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Setting Time And Solubility of Premixed Bioceramic Root Canal Sealer when Applicated with warm Gutta Percha obturation Techniques

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Abstract: *Endodontic sealers are used for obturation of the root canal system in combination with heat-softenned gutta-percha in order to achieve hermetic seal throughout the canal and its irregularities. During warm condensation of gutta-percha, high temperatures are also applied to the root canal sealer which may potentially lead to change in their physical properties. Both setting time and solubility of a premixed bioceramic sealer were investigated through laboratory testing. The material was subjected to two temperature regimes. We did not find signifficant differences in the tested physical parametres under two temperature conditions.The choice of the most suitable endodontic sealer should be consistent with the specific clinical situation as well as with the obturation technique. Different environmental conditions may occur in variation the physical and chemical properties of the sealers that may result in endodontic failure.*
Keywords: *root canal obturation, bioceramic sealer, setting time, solubility*

I. Introduction

Endodontic sealers are used for obturation of the root canal system in combination with gutta-percha in order to achieve hermetic seal throughout the canal and its irregularities. Therefore, sealers help prevent leakage by forming a fluid-tight obturation and are necessary to fill voids and gaps between the core material and the root canal wall. Warm condensation methods have been developed to produce three-dimensional root canal obturations because of the better flow of gutta-percha when heated [1]. Without a sealer, root canal obturations exhibit greater leakage.[2]. During warm condensation of gutta-percha, high temperatures are also applied to the root canal sealer which may potentially lead to change in their physical properties. Most thermoplasticised systems operate at 200^{o}C, althought the temperature athe tip of the pluggers is much lower. In a previous investigations of ours we documented 137^{o}C to be the highest temperature at the tip of 0.06 taper System B plugger. The effect of temperature during warm vertical compaction on root canal sealers has not been extensively investigated.

1.1Objective of the study

The aim of this study is to establish wether changes in setting time and solubility of premixed bioceramic sealer can be induced by application of heat fromthe tip of System B plugger.

II. Materials And Methods

2.1. Setting time

Setting time of Well Root ST bioceramic root canal sealer was tested by dispensing the material into 7 Paris molds containing 12 openings with 10mm diameter and 2mm height. For bioceramic materials require moisture for setting, the Paris molds were first stored at 37^{o}C in a water bath for 24 hours, and then Well Root ST was filled into the cavity. After filling all the molds with the tested material half of the probes(n=42) were subjected to the heat of the tip of System B plugger(137^{o}C), and then the molds were stored in an incubator at 37^{o}C, 95% relative humidity. To determine the setting time a modified Vicat apparatus was used, consisting of a weighted needle of square cross-section of side2mm with a total mass 100g (fig. 1). The needle was lowered vertically onto the horizontal surface of the sealer, and the setting time was identified as the point when the indenter needle failed to make an indentation. The materila was tested every 30 minutes for 3 hours, which 45 minutes longer than the setting time sited by the manifacturer. After acquiring fully set material, the probes were subjected to further investigation by a specific software program.

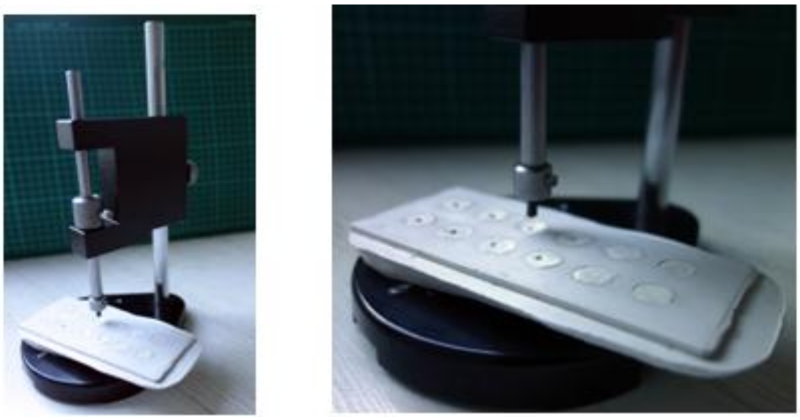

Figure 1. Modified Vicat apparatus-left and right-positioned Paris mold during the experiment.

2.2. Solubility

The solubility of Well Root ST was tested as a percentage of the mass of the specimen material removed from the distilled water compared with the original mass of the specimens. Fourteen Paris molds with 20mm diameter and 2mm height were prepared and were stored in 37°C water bath for 24 hours because of the moisture requierments of the bioceramic material. After filling the molds withe material half of the specimens(n=7) were subjected to the heat of the tip of System B plugger(137°C). All the specimens(n=14) were placed in an incubator at 37°C, 95% relative humidity for a period of time 50% longer than the settig time sited by the manifacturer. The sealer specimens were removed from the mold and weighed 3 times each with accuracy of 0.0001 g (OHAUS PA114 Pioneer Analytical Balance, OHAUS Corporation, New Jersey, USA). The samples were then put in a Petri dish, which was weighed before use and which contained 50ml distilled water. After 24 hours n the incubator , the samples were rinsed with 2-3 ml distilled water, and the washings were allowed to drain back into the Petri dish. The samples and the Petri dishes were dried in an oven at 110°C, cooled to room temperature, and reweighed. The amount of sealer removed from each specimen was calculated as the difference between the initial mass and the final mass of the specimen and the Petri dish.

III. Results And Discussion

At the 30th minute the needle passes through the entire height of the mold.Completely set material was reported at the 190th minute of the experiment in both temperature conditions (fig. 2).

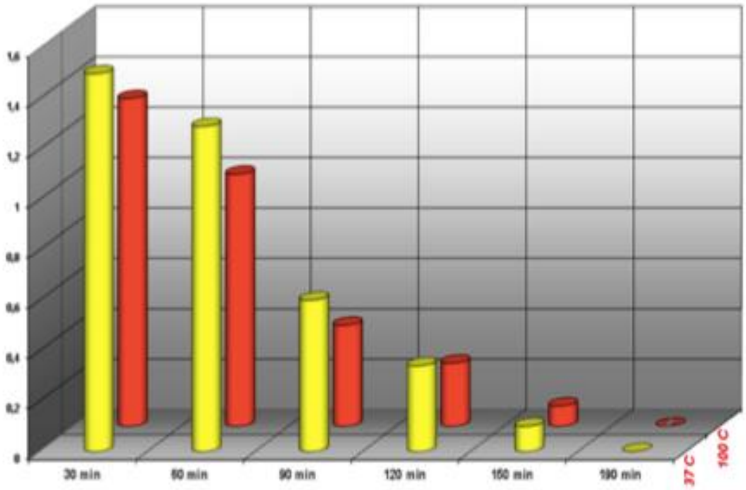

Figure 2 Setting time of Well Root ST in two temperature conditions-137°C(red) and 37°C(yellow)

Setting of the material begins after 30 min from the comencment of the experiment, but the debth of the needle impression shows significant difference after 90 min ($p<0.05$, n=7). The probes reach maximum hardness on the second hour ($p>0.05$, n=7) and their mechanical properties remain unchanged after 190 min.The results obtained differ from the setting time stated by the manufacturer-25th min at 100% humidity and 150 min in clinical conditions.

Changes in the probe hardness in time was evaluated by Kruskal-Wallis test followed by Dunn's Multiple Comparison test forstatistically significant results (Table 1).
The increase in temperature from 37°C to 137°C does not lead to changes in sealer's stiffness (p>0.05, n=7).

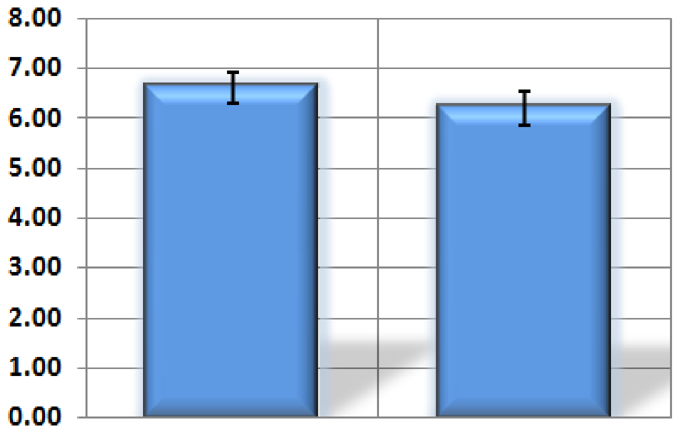

Figure 3. Solubility of Well Root ST in percentage-37°C(left) and 137°C(right).

Solubility of Well Root ST in distilled water is 6,7% for 37°C and 6,2% for 137°C (fig. 3). Insignificant difference was reported between the 2 temperature conditions (37°C VS 100°C**;** P>0.05; n=7, Paired t-test, Table 2). Both result values exceed ISO 6876/2001 of 3% loss of material.

Table 1. Statistically significant results for setting time of Well Root ST**.**

Table Analyzed Kruskal-Wallis test		
P value	**P<0.0001**	
P value summary	***	
Do the medians vary signif. (P < 0.05)	Yes	
Number of groups	12	
Kruskal-Wallis statistic	244,4	
Dunn's Multiple Comparison Test	**Difference in rank sum**	**P value**
37C 30min vs37C 90 min	82,5	P < 0.050
37C 30min vs 100C 90min	103,5	P < 0.001
37C 30min vs 37C 120min	132,3	P < 0.001
37C 30min vs 100C 120min	134,6	P < 0.001
37C 30min vs 37C 150min	176,8	P < 0.001
37C 30min vs 100C 150min	171,2	P < 0.001
37C 30min vs 37C 190min	214,5	P < 0.001
37C 30min vs 100C 190min	217,5	P < 0.001
100C 30min vs 37C 120min	103,5	P < 0.001
100C 30min vs 100C 120min	105,9	P < 0.001
100C 30min vs 37C 150min	148,1	P < 0.001
100C 30min vs 100C 150min	142,5	P < 0.001
100C 30min vs 37C 190min	185,8	P < 0.001
100C 30min vs 100C 190min	188,8	P < 0.001
37C 60min vs 37C 120min	102,5	P < 0.001
37C 60min vs 100C 120min	104,8	P < 0.001
37C 60min vs 37C 150min	147,0	P < 0.001
37C 60min vs 100C 150min	141,4	P < 0.001
37C 60min vs 37C 190min	184,7	P < 0.001
37C 60min vs 100C 190min	187,7	P < 0.001
100C 60min vs 37C 150min	115,3	P < 0.001
100C 60min vs 100C 150min	109,7	P < 0.001
100C 60min vs 37C 190min	153,0	P < 0.001
100C 60min vs 100C 190min	156,0	P < 0.001

37C 90 min vs 37C 150min	94,2	P < 0.010
37C 90 min vs 100C 150min	88,7	P < 0.010
37C 90 min vs 37C 190min	132,0	P < 0.001
37C 90 min vs 100C 190min	135,0	P < 0.001
100C 90min vs 37C 190min	111,0	P < 0.001
100C 90min vs 100C 190min	114,0	P < 0.001
37C 120min vs 100C 190min	85,2	P < 0.010
100C 120min vs 100C 190min	82,9	P < 0.050

Notice: Statistically significant observations are only included in the table (P < 0.050)

Table 2. Solubility of Well Root ST at 37^{o}C and 137^{o}C-variable analysis.

Paired t test	
P value	**P>0.05**
P value summary	***
Are means signif. different? (P < 0.05)	Yes
One- or two-tailed P value?	Two-tailed
t, df	t=0,113 df=7
Number of pairs	7

With novel endodontic sealers being successively develored and comercialized by manufacturers, it has become important for the clinician to understand the physicochemical properties of endodontic sealers. The properties of endodontic sealers are mainly determined by the type and proportions of the main components and can enable them to function adequately under clinical conditions.. Laboratory studies on these properties could contribute to a better understanding of the clinical behaviour and handling performance of endodontic sealers. Recently, new endodontic sealers have been developedthat are based on bioceramic materials in an attempt to create a biocompatible sealerwith ideal physical, chemical, mechanical and biological properties. Such endodontic sealer is Well Root ST [3], [4], [5].

Bioceramic sealers induce a strong interest because of the content of calcium phosphate, silicates and water-free thickening vehicles to enable the sealer to be delivered in the form of premixed paste [6]. Since the inorganic components of the sealer are premixed with thickening agents, water is required for the setting reaction. According to the manufacturers of EndoSequence BC Sealer or iRoot SP, the setting reaction is catalyzed by the presence of moisture in dentinal tubules. While the normal setting time is four hours, in patients with particularly dried canals, the setting time might be considerably longer [7] whereas presence of more water may result in decrease in microhardness of the material. The amount of moisture present in the dentinal tubules of the canal walls can be affected by absorption with paper points [8], the presence of smear plugs, or tubular sclerosis [9].Although the amount of water required the setting of Well Root ST was not investigated in the present study, it was noticed that a thin crust forms on the surface of the material for miniature water drop appear after its fission, at the beginning of the setting reaction. Loushine et al.[10] reported that EndoSequence BCSealer requires at least 168 hours before being completely set under different humidity conditions, as evaluated using the Gilmore needle method, while Zhou et al [11] reported a setting time of 2.7 hours. The setting reaction of EndoSequence BC Sealer is a two-phase reaction. In phase I, monobasic calcium phosphate reacts with calcium hydroxide in the presence of water to produce hydroxyapatite. In phase II , the water derived from dentin humidity, as well as that produced by the phase I reaction , contributes to the hydratation of calcium silicate particles to trigger a calcium silicate hydrate phase [10].

Although the setting reaction of the sealer proceeds a bit faster when subjected to heat, the difference between the two temperature conditions was not statistically significant in the present study. Some authors claim that increase in temperature can lead to faster setting of similar calcium-silicate materials. The setting time reported in our study differs from that given by the manufacturer. This may be a result of the unmetered moisture levels of the Paris mold used in the experiment

Solubility of Well Root ST in both temperature regimes does not meet the 3% ISO requierements by exceeding it with 3%. Both iRoot SP and MTA-Fillapex are highly soluble. This can be attributed to the inherent properties of bioceramic materials or more precisely to the hydrophilic nano-particles that allow more water molecules to come in contact with the sealer.Viapiana et al. [12] find MTA-Fillapex to be highly soluble, while Vitti et al. [13] report the solubility of MTA-Fillapex to be under 3%. This discrepancy between the findings of these studies might be atributed to variations in the methods used to dry the samples after having subjected them to solubility testing.

3.1.Conclussion

The choice of the most suitable endodontic sealer should be consistent with the specific clinical situation as well as with theobturation technique. Different environmental conditions may occur in variation the physical and chemical properties of the sealers that may result in endodontic failure. The laboratory experiments conducted by our team showed some differences in the setting time an solubility of Well Root ST in two different temperature conditions. These differences are not statistically significant which means further investigation and more tests are required for for establishing bioceramic sealers compatibility warm condensation techniques

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