura II and Elements obturating system. In the present study with the experimental technique followed, at no time did the temperature change on the external root surface exceeded 10^0C. However the maximum temperature rise in mandibular incisors reached to 7.3^0C.

One factor which can affect the temperature change on the external root surface is dentin thickness. Dentin is considered to be a good thermal insulator. The thicker the dentin, the less the heat is transferred to the outer root surface. The dissipating property of dentin has been proved in pulp tissue studies, and it is dentins low thermal conductivity that must be credited with promoting an effective insulating property.

In the present study, the temperature changes were determined on the proximal root surfaces of maxillary and mandibular teeth. In accordance with the findings of this investigation, mandibular incisors that were obturated with Elements obturating system exhibited higher rise in temperature on the proximal surfaces. This outcome was expected because the roots of mandibular central incisors have lower dentin thickness in mesiodistal dimension. The application of sealer also is said to have an influence on the rise in temperature on the outer root surface. Barkhordar *et al* measured the outer root surface temperature increase using ultrafil system, both with and without a sealer. The temperature rises recorded using thermocouples were only 1.98 to 3.02 ^{0}C, and the use of root canal sealer lowered the temperature by approximately 1^0C compared with obturations without sealer. The mean maximum temperature rise in Obtura II is 2.9 - 9.57^0C which is below critical level of temperature rise. However studies comparing the temperature rise of Elements obturating system are very few. Hence that was incorporated in this study. This group showed the highest temperature rise which was however below the critical level.

In vitro temperature measurements on the root surface is usually accomplished by using split tooth models where the tooth is embedded in acrylic or the teeth are left surrounded by air, fixed during the filling procedure by a holding device or held in the hands of the investigator. These models, however, do not take in account the water content and high vascularity of the PDL, which can possibly dissipate heat quite efficiently. It is therefore not surprising that the mean temperature increases found in the present study are less than those reported earlier.

Another reason for lower readings may be the fact that the actual temperature delivered was affected by the surrounding atmosphere and also the length of time gutta percha takes to reach the apex. By this time the temperature would reduce considerably to a safer range which could be tolerated by the periodontal tissues. The acute vascular reactions during heating consisted of vascular dilatation and an increase in blood flow rate. The increased blood flow rate was observed at a temperature of 40- 41^0C. Similar reactions have been observed in other connective tissues during heating. In a study of vital dental pulp, hyperemia was observed at temperatures around 39-42^0C and a blood flow standstill at a temperature of 46 ^{0}C with an exposure time of 2mins.During heating, intermittent blood flow and back and forth movements of the corpuscles were registered in some vessels and changes in direction of flow were observed. The first sign of connective tissue injury was a darkening of the fat cells regularly noticed 2-5 days after heating. The fat droplets become enlarged and later resorption of fat tissues follows. Peak resorption occurred at two weeks after thermal injury irrespective of applied temperature. This fat cell increase was only seen together with bone resorption, which is regarded as a sign of fat cell degeneration of the tissue. It seems likely that 47^0c is the border temperature for occurrence of morphologically evident bone tissue injury.

The use of Warm Vertical Compaction technique, Obtura II and Elements Obturating System resulted in a temperature rise below the theoritical critical level for damage to the attachment apparatus of the tooth. The relative low temperature rises on the root surface recorded in this study may even be smaller invivo because of the circulation present in the periodontal membrane. Additionally the thermal conductivity of the tooth root surrounding tissues help to dissipate the heat increase to the root surface.

Many studies have reported on the transfer of intracanal heat to the root surface during the continuous wave of compaction technique. They used thermocouples to measure temperature changes. According to the evidence above, the results of these studies are therefore only representatives of temperatures at selected points of thermocouple contact and do not represent the temperature changes on the whole surface. On the other hand, infrared camera records the temperature on the whole surface, therefore it is not possible to overlook the highest temperature which may occur during temperature recorded with a thermocouple and further more studies need to be designed to accurately and precisely record the radicular temperatures closely simulating the clinical conditions.

CONCLUSION

The following conclusions are drawn from the study

The use of Warm vertical compaction technique, Obtura II and Elements obturating system resulted in a temperature rise below the theoritical critical level for damage to the attachment apparatus of the tooth. The relative low temperature rises on the root surface recorded in this study may even be smaller invivo because of the circulation present in the periodontal membrane. Additionally the thermal conductivity of the tooth root surrounding tissues help to dissipate the heat increase to the root surface.

There is a significantly higher rise in temperature on the outer root surface of mandibular incisors in elements group when compared to obtura and warm vertical compaction groups. Out of 7mandibular incisor teeth 5 teeth exhibited temperature rise above 6^0C. So, the relatively higher temperature rises on the root surface suggest that caution should be exercised when using higher temperature thermoplasticized gutta percha technique to fill teeth with thin remaining root dentin.

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