

## PHYSICAL PROPERTIES OF ROOT-CANAL FILLING MATERIALS

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تستخدم حشوات قناة جذر السن لاجل إغلاق فتحة عنق جذر السن المتصلة بعظم الفك من الأسفل. تعمل هذه الحشوة على منع تسرب سوائل الخلايا والسموم والبكتيريا إلى قناة جذر السن عبر قنوات علاج السن. وقد أجريت دراسات عديدة للتعرف على الخواص الفيزيائية لهذه الحشوات. وفي هذا المقال نستعرض بعض هذه الخواص الفيزيائية وطرق تقويمها.

Root canal filling materials are used to obturate the root canal space. Several studies have been made in order to investigate their physical properties. A general review of these properties are discussed in this paper.

Root canal filling materials, including sealer cement and obturation points or cones, are used in root canal treatment to occlude the apical portion of the canal. These will block the dentinal tubules preventing passage of tissue fluids, toxins, and microorganisms into the root canal space. Many investigators have demonstrated the importance of a sealer cement for effective root canal obturations.<sup>1,2,3</sup> Without a sealer cement, complete canal obturation may not be obtained. According to Grossman,<sup>4</sup> the ideal root canal filling material should: (a) seal the canal laterally as well as apically, (b) not be toxic or irritant to the periapical tissue, (c) not shrink after being inserted or upon setting, (d) be impervious to moisture, (e) be bacteriostatic, (f) not stain the tooth structure, (g) set slowly, (h) be soluble in common solvents to permit easy removal from the canal, if necessary, and (i) be radiopaque.

Many studies have dealt with the physical properties of the root canal sealer cements such as setting time, flow, film thickness, solubility, and ability to seal (Table 1). These properties are very important for complete obliteration of the root canal space.

This paper discusses and reviews these properties and the methods for their evaluation.

### Setting Time:

The setting time of an endodontic sealer cement must allow adequate working time for better obtu-

ration. If the setting time is too fast, adjustment and condensation of the filling will be difficult. Slow setting will interfere with the post-endodontic restorative procedures and tissue irritation may be more pronounced as most root canal sealers are toxic before, than after setting.

TABLE 1. A comparison between three endodontic sealers.

Type of test	Materials Tested			Ref#
	Tubli-Seal	Diaket	AH26	
setting time (in min.)				
37°C and 100% hum.	23.5	22.5	-	6
unknown tem. & hum.	17.5	136	43 hrs	7
Flow rate (in min.)	17.5	5.5	7.4	20
	44.3	26.5	-	21
<b>Solubility</b>				
(amount lost in solution w/w)				
one week: in water	0.39	0.16	-	6
in acetic acid	7.84	4.26	-	6
(total weight lost in grams x 10 <sup>-5</sup> )				
oneweek:in2%Broth	5.82	3.00	0.28	25
<b>Marginal Leakage</b>				
0.5% methyl blue: ( 8 days)	1	2	0	7
(mm) (30 days)	0	2	0.5	7
electrochemical: (8days)	4.1	4.9	-	16
(30 days)	5.4	11.4	-	16
<b>Radiopacity</b>				
(in photographic density)	0.67	0.75	-	6

Studies dealing with setting time of root canal sealers<sup>5,6</sup> showed considerable differences due to unstandardized experimental testing techniques

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and products. In one study<sup>6</sup>, the setting time was assessed at 37°C and 100% humidity. In others it was unknown,<sup>7</sup> or at different levels of temperature and humidity.<sup>5</sup> The sealers are to be used at body temperature and at very high relative humidity. Thus, it is important to consider these factors when mixing the sealer; it should be realized that most sealers set much more rapidly at body temperature than at room temperature. The rate of chemical reaction increases with temperature elevation,<sup>5</sup> and small particles set more rapidly than do large ones.<sup>8</sup> Despite the considerable range of setting times determined in the laboratory, no reports yet indicate that the setting times of endodontic sealers cause clinical problems.

#### *Sealing properties:*

The sealing properties of root canal filling materials have been evaluated by many investigators using extracted human teeth, wire core, and glass tube. These leakage studies employed three techniques: (a) dye penetration either with methylene blue or India ink,<sup>9-12</sup> and (b) radioisotopes penetration with <sup>45</sup>CaCl<sub>2</sub>, <sup>14</sup>C-urea, <sup>125</sup>I-albumin, <sup>3</sup>H-uridine or <sup>35</sup>S-sodium sulphate.<sup>13-15</sup> These are intermittent methods as they do not provide continuous data. Measurement are made only at discrete time intervals. The third method (c) is an electrochemical method,<sup>16, 17</sup> which provides continuous measurement of leakage and data that can be reproduced.

There is no general agreement in the literature regarding the relative effectiveness of the sealing action of endodontic sealer cements. An example is the sealing efficacy of, e.g., Tubliseal®. Some investigators reported that it leaks slightly more than Diaket®, and Proco-Sol®,<sup>18</sup> while another reported that Tubliseal® produced a better seal than the other two.<sup>1</sup> Yet one study indicated that Tubliseal® provides a more effective seal than Diaket® but is less effective than Proco-Sol®.<sup>16</sup> Thus, there is a considerable disagreement about the sealing efficacy of endodontic sealers.

Until now, there is no good study established to determine the sealing property of root canal filling materials.

#### *Flow Rate and Film Thickness:*

Flow, which is the ability of a sealer cement to penetrate into irregularities and accessory canals of

the root canal system, is a very important property. It has been evaluated by many investigators. Film thickness can be assessed by the glass plate method,<sup>19</sup> while flow rate has been studied by the capillary tube method.<sup>18, 20, 21</sup> Some flow studies<sup>18</sup> reported rapid flow with certain materials, whereas others<sup>20</sup> reported very slow flow rate. Weisman<sup>20</sup> reported that the particle size plays a role in sealer flow, and that there is a relationship between film thickness and flow rate. The film thickness of sealer cement is influenced by the viscosity and size of filler particles in the sealer. A thin film, for example, maximizes the volume of the gutta percha core.<sup>6</sup> The ability to form a thin film is a similar characteristic, as the flow rate, but, according to Higginbotham,<sup>6</sup> they have poor correlation<sup>11</sup> due to differences in the measuring techniques.

#### *Compressive Strength:*

Compressive strength is also an important characteristic. A sealer with a high compressive strength is durable and supports the tooth structure weakened by the cleaning process. Also, it effectively resists the displacement of cones during post and core placement.<sup>6</sup> A study was reported by Curson and Krik,<sup>7</sup> where tapered stainless steel posts were cemented into prepared root canals of extracted teeth using ten different root canal sealers. The teeth were then stored in water and the post was pulled out with a tensometer after 1, 2, 7, 16, and 30 days. The strength of some sealers decreased over time, and depended in part on adhesion of the sealer cement to the canal wall and root filling point.<sup>24</sup> Also, some cements allowed an ingress of fluid causing the cement surface to dissolve and, therefore, affecting its strength.

#### *Solubility:*

Low solubility retards dissolution of the sealer cement and prolongs its integrity, mechanical strength, and sealing action.<sup>6, 22</sup> Although root canal sealers solubility is essential for permanent obturation, it is undesirable because the dissolution process can cause the sealer to release components that may be biologically incompatible. Solubility of sealers do not constitute a clinical problem as sealers are rarely used without an obturation points. In general, most sealers had comparable solubilities<sup>6</sup> except, e.g., AH26®, Roth 801®, and Proco-Sol® sealers, which have higher solubility.

**Adhesion and Shrinkage:**

Adhesion of endodontic sealer cements is the mechanical interlocking between the sealer cement and root dentin. It was found that adhesion increased with time reflecting dimensional changes.<sup>7</sup>

Shrinkage of sealer upon setting can affect the integrity of the bond between the sealer and the tooth or obturation point. Wiener and Schilder<sup>23</sup> observed dimensional changes in nine root canal sealers, both visually and photographically, after 7, 30, and 90 days by using suction machine and 'Y' glass tube. In the absence of a solid core, they found that all of the sealers exhibited shrinkage from initial mixing up to 90 days.<sup>24</sup>

**Radiopacity:**

Radiopacity is always mentioned as one of the physical properties of the endodontic filling materials. Higginbotham<sup>6</sup> studied radiopacity by measuring the photographic density with a reflection-transmission color densitometer indicating the transmission of light. The higher the resulting figure, the more light is transmitted through the sample. Radiopacity is important in the selection of the materials for radiographic assessment of the technical quality of the root canal therapy and has nothing to do with the physical properties of the filling material.

**Conclusion**

In order to study the physical properties of endodontic filling materials, a standard methodology should be developed. Due to the lack of standardization, data collected on physical properties of endodontic filling materials is poor.

There is a need for clinical studies and long term in vitro studies as most of the reported research dealing with the physical properties were laboratory based and of short term.

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