Capurro, M. A., F. Goldberg, et al. (1993). "Evaluation of the dimensional stability of different thermoplasticized gutta-percha fillings using simulated glass root canals." Endod Dent Traumatol **9**(4): 160-4.

The dimensional stability of different thermoplasticized gutta-percha fillings was analyzed using simulated glass canals. For comparison, gutta-percha fillings obtained with the cold lateral condensation technique was used. The evaluation was done at 0 min, 2 min, 5 min, and 30 min after the filling was completed. The general analysis showed statistically significant differences between 0 min and 5 min- 30 min recordings. No significant differences were found between 0 min and 2 min, and between 2 min, 5 min, and 30 min. Although warm lateral condensation resulted in a poor obturation, it was the only thermoplasticized technique analyzed that did not produce significant volumetric changes between 0 min and 30 min. All the other thermoplasticized filling techniques showed important shrinkage during cooling.

Grassi, M. D., D. J. Plazek, et al. (1989). "Changes in the physical properties of the Ultrafil low-temperature (70 degrees C) thermoplasticized gutta-percha system." J Endod **15**(11): 517-21.

Three tests were used to obtain a basic understanding of the changes taking place in the physical properties of the Hygienic Ultrafil system. The materials studied were raw gutta-percha, gutta-percha points, and the two Ultrafil materials Blue (firm set) and White (regular set) gutta-percha. In the first test a differential scanning calorimeter was used to determine melting points; two crystalline forms were observed in the dental materials and only one crystalline form in the raw gutta-percha. In the second test a magnetic bearing torsional creep apparatus was used in which the rates of crystallization were observed. The differences seen in the induction times of the crystallization are related to the amount of mastication of the gutta-percha. Mastication in this usage is the manufacturers process of mixing the raw gutta-percha with its other components. The gutta-percha is masticated slightly in the points and considerably more in the Ultrafil material. Ultrafil exhibits longer periods of time required to induce nucleation at any specific temperature due to the increased mastication. Melting points were also decreased with increased mastication. In the third test a dilatometer was used to observe isothermal volumetric shrinkage of the materials during crystallization. When the Ultrafil material was compared with the gutta-percha points, the blue material had approximately the same amount of shrinkage, 2.6%; the white material shrank slightly less, 2.2%. The raw gutta-percha being 100% polymer had the greatest amount of shrinkage, 4.6%.

Lee, C. Q., Y. Chang, et al. (1997). "Dimensional stability of thermosensitive gutta-percha." J Endod **23**(9): 579-82.

The expansion and shrinkage of four commercial brands of endodontic thermosensitive gutta-percha were evaluated. A modified volume dilatometry technique was used; the dilatometric system (DS) consisted of Pyrex glass capillary tubes and a specimen chamber. Each sample was weighed to 10(-4) mg, placed in the specimen chamber, and subjected to vacuum for 45 min to eliminate moisture or gases. The DS was gradually heated from 24 degrees C to 80 degrees C and then cooled to 24 degrees C using a well-agitated temperature-controlled water bath. In a parallel set of experiments, the DS was heated in the same manner but cooled to body temperature (37 degrees C) in the water bath and the temperature kept stable at 37 degrees C for 24 h. The level of the mercury meniscus within the DS was monitored to determine the percent volume change of each sample at 2 degrees C intervals. All samples expanded as the temperature was elevated and shrank during cooling. The percent volume change for each of the four gutta-percha products, as the temperature was raised to 80 degrees C, ranged from an expansion of +11.62 to +12.25. As the temperature was lowered from 80 degrees C to 24 degrees C, the percent volume change representing shrinkage ranged from -2.22 to -3.53. When the temperature was lowered from 80 degrees C to 37 degrees C, the products continued to exhibit shrinkage for a range of time between 45 min and 10 h before stabilizing at a fixed volume. The final percent volume change for each experiment, with each product, was positive, ranging from +5.50 to +7.20, with discernible differences between products.

Meyer, K. M., F. Kollmar, et al. (2006). "Analysis of shrinkage of different gutta-percha types using optical measurement methods." Schweiz Monatsschr Zahnmed **116**(4): 356-61.

The aim of this study was to compare the shrinkage of alpha- and beta- gutta-percha of the Multifill-system with commercial gutta-percha. Ten gutta-percha blocks of each of the three types were used. Speckle pattern shearing interferometry was used to prove that no trapped air and material defects were present in the specimens. The optical triangulation method was applied to assess shrinkage. The three gutta- percha types were examined after heating up to 90 degrees C and cooling down to 35 degrees C. Commercial gutta-percha showed less shrinkage (6.5%) than alpha- (7.2%) and beta-gutta-percha (7.3%; p=0.0051 for both comparisons; Wilcoxon's signed rank test). There was a significant difference between alpha- and beta-gutta-percha (p=0.0093; Wilcoxon's signed rank test). In the range of 45 degrees C to 40 degrees C, alpha- and beta-gutta-percha revealed the highest shrinkage (2.2%/5 degrees C and 2.1%/5 degrees C, respectively). Commercial gutta-percha showed the highest shrinkage (1.1%/5 degrees C) in the range of 55 degrees C to 40 degrees C. Overall, shrinkage of all types of gutta-percha was higher than could be assumed from former studies.

Tsukada, G., T. Tanaka, et al. (2004). "Shear modulus and thermal properties of gutta percha for root canal filling." J Oral Rehabil **31**(11): 1139-44.

The purpose of this investigation was to investigate the rheological properties of four commercially available gutta perchas for root canal filling. The relaxation modulus [Gr(0): instantaneous shear modulus] and specific volume of their materials were examined. In addition, the quantity of heat was also studied by differential scanning calorimeter. In a lower temperature range than the first-order transition temperature (melting point), the Gr(0) values of each material were almost identical. A marked decrease of Gr(0) was observed at the melting point, and the range of the first-order transition temperature at heating was from 42.0 to 60.0 degrees C. At higher temperatures than the first-order transition temperature of each material, a considerable difference in Gr(0) values was observed. The transition temperatures obtained by the results of the Gr(0), specific volume and quantity of heat agreed with one another. A marked specific volume change was observed at the first-order transition temperature. The technique using melted gutta percha may not be favourable compared with the conventional lateral condensation technique because melted gutta percha undergoes a large amount of shrinkage during setting.