

# Comparative Evaluation of Physical Properties of Four Tissue Conditioners Relined to Modeling Plastic Material

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## Abstract

**Objective:** Little is known about the interaction of tissue conditioners and modeling plastics.

This study evaluates the influence of a variety of commercial tissue conditioners on alteration of viscoelastic properties of modeling plastics.

**Materials and Methods:** In this in vitro study, the dynamic viscoelastic properties of four commercially available tissue conditioners (TC), Visco-gel (VG), GC Soft-Liner (SL), FITT (FT), and Coe Comfort (CC), relined to modeling plastics with a thickness of 2mm were evaluated after 1 and 7 days of water immersion with the use of storage modulus, loss modulus, and tan delta parameters. Values for these three parameters for each tissue conditioner were statistically analyzed by Kruskal Wallis and Mann Whitney tests with *P* value sets at <0.05.

**Results:** Complex modulus and loss tangent values of TC were not significantly different among specimens containing 0, 2, 5 and 10 wt.%-SZ, respectively. In FT and TC containing 2 wt.%-SZ, these values were not significantly different between 1 and 28 days in both water- and saliva immersions.

**Conclusion:** The results suggest that relining with modeling plastics does affect TC's inherent dynamic viscoelastic properties, while the other tissue conditioners investigated may be found to have changed viscoelastic properties as a consequence of vicinity to the modeling plastics.

**Key Words:** Elastic Modulus; Tissue Conditioning, Dental; Modeling Plastics

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## INTRODUCTION

Tissue conditioners are used for the conditioning of denture-bearing mucosa abused by ill-

fitting dentures prior to fabricating new dentures [1-4] stabilizing a record base, and immobilizing skin grafts held in place with sur-

gical stents [1-3]. A number of dentists also use tissue conditioner as a border-molding and functional impression material, relining existing dentures and interim dentures over implant sites, provisional relining of immediate dentures and ill-fitting dentures, and lining surgical splints. [5,6] When a denture needs relining, it is first observed intra orally to assess the need for peripheral reduction or extension, and a posterior palatal extension is developed with an auto polymerizing resin or modeling plastics.[7] A liner is next placed inside the denture. The final placement of soft liner material can be used as the final impression either following the initial set of the material (as with other final impression materials) or by having the patient wear and function with the prosthesis for a defined period of time.

There may be unsupported parts of the liner on the borders of the denture, and this indicates that localized border molding with stick modeling plastics may be needed before placement of a fresh mix of liner. Although modeling compound and acrylic resin are used clinically, several limitations have mentioned their use including difficult manipulation of resin in the mouth and its limited modeling compared to the modeling compound. On the other hand, modeling compounds are supposed to rapidly deteriorate intra orally, especially if used in conjunction with tissue conditioner materials [7]. Another application of tissue conditioners along with modeling plastics is improving the adaptation of surgical obturators after maxillary resections. The surgical defects in these clinical conditions could be so large that the thickness of lining material would affect the properties of tissue conditioners.

Murata et al. best explored differences among various tissue conditioners in several investigations.[8-11] Their results indicated that materials should be selected in accordance with the specific clinical purpose because of the wide range of viscoelastic properties and property changes with time among materials. Efficacy of issue conditioning materials as

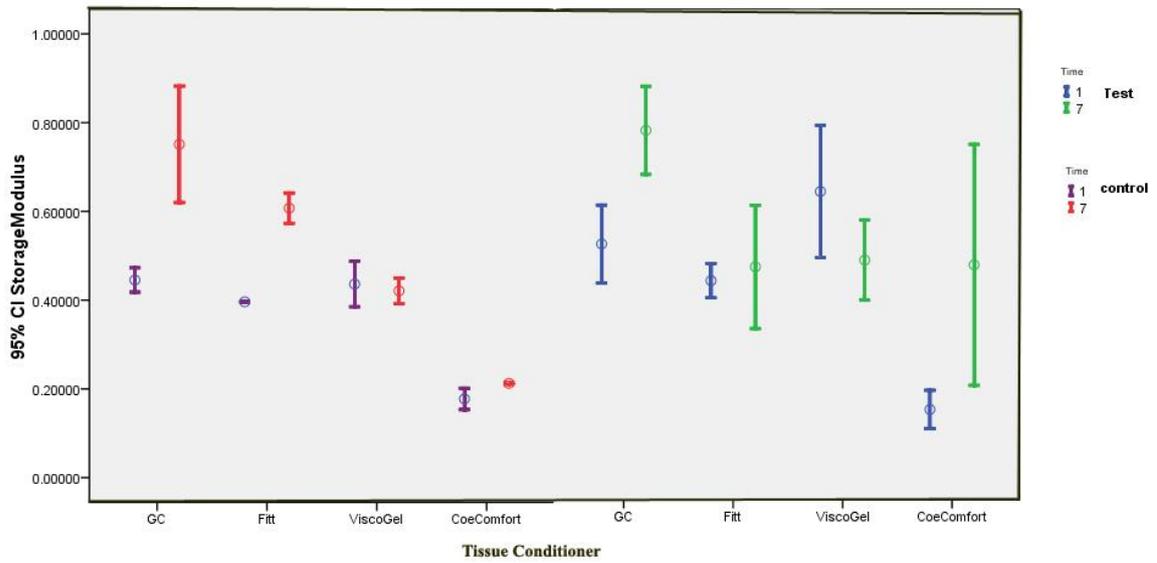
functional impression materials is influenced by their rheological properties, [8-12] dimensional stability, [4,13,14] and ability to reproduce details [4,13] and undercuts. [15] To assess the physical properties of tissue conditioners used as functional impression materials, it is also necessary to determine the changes in viscoelastic properties of the materials over time and the compatibility with modeling plastics in addition to the previously mentioned properties.

Despite these clinical particulars, little information is available on the rheological properties of tissue conditioners relined to modeling plastic material. The purpose of this in vitro study was to determine the effects of lining of four tissue conditioners with modeling plastics on their dynamic viscoelastic properties after 1 and 7 days of water immersions.

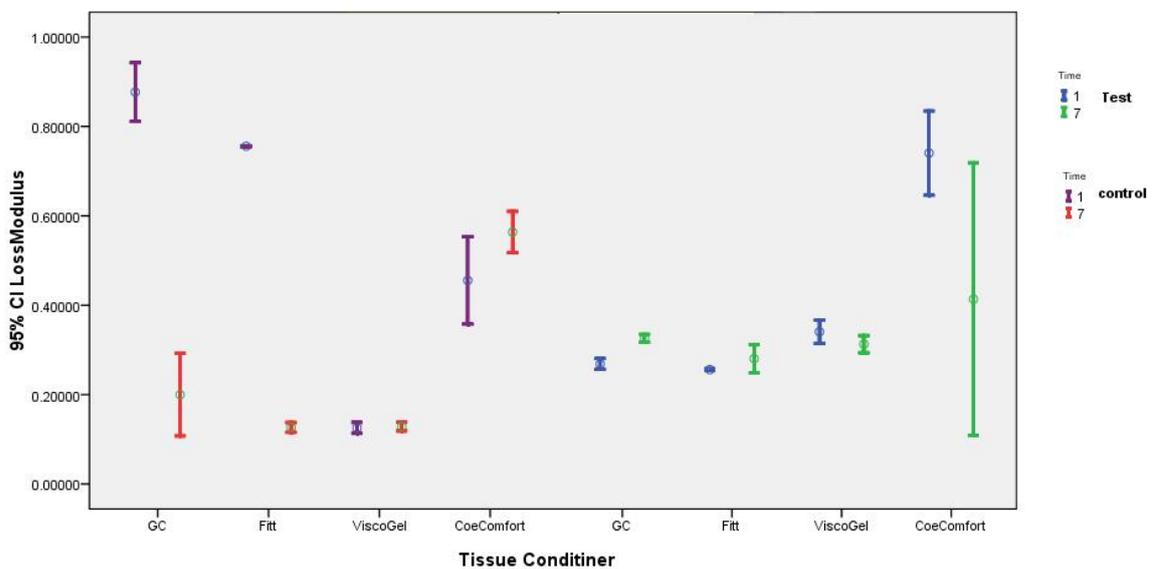
## MATERIALS AND METHODS

Four commercially available tissue conditioners (TC); Viscogel (VG), GC Soft-Liner (GC), FITT (FT), and Coe Comfort (CC) were selected for this in vitro investigation (Table 1). The stick modeling plastic material (Kerr Corp., Orange, CA) was softened in 70°C water bath and was loaded into a stainless steel split mold of 18 mm in diameter and initial height of 2 mm, positioned on a glass plate. A second glass plate covered the container and was pressed down onto the mass and the assembly was put in distilled water at 37°C. After 10 minutes, the powder and liquid of the tissue conditioners were mixed according to the manufacturer's recommendation, and each mixture was poured into the container and its height was increased 2 mm, until slightly overfilled.

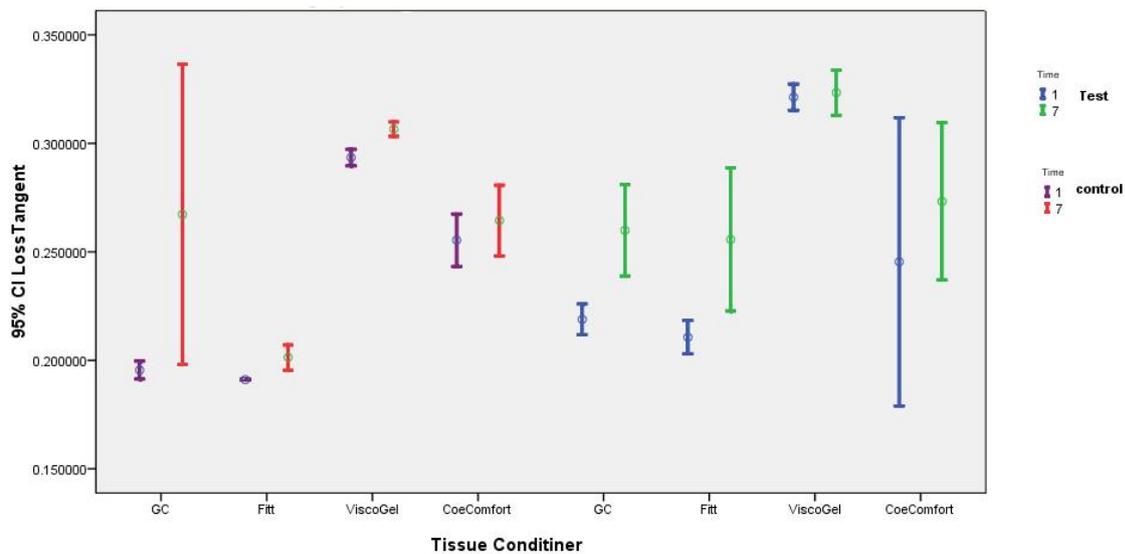
Then a flat glass plate was immediately placed above the mold to extrude excess material. Ten specimens of each of the materials were produced and five of each were immersed in distilled water for 1 and 7 days. Next, [10] of each of the specimens were prepared without modeling plastic liner as control.



**Fig 1.** Average storage modulus in each of the tissue conditioner materials for the test and control groups in 1 and 7 day periods



**Fig 2.** Average loss modulus in each of the tissue conditioner materials for the test and control groups in 1 and 7 day periods



**Fig 3.** Average of loss tangent in each of the tissue conditioner materials for the test and control groups in 1 and 7 day periods

In total, 20 specimens were prepared for each tissue conditioner with/without modeling plastics that resulted in five specimens of each combination for each period of water immersion (Figure 1).

The dynamic viscoelastic properties of the specimens of each tissue conditioner were measured at 1 and 7 days using an automatic dynamic thermo-mechanical viscoelastometer. Loss tangent ( $\tan \sigma$ ) was calculated by the equation:  $E''/E'$ .  $E'$  describes the elastic stiffness of the material and  $E''$  describes the viscous behavior.  $\tan \sigma$  means the scale of energy loss, and materials that absorb energy as a result of deformation show a high  $\tan \sigma$  value. Regression analyses and other nonparametric tests (Mann-Whitney) were used to determine the effect of various tissue conditioners layered with modeling plastics, and time, on the dynamic viscoelastic properties of each material. All statistical analyses were performed using SPSS version 14.0.2 (SPSS, Chicago, IL).

## RESULTS

The mean values of  $E'$ ,  $E''$ , and loss tangent in each of the tissue conditioner materials for test and control groups after 1 and 7 days of water immersion are depicted in figures 1 through 3. Regression analysis indicated significant differences among the materials for storage modulus and  $\tan \sigma$  ( $P < 0.05$ ). It also showed significant effects of time of storage on all three evaluated factors (Table 2). Furthermore, considering layering with modeling plastics, it was showed that storage modulus and loss modulus were affected significantly. Significant storage modulus and loss modulus differences were observed between all the layered and unlayered tissue conditioners after 24 h (Table 3). However, this was observed only in VG and CC for  $E'$ , and VG for  $E''$ , after one week storage. Layering with modeling plastics significantly affected  $\tan \sigma$  in all materials except GC after 1-week storage; and CC after both storage times (Table 3). Mann Whitney test evaluated the effect of storage time in both layered and unlayered groups, (Table 4).

**Table 1.** The Tested Tissue Conditioners

Brand Name	Manufacturer	Code	Powder	Liquid		P/L %W
				Plasticizer	EtOH	
Visco-gel	De Trey/Dentsply, Weybridge, UK	VG	PEMA (86.2%) PMMA (13.8%)	BPBG (86.9%) DBP (8.2%)	4.9%	4.9%
GC Soft-Liner	GC Co., Tokyo, Japan	GC	PEMA (100%)	BPBG (80.9%) DBP (4.3%)	14.8%	14.8%
FITT	Kerr, Romulus, MI, USA	FITT	PEMA (79.4%) PMMA (20.6%)	DBP (80.4%)	19.6%	19.6%
Coe Comfort	Coe, Chicago, IL, USA	CC	PEMA (100%)	BB (87.3%) DBP (4.5%)	8.2%	8.2%

PEMA, polyethyl methacrylate; PMMA, polymethyl methacrylate; DBP, dibutyl phthalate; EtOH, ethyl alcohol; BBP, butyl benzyl phthalate; BPBG, butyl phthalyl butyl glycolate; DBS, dibutyl sebacate.

**Table 2.** Regression Analysis to Evaluate Material, Time, and Modeling Plastic Effects on the Storage Modulus, Loss Modulus, and Loss Tangent

Factor	Storage Modulus	Loss Modulus	Loss Tangent
	P value	P value	P value
Time	<.001	<.001	0.003
Group	<.001	0.002	0.06
Tissue Conditioner	<.001	0.15	<.001

**Table 3.** Multiple Comparison (*P*-value) Results Between Test and Control Groups of Each of the Conditioner Materials in 24-Hour and 1-Week Periods

Comparison	Time	Group	Storage Modulus	Loss Modulus	Loss Tangent
FITT/GC	24h	Test	----	----	----
		Control	<b>0.03</b>	<b>0.005</b>	----
	7 day	Test	<b>0.011</b>	----	----
		Control	<b>0.004</b>	----	<b>0.011</b>
VG/GC	24h	Test	----	----	<.000
		Control	----	<.000	<.000
	7 day	Test	<b>0.016</b>	----	<b>0.002</b>
		Control	<.000	----	----
CC/GC	24h	Test	<.000	----	----
		Control	<.000	<.000	<.000
	7 day	Test	<b>0.012</b>	----	----
		Control	<.000	<.000	----
FITT/VG	24h	Test	<b>0.003</b>	<b>0.018</b>	<.000
		Control	----	<.000	<.000
	7 day	Test	----	----	<b>0.001</b>
		Control	<.000	----	<.000
FITT/CC	24h	Test	<.000	<.000	----
		Control	<.000	<.000	<.000
	7 day	Test	----	----	----
		Control	<.000	<.000	<b>0.015</b>
VG/CC	24h	Test	<.000	<.000	<b>0.02</b>
		Control	<.000	<.000	<.000
	7 day	Test	----	----	<b>0.011</b>
		Control	<.000	<.000	----

**Table 4.** The Results (*P*-value) of Mann-Whitney Test Between Control and Test Groups of Each of the Conditioner Materials in 24-Hour and 1-Week Periods of Keeping in Water

Comparison	Description	Storage Modulus	Loss Modulus	Loss Tangent
		<i>P</i> value	<i>P</i> value	<i>P</i> value
Layered GC/Unlayered GC	24h	0.009	0.009	0.009
Layered GC/Unlayered GC	1 week	1.00	0.60	0.60
24h GC/1week GC	Layered GC	0.009	0.009	0.009
24h GC/1week GC	Unlayered GC	0.009	0.009	0.009
Layered VG/Unlayered VG	24h	0.009	0.009	0.009
Layered VG/Unlayered VG	1 week	0.009	0.009	0.009
24h VG /1week VG	Layered VG	0.07	0.07	0.75
24h VG /1week VG	Unlayered VG	0.75	0.75	0.009
Layered FITT/Unlayered FITT	24h	0.009	0.009	0.009
Layered FITT/Unlayered FITT	1 week	0.11	0.91	0.009
24h FITT /1week FITT	Layered FITT	0.75	0.07	0.009
24h FITT /1week FITT	Unlayered FITT	0.009	0.009	0.009
Layered CC /Unlayered CC	24h	0.009	0.009	0.17
Layered CC /Unlayered CC	1 week	0.009	0.11	0.60
24h CC /1week CC	Layered CC	0.009	0.11	0.17
24h CC /1week CC	Unlayered CC	0.009	0.01	0.25



**Fig 4.** Specimen samples of four tissue-conditioning materials layered with modeling plastics

It showed that GC was affected in both groups and all three evaluated factors.  $\tan \sigma$  in non-layered VG was the only factor that was significantly different between the two storage times.  $E'$  was significantly affected in CC in both layered and unlayered groups, and  $E''$  only in the unlayered group after 24 and 1-week water storage.

The only values that were not significantly different between the two storage times of FITT were storage modulus and loss modulus in layered FITT.

## DISCUSSION

Several articles have described the effect of replacement of a part of denture base with a tissue conditioner or resilient denture liner [3,16,17].

However, most of these articles evaluated the effect of this replacement on the strength of acrylic resin and the role of leaching ethanol of tissue conditioners on this strength. This article tried to investigate how relining with modeling plastics affects dynamic viscoelastic properties of tissue conditioner materials.

The results showed that the dynamic viscoelastic behavior of all evaluated tissue conditioners was somewhat affected by lining with modeling plastics. However, large differences in rheological parameters were found among the materials. Soft liners should ideally exhibit elastic behavior against masticatory forces to transmit the energy required for crushing foods. At the same time, they should behave viscously to distribute forces, absorb energy, and prevent transmission of forces to the denture-bearing tissues by means of a cushioning effect.

In other words, the viscoelastic characteristics would simulate behavior under typical masticatory conditions and under exposure to a continuous weak pressure caused by mucosal tissues returning to their normal positions. In particular, loss tangent values are considered to be important for clinical assessment of the results of dynamic mechanical tests. The higher values of loss tangent would reflect a greater cushioning effect on masticatory forces or higher efficacy in reconditioning of abused tissues depending on the frequency [11].

Murata et al. showed that Visco-gel and Coe-comfort are suitable materials for reconditioning of abused tissues because the change rate of their properties is very low [18]. This finding is in agreement with the result of this study that shows the viscose and elastic behavior of VG are not affected by time. However, regarding elastic behavior, the change rate of Coe-comfort was remarkable that may have been due to the different tests used (dynamic versus static) in these two studies. They also recommended GC soft liner and FITT as suitable materials for temporary relining because of their higher viscosity [18]. Among the tissue conditioner materials, which were layered with modeling plastics, GC and FITT had no significant change in their elastic behavior after one-week storage compared to the non-layered materials. This may imply their use in relining procedures, when it is necessary to use them next to modeling plastics.

When tissue conditioner materials are used together with the modeling plastic, the viscoelastic properties should fit any clinical usage. FITT and GC soft liner had the lowest viscosity among four tissue conditioner materials layered with modeling plastic and the viscosity greatly increases over a week. Thus, the concurrent usage of modeling tissue conditioner materials could be suitable for functional casting. When Visco-gel was used along with modeling plastic, viscosity increased considerably. Viscosity in the layered Visco-gel was significantly more than GC soft liner and FITT, but it did not change significantly over time. The Visco-gel had the most  $E'$  and loss tangent (highest elasticity and impact resilient) and time had a significant effect on the property of the elasticity of Visco-gel. So when Visco-gel is used with modeling plastic material, it may be appropriate for temporary relining [19].

In this study, 7-day samples showed a significant viscosity difference with the 24-hour samples. This may be because when tissue conditioner materials are placed in water, they

simultaneously lose plasticizer and ethanol, and absorb water. Loss of ethanol is significantly more than plasticizer. Most of the ethanol loss happens in the first 24 hours, as the weight percent of ethanol in the Visco-gel, Coe-comfort, GC soft liner, and FITT liquids are 4.9, 8.2, 14.8, and 19.6, respectively.<sup>20,21</sup>

It is possible that when the weight percent of ethanol in the tissue conditioner material is less, it saves the viscoelastic properties more, if kept longer in water. In this study, Visco-gel ranked the lowest ethanol and the time kept in water had the least effect on viscoelastic properties. In addition, GC soft liner and FITT had more ethanol so  $E'$ ,  $E''$  and loss tangent changed considerably. The study conducted by Murata et al. were consistent with this finding.<sup>22</sup> Comparison of changes in viscoelastic properties during a week between the modeling plastic layered samples and samples without modeling plastic layer showed that in Visco-gel samples without layer, only loss tangent changed significantly while the viscoelastic properties did not. In FITT samples with no layers,  $E'$ ,  $E''$  and loss tangent changed significantly, but viscoelastic properties did not change significantly in layered samples during a week. Coe-comfort samples without layers had significant changes in  $E'$  and  $E''$ , but only loss tangent changed significantly in layered samples during a week.  $E'$ ,  $E''$  and loss tangent changed significantly in GC soft liner samples without modeling plastic layers and with layers during a week. This shows that long-term use of modeling plastic could be effective in improving the inherent viscoelastic properties of some tissue conditioner materials, such as FITT, Coe-comfort, and Visco-gel. This effect may be through the release of plasticizer and ethanol [18].

## CONCLUSION

Viscosity of the four tissue conditioner materials without modeling plastic were significantly different and time had no significant effect on their viscosity, except for Visco-gel.

For various clinical purposes, dynamic viscoelastic properties of tissue should be appropriate to the target. Thus, comparison among the four tissue conditioner materials without modeling plastic shows that Visco-gel due to low initial viscosity and lowest viscosity changes over time is a suitable material for tissue conditioning under denture. Coe-comfort is appropriate for functional impressions due to the low initial viscosity and high viscosity decrease over time. FITT and GC soft liner are suitable materials for temporary reline because of their high initial viscosity and high elasticity. Besides, comparison among the four tissue conditioner materials layered with modeling plastic shows that FITT and GC soft liner are suitable materials for functional impressions due to low initial viscosity and high viscosity increase over time. Visco-gel is an appropriate material for temporary reline because of its high initial viscosity and low viscosity change over time and also the highest level of elasticity. The highest effect of modeling plastic on viscoelastic properties of four tissue conditioner materials is in short term and apart from Visco-gel, it does not have a significant effect on tissue conditioner materials in long term.

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