Temperatures of the Ultrafil Cannula Surface and Extruded Gutta-Percha Mass

Temperature ultrafil sustava za punjenje korijenskog kanala

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Summary

Temperature elevation on external surfaces of a low-temperature Ultrafil system cannula and on the surface of extruded thermoplasticized gutta-percha mass was studied.

The Ultrafil cannula warmed for 15 min exhibited a mean surface temperature of 82.26 °C immediately after withdrawal from the heater. The highest cannula metal applicator surface mean temperature of 34.52 °C was recorded after 8 s. Temperature of the gutta-percha mass extruded from the cannula was observed to fluctuate. Thus, the highest mean temperature of 53.90 °C at the needle orifice and 45.22 °C at the gutta-percha mass extruded for 3-5 mm, was recorded after 12 and 8 s, respectively.

Key words: *thermoplasticized gutta-percha, temperature, thermocamera*

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Introduction

The most common cause of failure of root-filled teeth was a poorly filled root canal. Gutta-percha has been the material of choice for root canal obturation. Several techniques for root canal obturation with room temperature or thermoplasticized gutta-percha have been described. Lateral condensation with the room temperature accessory gutta-percha cones has proven to be a very popular technique, however, it does not provide a homogeneous mass nor is closely adapted to the canal walls (1). Based on the techniques published by Shilder in 1967 (2), a modification of warm gutta-percha using thermomechanical condensation was introduced by McSpadden in 1980 (3). Several years before, in 1977, Yee et al. (4) introduced injectable thermoplasticized gutta-percha for root canal obturation. Several studies have shown the technique to be comparable to other conventional techniques of root canal obturation (5,6). Recently, two new instruments have been introduced which provide electrically heated spreader to allow controlled warm lateral condensation of gutta-percha inside the root canal (7). In the Obtura system (Unitek Corp., Monrovia, Ca), the gutta-percha is warmed to approximately 160 °C before injection into the root canal (8).

A concern has been expressed over the injection of highly heated material into the root canal and using a heat source directly inside the canal (9). Therefore, the aim of this study was to measure the temperatures of the Ultrafil system cannula surface and gutta-percha extruded from the cannula applicator.

Materials and methods

Temperature measurement

Temperature changes on the cannula surface, extruded gutta-percha and root surfaces were monitored using a thermovision camera (Thermovision 880 AGEMA, Infrared Systems AB, Danderyd, Sweden). The data, recorded in real time, were stored on a PC hard disc and analyzed using a corresponding Thermal Image Computer TIC-8000 system (AGEMA, Danderyd, Sweden).

According to the manufacturer's instructions, the Ultrafil cannula (green color) was inserted into the heater prewarmed to 90 °C. After 15 min, the cannula was placed into the cannula slot in the syringe barrel. To standardize the measurement conditions, an ice box was positioned 20 cm beyond each cannula. A computerized temperature recording system was started without delay after the cannula was placed into the measurement position and stopped after 60 s. The cannula was then reinserted into the heater for additional 15 min. The temperature measurement process was repeated, but this time the thermoplasticized gutta-percha was extruded with a squeeze/release motion throughout the measurement period (30 s), with a 3-s pause between squeeze motions. Measurement areas are shown in Fig. 1.

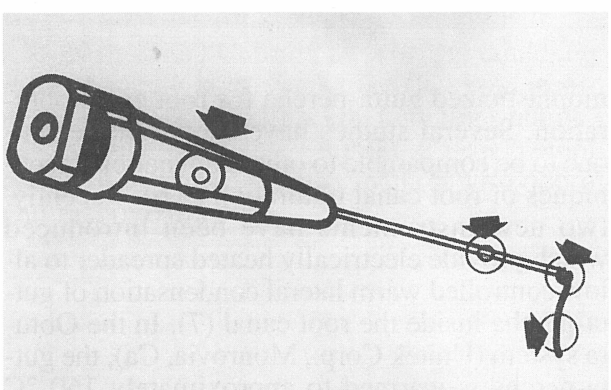

Figure 1. *Measurement points designated by the computer cursor on the Ultrafil cannula and extruded gutta-percha*

Slika 1. *Mjerne površine načinjene kompjutorom na površini Ultrafil kanile i površini istisnute gutaperke*

The measurement was performed in a dental office with normal air-conditioning system, room temperature of 24 °C and humidity of 60%. The experimental model of open air evaluation was chosen to determine the results that might be of clinical relevance.

Results

The mean temperature elevation value of 82.26 °C was recorded on the cannula surface immediately after the cannula withdrawal from the heater. After a 40-s measurement period, the mean temperature decreased to 65.96 °C (Table 1). In contrast, the highest temperature rise

Table 1. *Temperature elevation recorded at the Ultrafil cannula surface*

Tablica *1. Temperaturne promjene izmjerene na površini Ultrafil kanile*

Time (s)	Cannula surface temperature		
	Mean (°C)	SD	Range
2	82.26	2.753	77.0-84.3
4	81.14	2.164	76.5-83.5
6	79.46	2.926	73.6-82.3
8	79.16	1.945	75.4-81.5
10	78.24	1.931	74.6-80.7
12	77.20	1.703	74.0-79.6
14	76.42	1.430	73.7-78.6
16	75.58	1.587	72.9-78.0
18	74.74	1.509	72.4-77.0
20	73.74	1.515	71.4-76.1
22	72.98	1.410	70.4-75.2
24	72.10	1.444	69.2-74.3
26	71.36	1.573	68.1-73.8
28	70.69	1.696	67.2-73.5
30	69.80	1.725	66.0-72.4
32	69.02	1.759	65.0-71.6
34	68.30	1.803	64.1-70.9
36	67.52	1.901	63.1-70.2
38	66.85	1.954	62.5-69.5
40	65.96	1.980	71.7-68.7

(34.52 °C) at the needle surface was recorded 16 s after withdrawal from the heater (Table 2). Thermoplasticized running gutta-percha, extruded from the applicator and scanned at the applicator tip orifice, showed the highest temperature elevation of 53.90 °C, recorded after 12

Table 2. *Temperature elevation recorded at the metal surface of the applicator tip*
Tablica 2. *Temperaturne promjene na površini kovinskog aplikatora*

Time (s)	Applicator surface temperature		
	Mean (°C)	SD	Range
2	29.02	0.889	27.6-29.8
4	29.48	1.613	27.3-31.1
6	29.88	2.268	27.7-32.4
8	29.64	3.432	26.1-34.1
10	29.72	2.164	28.2-33.5
12	31.92	3.060	28.6-35.5
14	32.50	1.850	30.3-35.1
16	34.52	1.194	32.6-35.4
18	32.06	2.569	29.2-36.1
20	32.26	3.131	28.1-36.1
22	30.26	1.605	28.7-36.1
24	29.56	1.161	28.1-31.2

s. The running gutta-percha, recorded at a distance of 3—5 mm from the tip, revealed the highest temperature elevation of only 45.22 °C 16 s after the beginning of extrusion (Table 3). Thermal images of the extruded running gutta-percha are shown in Figs. 2 and 3.

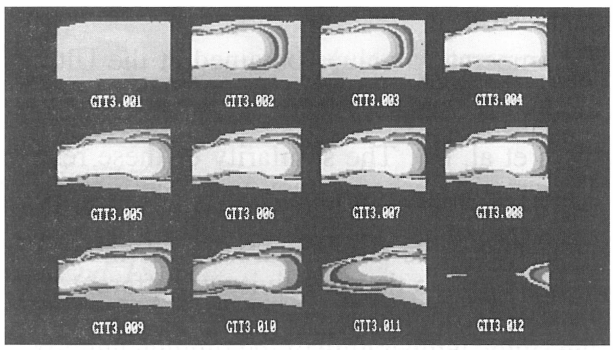

Figure 2. *Thermal image of applicator tip and flowing gutta-percha recorded from 0 to 24 s after withdrawal from the heater*
Slika 2. *Toplinski odraz s površine Ultrafil kanile i gutaperke zabilježen između 0. i 24. sekunde nakon izvlačenja iz grijača*

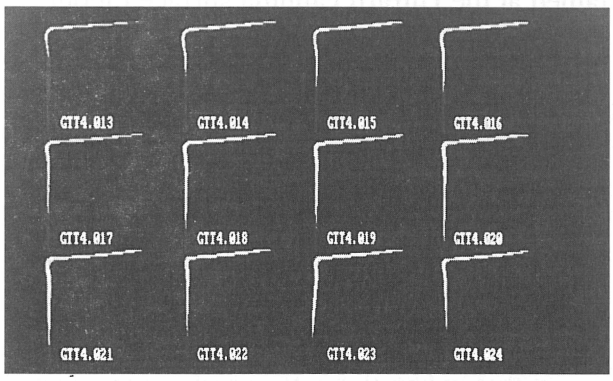

Figure 3. *Thermal image of applicator and extruded gutta-percha recorded from 26 to 48 s after cannula with drawal from the heater*
Slika 3. *Toplinski odraz površine igle i istisnute gutaperke zabilježen između 26. i 48. sekunde nakon izvlačenja iz grijača*

Table 3. *Temperature elevation of thermoplasticized gutta-percha*
Tablica 3. *Temperaturne promjene termoplastične gutaperke*

Time (s)	Gutta-percha temperature at the applicator tip (°C)			Temperature of the gutta-percha mass extruded for 3-5 mm (°C)		
	Mean	SD	Range	Mean	SD	Range
2	34.12	4.146	29.5-37.8	29.16	4.462	21.8-33.7
4	40.28	2.323	38.1-43.8	34.90	2.182	32.2-37.2
6	53.84	4.511	48.0-58.3	42.38	5.023	35.3-48.3
8	53.22	6.032	45.4-57.2	45.22	5.651	37.3-49.9
10	52.82	4.754	45.3-56.0	44.54	4.539	39.7-49.9
12	53.90	3.466	48.5-56.9	44.48	3.863	39.1-48.2
14	49.18	3.063	44.6-52.3	43.00	2.570	39.8-46.6
16	48.90	2.577	46.7-53.0	39.78	2.853	36.6-43.4
18	44.20	3.375	39.7-48.5	36.02	2.012	33.2-38.4
20	41.94	3.710	38.3-47.9	33.42	2.997	29.4-36.6
22	35.80	1.770	33.4-37.7	32.12	1.101	31.4-33.8
24	34.04	1.262	32.3-35.3	27.16	3.601	22.1-31.5

Discussion

Temperature values obtained at the Ultrafil Cannula applicator tip (mean 40.70 °C) were similar to those (mean 46.3 °C) found by Gutmann et al. (8). The similarity of these results is interesting because they used the high-temperature Obtura system and units set to the highest possible temperature. The similarity is possibly due to the sensitivity of different temperature recording systems. However, in the present study, temperature of the running gutta-percha extruded from the cannula was significantly lower (mean values between 34.61—40.70 °C) as compared to 55.3 °C obtained in their study. Temperature values (mean 82.26 °C) obtained at the Ultrafil cannula surface (about 3 s after withdrawal from the heater) are comparable with temperature of 92.40 °C recorded by Donley et al. (10) directly inside a cannula placed into the heater. This temperature difference might be due to quick cooling of the cannula out of the heater and because the plastic cannula walls may have partially preserve the temperature flow. Furthermore, they found the mean intracanal temperature of 33.26 °C (range, 30.65—44.65 °C) after injection of Ultrafil thermoplasticized gutta-percha. Gutmann et al. (8) report that, when the gutta-percha was injected into the prepared canal, the time necessary to fill the canal was less than 10 s. According to this, attention should be focused on the temperature elevation during the first 10 s. In our previous study (11) we showed that during root canal obturation with the Ultrafil low-temperature thermoplasticized gutta-percha, no temperature elevation of the external root surface was observed. There are two possible explanations of such findings. The first (and less probable) is inadequate sensitivity of the thermovision camera. Opposite to this explanation is the fact that the monitored root area was large enough according to the sensitivity of the detector sensitive to radiation between 2 and 5 microns (12). The second explanation could be that the intracanal temperature of the injected gutta-percha mass was not capable to overcome dentin as a thermal barrier. The relatively large amount of dentin remaining after instrumentation is important in limiting the amount of temperature rise (13). In addition, a root canal sealer may also serve as a vehicle for heat dissipation.

The highest mean temperature values (53.90 °C) recorded for the extruded gutta-percha at the tip of the applicator were lower than 62.88 °C, the value recorded by Donley et al. (10). The difference is significant because, in the present study, the gutta-percha extruded at the beginning was relatively cold. This could be due to the quick cooling of the metal applicator. Clinically, however, this would cause no problem, since this gutta-percha only served to establish the gutta-percha flow and not for intracanal injection. With each 14-s squeeze motion gutta-percha becomes warmer at the applicator tip. After that time, a decrease in temperature of the running gutta-percha was recorded at the applicator tip in the experimental conditions. The point is that clinically, if the starting temperature is lower than the safety threshold, rapid cooling is not desirable. Gutta-percha which exists in the molecular a phase, at temperature of 46 to 48 °C begins to convert to the b phase. Finally, between 56 and 62 °C, the a phase starts changing to the amorphous mass (14). Upon rapid cooling, amorphous gutta-percha will crystalize into the b phase between 37 and 40 °C without returning to the a phase, resulting in gutta-percha contraction. This can be avoided by vertical pressure applied during the cool-down phase. However, the green Ultrafil cannula contains gutta-percha which does not allow compaction during obturation, the volumetric shrinkage is reduced by slower cooling of the low-temperature thermoplasticized gutta-percha. Furthermore, canal sealer may also compensate for the volumetric shrinkage.

TEMPERATURE ULTRAFIL SUSTAVA ZA PUNJENJE KORIJENSKOG KANALA

Sažetak

U radu su mjerene temperaturne promjene tijekom rada s Ultrafil niskotemperaturnom gutaperkom, a prije punjenja korijenskog kanala. Neposredno nakon izvlačenja iz grijača, srednja temperatura površine plastične kanile, nakon zagrijavanja od 15 sekundi, iznosila je 82,26 °C. Najviša srednja vrijednost temperature metalnog nastavka kanile 34,52 °C, izmjerena je 16 sekundi nakon izvlačenja iz grijača. Najviša srednja vrijednost temperature mase gutaperke istisnute iz kanile, a mjereno na vrhu igle, iznosila je 53,90 °C. Na površini gutaperke tijekom istiskivanja, mjereno 3-5 mm od vrha igle, najviša srednja vrijednost temperature 45,22 °C, izmjerena je 8 sekundi nakon početka istiskivanja.

Ključne riječi: *termoplastična gutaperka, temperatura, termokamera*

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