THE RHEOLOGY OF THE SOFT LINER WITH 4-META

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statement of problem The viscoelastic property is the most important and peculiar characteristics of soft liners. But the authorized standard is not certainly established than other dental materials.

purpose of study This study is aimed to compare the initial flow of gelation of the modified soft liner with 4-META with that of PMMA soft liners using dynamic method and evaluate the clinical acceptance of the trial materials.

materials and method This study consists of 3 groups with the given % of 4-META powder in the Coe soft liquid; 0%, 5%, 10%

Each group was tested for 10 times to record the change of G′ values during 3 hours.
the gelation time was recorded by the oscillating rheometer with parallel plate with 1 rad/sec.

results As the results of this study, the gelation time of modified soft liner was elongated by 5 to 6 minutes.

conclusion The mean gelation time of modified soft liner could be within the range of clinically acceptable.

Soft lining materials are well established in prosthodontics, and their clinical application is well documented. Most of these materials are supplied to the dentist in form of polymer powder and liquid. Nowadays, there are the soft liners made of the silicone materials supplied in form of paste like impression materials.[1,2]

Soft liner can be used for the various purpose to patients, for example, treatment of abused residual ridge of the denture wearer, stabilizing aid of recording base, and the reinforcing material for the maxillofacial prosthesis.[2-4]

But, a wide range of gelation characteristics and viscoelastic properties after gelation are found in various commercial soft liners.[5]

Though the physical properties of soft liner have been studied in many laboratory, there are only a few studies about the gelation properties under the condition close to the clinical situations.[6,7] That is to say, some properties of soft liners evaluated in laboratory are sensitive to the test condition. International Standards Organization (ISO) specification 10139-1 was issued recently for short-term resilient lining materials for removable dentures. It specifies requirements for initial flow as determined by the consistency test.[5,8]

Initial flow of soft liners is an important prop-

erty which allows good adaptation of material to the oral tissues with minimal tissue displacement before it sets.[5,9]

The initial flow of the materials determines working time and adaptation between the oral mucosa and the denture surface. So the gelation time of the soft materials can determine the viscoelastic properties of materials and their treatment purpose.[10,11]

There is general agreement on some of the desirable properties of these materials when used as soft liner. Wilson et al. stressed the importance of softness and elasticity. But he also emphasized that the importance of plastic flow for the functional impression materials.

The initial flow of soft liners has been measured with a parallel-plate plastometer by McCathy & Moser in 1978, a cone and plate viscometer (Brandon, 1970) and a reciprocating rheometer.[8]

According to their study, the more accurate and useful data could be obtained by the rheology than by the creep test.

The purpose of this study is the evaluation of the gelation time of the modified adhesive soft liner with rheometer and consider the clinical evaluation of the clinical acceptance of the modified soft liner.

MATERIALS AND METHOD

- Materials -

Table Ⅰ. shows the materials used in this study.

Table Ⅰ. Materials used in this study

Material	Lot No.	Manufacturer
Coe-Soft	0103013	GC America,IL, USA
4-META	98001	Sun Medical Co.,Osaka,Japan

The soft liner used in this study was Coe-soft(GC America, Illinois, USA) which is PMMA soft liner, and the 4-META powder was supplied by the Sun Medical Corporations.

- Apparatus -

The rheometer used in this study was the oscillating rheometer (Haake RS 150 W/TC50, Haake Co., Germany) of parallel plate type with the dimension of 35mm diameter round plate. This appratus, which gives the torsional force of the material, measure the change of the viscoelastic properties of materials over time(Fig. 1).

The frequency of oscillation was 1rad/sec, and the temperature was maintained with 37℃ during whole experiment.

- Method -

This experiment consist of 3 groups ;
Group1-0% 4-META containing group,
Group2-5% 4-META containing group,
and group3-10% 4-META containing group.

To prepare the test specimens, 4-META powder

Fig. 1. Rheometer used in this study.

was mixed into the Coe-soft liquid by the given % concentration by weight till the powder was totally solved.

Then, the liquid containing 4-META was incorporated to the powder by the P : L ratio according to the manufacturer's guide.

Immediately after mixing for 30s at 22±2℃, the paste was placed on the lower plate of rheometer and the upper plate was lowered on its guide into position so that the thickness of material between the two plate was 2mm.

Polymer powder and liquid were kept at 22±3℃ before the test.

During the whole experiment, the temperature of specimens was maintained at 37℃.

To make it as a reference, the preliminary test was done for 3 times during 12 hours. As the result of preliminary test, every specimen recorded the plateau after 3 hours in average. So, in this study we recorded the change of the G′ values for 3 hours. Ten tests were carried out for each groups at 37℃. The gelation time was defined as the time when the G′ value was the 75% of that of the plateau after 3 hours.

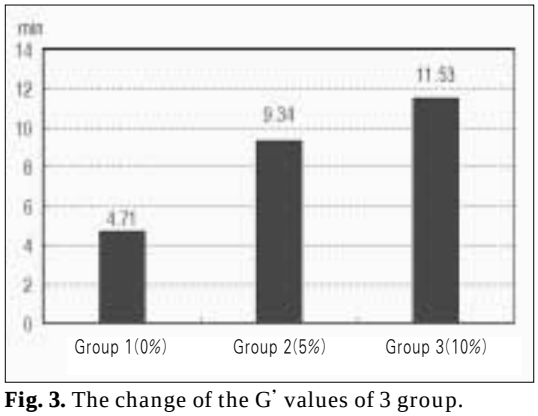

Fig. 3. The change of the G' values of 3 group.

RESULT

As the result of the test, the gelation times are given in Table Ⅱ. and the change of G' values during the experiments are shown in Fig.2.

The mean gelation time of Coe-Soft was 282.7 seconds(4.71 minutes), and those of 5% and 10% 4-META containing soft liner were 560.74 sec(9.34minutes) and 692.2 seconds(11.53 minutes).

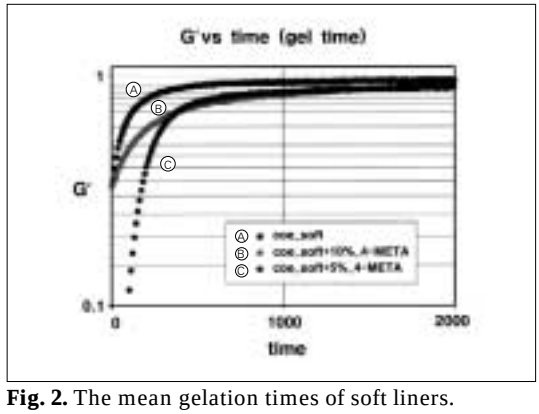

Fig. 2. The mean gelation times of soft liners.

Table Ⅱ. The data and mean values of gelation time

Group1	Group2	Group3
213(sec.)	650.5(sec.)	798.9(sec.)
268	568.5	718.7
290	571.1	635.6
280	682.1	600.9
295	630.4	750.8
286	651	711.3
310	650	667.3
300	602.1	681.3
287	602.5	676.5
298	601.7	680.7
mean: 282.7	mean:560.74	mean:692.2

DISCUSSION

Rheology is not familiar to the dentists. But its application and usefulness are very wide and various to evaluate the dental materials especially for the soft liners.

The rheology defines the ideal material as the elastic solid and the viscous fluid.

So the purpose of rheology is explaining the kinetic movement of all the material and body in terms of phenomenology. In the field of rheology, the soft liner can be defined as the high molecular viscoelastic fluid.[12,13]

Viscoelasticity is the peculiar characteristics of the soft liner and it consist of two characters ; elasticity and viscosity.

To evaluate their viscoelasticity, we can employ several method such as the creep test, stress relaxation test, and the dynamic mechanical test.[13]

Creep test can be defined as the test which measures the deformation of materials under the particular load or force. It is very simple and easy to explain but cannot explain the dynamic phenomenons occurring in the mouth.

Stress relaxation test is the test which measures the stress change according to the time flow after the rapid deformation of specimens. It is very useful to understand the viscoelastic properties of many materials, but needs complicated apparatus and laboratory environments.[10,14]

The dynamic mechanical test is the evaluating the strain of the given specimens under the sinusoidal stress and can predict the characteristics of the micro-molecular structure within the wide range of temperature.

In this study, the gelation time was evaluated using the dynamic mechanical test by oscillating rheometer. An oscillating rheometer is a useful tool to measure setting time for dental materials and represents a complex value involving dynamic viscosity, modulus of storage, elasticity and elastic modulus.[15]

The oscillating rheometer gives the torsional force of the material and measures the change of G′ value according to the increase of the material viscosity.

This apparatus, like the reciprocating rheometer, does not measure absolute value of viscosity, but allows viscosities of various materials to be compared simply and conveniently.

Our definition of gelation time is based on the assumption that the soft liner at a 75% level of G′ value was stiff enough that it could have been removed from the mouth.

G′ value can represent the storage modulus, and can be considered as the elasticity of the soft liner.

The viscoelastic materials behave elastically in response to a rapidly applied force and viscously in response to a more long term force. Considering such properties of soft liners, it needs to evaluate both elasticity and viscosity.[5]

That is to say, the viscoelasticity consists of the G′ and G″. So the G′ means the storage modulus and elasticity and G″ means the loss modulus and viscosity.[13,14]

In this study, the G′ value was selected for measuring gelation time because the degree of stiffness and elasticity have more effect on the time to removal the relined denture from the mouth.

According to manufacturer's recommendations, a denture which has been relined with these material should be removed from the mouth from 3 to 15 minutes after starting to mix.[11]

Murata et al[5](1993) has reported the gelation time of commercial soft liner by oscillating rheometer, and insisted the gelation time of soft liner is within the 3 to 15 minutes.

From their researches, there are several factor affecting the gelation time such as the molecular weight of polymer, powder : liquid ratio, type of

plasticizer and the contents of the ethanol. This can be explained more easily when the gelation reaction and the composition of soft liner are understood.[11]

Soft liner is mainly composed of polymer powder and the liquid. The most commonly used polymer is the PMMA(poly methyl methacrylate) and PEMA(poly ethyl metha crylate). Nowadays, to lower the glass transition temperature, the PEMA powder and copolymer powder were preferred. The liquid is the mixture of the aromatic ester and the ethanol. The aromatic ester is so called plasticizer which has the most important role in the soft liner. Plasticizer such as butyl phthalyl butyl glycolate can lower the glass transition temperature of the soft liner below the room temperature and maintain the softness of this materials.[9,11,18]

The ethanol can be incorporated into the liquid up to 30% and act as a solvent for polymer powder.

When powders and liquids of soft liners are mixed, the PEMA polymer powders swell, diffuse, and dissolve in the solvents. The result is polymer chain entanglement and coherent gel formation.[15]

In this study, the soft liner was modified with 4-META powder.

4-META is the synthesized chemical which is known as the adhesion promoting chemical developed by Tanaka et al.[16,17]

In other study of ours, we reported the increased bond strength of the modified soft liner.

As the result of this study, the gelation time of the modified soft liner was much longer than the control group, and the more 4-META in liquid, the longer became the gelation time.

The exact reason of the elongated gelation time was not analyzed yet, but it could be assumed that the 4-META in liquid may inhibit the entanglement of the polymer to liquid via ethanol.

But the gelation time was the within the range of the clinical application. So the modified soft liner can be used in the metal based denture relining to improve the bond strength between two materials.

To manipulate more easily and produce the optimum thickness in the mouth with the modified liner, it is more helpful for the clinicians to delay the time of removal the relined denture from mouth for about 5 minutes and raise the P;L ratio because of their larger flow at initial stage and the elongated gelation time.

The results of this study suggests that it is possible to reline the metal based denture using trial modified soft liners with 4-META to obtain the desirable treatment goal with somewhat correction of P : L ratio accompanied.

CONCLUSION

1. From this study, the mean gelation times of the 0%, 5%, 10% 4-META containing groups were about 4.7minutes, 9.3 minutes and 11.5 minutes.
2. The gelation times of the modified soft liners were whithin the range of clinincal applicaion.

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