

# The Effect of Storage Temperature on Mechanical Properties of Gutta-Percha and Resilon

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## Abstract

**Objectives:** To compare the mechanical properties of Resilon and gutta-percha cones after storing at three different temperatures.

**Materials and Methods:** One-hundred standardized size 40/02 gutta-percha cones and 100 Resilon cones were randomly divided into four groups. The first group of the materials were tested immediately after receipt as the control group. The other three were stored in their packages at  $-12^{\circ}\text{C}$ ,  $4\pm 1^{\circ}\text{C}$  and  $22\pm 2^{\circ}\text{C}$  for three months. Then, obturating cones were loaded by a tensile force at the rate of 5mm/min. Physical integrity of gutta-percha and Resilon cones were also evaluated according to ISO6877. The data were analyzed by one-way analysis of variance, post hoc and t-test. A p-value  $<0.05$  was considered significant.

**Results:** The elasticity modulus of gutta-percha reduced significantly after three months storage at  $-12^{\circ}\text{C}$ , while storage at  $4\pm 1^{\circ}\text{C}$  and  $22\pm 2^{\circ}\text{C}$  had no effect on its modulus of elasticity. In addition, the tensile strength of gutta-percha did not change after three months of storing. The modulus of elasticity of Resilon reduced significantly in all storage conditions; however, its tensile strength did not change. The storage conditions did not have a significant effect on the elongation rate of gutta-percha and Resilon. Eighty percent of gutta-percha cones lost their physical integrity after storage in  $4\pm 1^{\circ}\text{C}$  and  $22\pm 2^{\circ}\text{C}$ . However, storage conditions had no impact on the physical integrity of Resilon cones.

**Conclusion:** Storing gutta-percha at  $-12^{\circ}\text{C}$  can benefit its properties, while keeping Resilon at both refrigerated and room conditions can preserve its mechanical properties.

**Key Words:** Elastic Modulus; Gutta-Percha; Mechanical Phenomena; Tensile Strength

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## INTRODUCTION

Root canal obturation is an important step in achieving a successful endodontic treatment. The main objective of this procedure is eliminating leakage from the oral cavity or the periradicular tissues and it achieves fluid-tight seal along the dentinal wall [1, 2].

The commonly used obturation material in endodontics have remained Gutta-percha and root canal sealers[2-8], although the adhesive strength between dentin, endodontic sealers, and gutta-percha have been shown to be very weak and a fluid tight seal along the dentinal walls is not usually obtained [3,4].

Resilon (Pentron Clinical Technologies, Wallingford, CT) is a polymer-based material which has been developed to be used for obturating of the root canal system. It is a thermoplastic-filled polymer composite that has been shown to have higher bond strength to root canal dentin compared to gutta-percha [9]. Even though increase in the fracture resistance of endodontically treated roots by Resilon has been reported [10], some studies reported undesirable properties of Resilon including low push-out bond strength [11-13], low cohesive strength plus stiffness [14] and low flexural strength [15]. Tay et al. [16] found that Resilon could not achieve a complete hermetic apical seal. Physical properties and handling characteristics of a root filling material have effect on its ability to seal the root canal space adequately [17]. Physical and mechanical properties of gutta-percha are affected by temperature [18,19] and contact with chemical materials [20,21], including soaking in chemical disinfectants [2,22,23]. In a study conducted by Goodman et al. [18], an increase of 4°C in gutta-percha was sufficient to produce softening for compaction. Pang et al. [2] reported an increase in tensile strength and elongation rate of gutta-percha cones after 5 minutes immersion in chemical disinfectant.

Gutta-percha and Resilon may be stored and reserved for months or years under different conditions in supply shops and dental clinics. General terms like "store in a cool area" or "keep away from heat and sun light" that are stated by manufacturers on the package of gutta-percha do not indicate the specific or best conditions that preserve its quality during storage.

However, the manufacturer recommends storage of Resilon cones at 18-24°C.

The aim of this study was to compare the mechanical properties of Resilon and gutta-percha cones and to evaluate the effect of storage temperature on tensile strength, modulus of elasticity, elongation rate and physical integrity of these materials.

## MATERIALS AND METHODS

A total of 100 gutta-percha (DiaDent Group Int, Korea) and 100 Resilon (Pentron Clinical Technologies, LLC, Wallingford, CT) of standardized size 40/02 taper cones were randomly selected from 12 freshly opened boxes of both materials. The cones were randomly divided into four groups. The first group of gutta-percha and Resilon were tested immediately after receipt and considered as the control group. The other three were stored in their packages at -12°C, 4± 1°C and 22±2°C for three months. Then the packages that were stored at -12°C and 4± 1°C were removed and held at room temperature for 24 hours before mechanical testing.

In order to calculate the modulus of elasticity, tensile strength, and elongation rate, obturating cones were loaded by a tensile force at the rate of 5mm/min by universal testing machine (Z050, Zwick/Roell, Ulm, Germany).

Physical integrity of gutta-percha and Resilon cones were also evaluated. In this test, the cones were gripped in a standard device that was designed according to ISO6877 [24]. Briefly, the first five millimeters of the tip of cones were grasped gently in lower grip carefully to minimize damages to the cones. Then the cones were adjusted so that the middle of them were located at the center of the rotating part of the device and the distance between the upper and lower grip was 14mm. The starting point of bending was considered as 0°, then the specimens were first rotated 30° counterclockwise then 60° clockwise and again 30° counterclockwise and these sequences were considered as a cycle. Each bending cycle was completed in approximately 2s and 100 bending cycle were performed for each specimen. After every five cycles, the specimens were observed under a stereomicroscope and presence of any crack was considered as failure in their physical integrity. Ten specimens were examined in each test group for physical integrity and fifteen specimens were used for other mechanical properties.

One-way analysis of variance followed by DunnettT3 as post hoc test and t-test were used to determine the statistical association between the tested groups. A p-value less than 0.05 was considered significant.

## RESULTS

The mean values of tensile strength, modulus of elasticity and elongation rate of gutta-percha and Resilon cones are summarized in Table 1. The modulus of elasticity of gutta-percha reduced significantly after three months at -12 °C storage in comparison with the control group, while storage at 4 ±1°C and 22 ±2°C had no effect on its modulus of elasticity. The tensile strength of gutta-percha did not change after three months storage at different temperatures. Storage of gutta-percha at -12°C for three months resulted in significant decrease in its modulus of elasticity and tensile strength compared to storage at 22± 2°C. There was no significant difference between the gutta-percha specimens stored at -12°C and 4±1°C regarding the modulus of elasticity and tensile strength.

The modulus of elasticity of Resilon reduced significantly after storing at -12°C, 4 ±1°C and 22± 2°C compared to the control group.

The tensile strength of Resilon did not change during storage at -12°C, 4±1°C and 22± 2°.

Storage of Resilon at -12 °C for 3 months resulted in significant reduction in its modulus of elasticity and tensile strength compared to 4±1 °C and 22± 2°C. There were no significant differences between the Resilon cones stored at 22±2°C and 4±1 °C in terms of modulus of elasticity and tensile strength. The storage conditions did not have a significant effect on the elongation rate of gutta-percha and Resilon. The modulus of elasticity of gutta-percha was significantly higher than Resilon in all tested groups. However, the tensile strength of Resilon was significantly higher than gutta-percha only in the group stored at 4±1 °C. The elongation rate of Resilon was significantly higher than gutta-percha cones in all tested groups. Storage for three months at -12° had no effect on the physical integrity of gutta-percha cones compared to the control group. On the other hand, 80% of gutta-percha cones lost their physical integrity after storage in 4±1 °C and 22±2°C for three months. In addition, the least required cycles for inducing fracture in gutta-percha cones reduced to half after storage at 4±1 °C and 22°±2C compared to storing at -12°C.

**Table 1.** The Mean Values (MPa±SD) of Mechanical Properties of Resilon and Gutta-Percha at Different Storage Conditions

Mechanical Properties	Materials	Control	22± 2°C	4± 1 °C	-12 °C	P-value
Elastic Modulus	Gutta-Percha	7.94±2.41	8.84±3.25	5.75±1.95	4.87±1.48	<0.001
	Resilon	4.70±1.17	2.84±1.29	3.41±1.19	1.39±0.24	<0.001
Tensile Strength	Gutta-Percha	7.82±1.57	11.12±4.12	7.89±1.76	8.53±1.72	0.002
	Resilon	9.41±1.54	10.82±1.45	10.33±1.40	8.59±1.64	0.001
Elongation Rate	Gutta-Percha	7.74±3.71	6.64±2.18	9.71±4.67	7.58±2.16	0.09
	Resilon	22.67±5.30	22.82±8.07	27.15±5.46	27.11±7.36	0.10

Different storage conditions had no effect on the physical integrity of Resilon since none of the cones exhibited any fracture after 100 cycles of bending.

## DISCUSSION

Any changes in physical and mechanical properties of obturating materials can compromise the main purpose of their application that is achieving fluid-tight seal along the dentinal wall [1, 6]. In this study, in order to evaluate the effect of temperature on mechanical properties of gutta-percha and Resilon during storage, the following temperatures were selected;  $22\pm 2^{\circ}\text{C}$  as a convenient room temperature,  $4\pm 1^{\circ}\text{C}$  representing the refrigerator's temperature and  $-12^{\circ}\text{C}$  as the freezer temperature. This study showed that the tensile strength of gutta-percha did not change after three months storage at different temperatures, but its modulus of elasticity reduced significantly by storing at  $-12^{\circ}$  for three months. Therefore, storage of this material at freezer temperature resulted in less stiff cones. In a manipulating perspective, decrease in the stiffness of a root filling material might be considered desirable since it could flow into the irregularities and inaccessible spaces of the canal when condensed laterally and/or vertically [2]. Eighty percent of gutta-percha cones lost their physical integrity after storage in  $4\pm 1^{\circ}\text{C}$  and  $22\pm 2^{\circ}\text{C}$  for three months. In addition, the least required cycles for inducing fracture in gutta-percha cones reduced to half after storing at  $4\pm 1^{\circ}\text{C}$  and  $22\pm 2^{\circ}\text{C}$  compared to  $-12^{\circ}\text{C}$ . Storage of gutta-percha cones for three months at  $-12^{\circ}\text{C}$  had no effect on their physical integrity. Therefore, storage of gutta-percha cones at  $-12^{\circ}\text{C}$  could be recommended to improve their flexibility and to preserve physical integrity. The modulus of elasticity of Resilon reduced significantly after storing at  $-12^{\circ}\text{C}$ ,  $4\pm 1^{\circ}\text{C}$  and  $22\pm 2^{\circ}\text{C}$  compared to the control group. Therefore, the flexibility of Resilon cones improved after three months storage at tested temperatures.

The tensile strength of Resilon did not change after 3 months storage at different temperatures. In addition, three months of storage at tested temperatures had no effect on the physical integrity of Resilon cones compared to the control group.

Storing of Resilon cones at  $-12^{\circ}\text{C}$  resulted in significant decrease in their modulus of elasticity and tensile strength compared to  $4\pm 1^{\circ}\text{C}$  and  $22\pm 2^{\circ}\text{C}$ . Thus, storing of Resilon cones at  $-12^{\circ}\text{C}$  improved their flexibility, although it resulted in a reduce in tensile strength. A decrease in tensile strength of endodontic filling material is not advantageous because it means cones will be fractured by lower forces. Hence, storing of Resilon cones at  $-12^{\circ}\text{C}$  is not be recommended. Physical integrity of Resilon cones were preserved at all tested temperatures. There were also no significant differences between the Resilon cones stored at  $22\pm 2^{\circ}\text{C}$  and  $4\pm 1^{\circ}\text{C}$  in terms of modulus of elasticity and tensile strength. Therefore, both conditions would be suitable in preserving its quality.

However, the manufacturer recommends storage of Resilon cones at  $18-24^{\circ}\text{C}$ .

As shown in Table 1, in all conditions, the elastic modulus values of gutta-percha were higher than Resilon. The higher values of the elastic modulus of gutta-percha cones in comparison with Resilon means they are less flexible under the same loading forces indicating that gutta-percha cones need more forces to adapt to root canal walls.

In addition, the elongation rate of Resilon was significantly higher than that of gutta-percha. According to these findings, it may be concluded that a change in the shape of the Resilon cone to an irregular canal shape may occur more readily in response to the same load, and it may compact the space between the cones more densely [2]. Although in clinical situations, these properties of Resilon may benefit for the outcome of root canal filling, other properties such as compressive strength need to be considered jointly.

The higher elongation rate of Resilon than that of gutta-percha in the present study was similar to the findings of a study performed by Williams et al. [14]. In their study, maximum elongation of thermoplasticized Resilon was significantly higher than gutta-percha at room temperature. In the present study, there were no differences between the tensile strength of gutta-percha and Resilon groups after three months storage at  $22 \pm 2^\circ\text{C}$  and  $-12^\circ\text{C}$ . However, storage at  $4 \pm 1^\circ\text{C}$  caused significant increase in the tensile strength of Resilon compared to gutta-percha. Therefore, the Resilon cones that were stored at  $4 \pm 1^\circ\text{C}$  for three months showed a significant better tensile strength compared to gutta-percha in the same condition.

It means higher forces are needed to induce fracture in Resilon cones after three months storage at  $4 \pm 1^\circ\text{C}$  compared to gutta-percha. On the other hand, higher flexibility of Resilon means it is a more suitable material for filling the irregularities and inaccessible spaces of the root canals that can result in a better seal along the dentinal wall and less microleakage from the oral cavity or the periradicular tissues.

### CONCLUSION

Within the limitations of this study, it may be concluded that Resilon is a more suitable material for filling the inaccessible spaces and irregularities of the root canals and it needs less force to adapt to the dentinal walls. Storing gutta-percha at  $-12^\circ\text{C}$  can preserve its quality better than the other tested conditions, while keeping Resilon at both refrigerated and room conditions can benefit its mechanical properties.

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