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Tissue Conditioning Materials as Functional Impression Materials

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Abstract - *There has been much written on the subject of tissue conditioner materials. In the context of functional impressions however there exists a lack of consensus opinion. In this article various aspects of functional impression materials have been considered. These include the effects of powder to liquid mixing ratio (P/L) on the visco elastic properties, effects on the surface hardness of dental stone when these materials are cast, undercut reproducibility, compressibility and dimensional stability. Definitive conclusions are difficult to draw however it seems the evidence supports the use of tissue conditioners as functional impression materials.*

KEY WORDS: Dental impression materials, Denture liners, Functional impressions, Tissue conditioners

INTRODUCTION

The British Society for the Study of Prosthetic Dentistry defines a functional impression material as an impression modified by masticatory loads and adjacent muscular activity[1]. Within the definition a reference is also made to mucodisplasive impression materials. These are defined as impression materials used with the intention of displacing soft tissues under the denture base. Central to this definition is that functional impression materials may be modified by masticatory loads. Edgar et al[2] defined functional impression materials as those which when applied to the fitting surface of a denture or an impression tray, records the topography and position of the basal seat and border tissues as they exist in a functional state.

The key words masticatory load and functional state imply the material must be left within the patient's mouth for an extended period of time to create an impression under functional loading and movement. The authors of this article consider functional impression materials having the ability to record surface details accurately for a period of time in the mouth under masticatory loads, to retain this form during the removal from the oral cavity and subsequent cast production. There has been no recent review of the literature in the last decade, therefore an outline of the properties and behavioural characteristics required of a functional impression material is reviewed and placed into a clinical context in this article.

There exists in the literature a spectrum of reports advocating the use of a variety of historical materials and methods for the taking of functional impressions, for example black gutta percha and other thermoplastic materials[3]. Despite the use of these materials todate in a few dental units, the selection of materials reviewed in this article has been limited to those that are employed in contemporary clinical practice. A number of articles have been written advocating tissue conditioning materials for use in functional impression taking[2,4,5]. There is evidence to support dentures constructed involving the use of functional impressions are comparable to dentures constructed using conventional techniques [6,7] yet this is not without controversy. Wilson and co-workers[5,8] in their work on tissue conditioners concluded that the materials used as functional impression materials should be plastic with low elastic recovery presumably in the context of retaining the accuracy of the functional impression, while those used for tissue conditioning should be soft and elastic. They state that these properties could not be present in the same material and therefore a product which is said to be applicable for both functional impression taking and tissue conditioning; have properties which are far from ideal for either purpose. However Wilson's study also indicates that tissue conditioning materials do have the essential properties required to create a satisfactory impression material provided working casts are poured promptly due to the rapid recovery of these materials.

It is the viscoelastic properties of tissue conditioners that enable them to act as functional impression materials. They are able to flow under linguistic and masticatory forces, whether static or dynamic, thereby creating the impression over time. As for all materials used intraorally, there exist the general prerequisites which include ease of manipulation and lack of toxicity.

The ideal properties of functional impression materials include:

1. Plastic flow, allowing the material to record the tissue surfaces during function.
2. Dimensionally stable, so that they can be removed accurately from the mouth and cast accurately.
3. Compatibility with gypsum products.

The ideal properties for tissue conditioners require the material at first to flow readily, with even consistency throughout the fitting surface of the denture when the den-

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ture is first inserted. Subsequently the material progresses through a pre-gelation (sol) phase through to a sol-gel transition and post gelation (gel)[9] phase. The gel state helps the material to remain within the denture borders under functional loading. These properties equate to a visco-elastic material. The material deforms under functional loading, allowing the tissues to modify the fit surface, whilst remaining intimately adapted to them. When used as a tissue conditioner this is conducive to the healing of tissues. Soft tissues will exert a spectrum of forces of differing durations depending upon the activity chosen by the patient. The beauty of a functional impression is it provides the clinician with the most complete picture of soft tissue activity over a time period consistently longer than conventional impression materials.

In order for a material to allow the generation of a functional impression, it should exhibit a number of characteristics. Some of these are inherently present within tissue conditioning materials. An understanding of the requirements of functional impressions materials requires a brief analysis of tissue conditioning materials. Therefore, a review of the literature was undertaken with a view to determine the ability of this class of material to be used in the generation of functional impressions.

DISCUSSION

Tissue conditioning materials develop a spectrum of qualities over time. After initial mixing there first develops a viscous quality followed by a plastic and finally an elastic stage, which, if the material is left in the mouth long enough, chemically alters and hardens. It is these characteristics which allows use of these materials in the creation of functional impressions.

Modern materials used for functional impressions tend to be packaged as a powder and liquid. The powder is usually methacrylate in the form of polymer beads. The liquid contains ethanol, and an aromatic ester. (which varies from product to product, acting as a plasticizer). Polyethyl methacyrlate is a frequently chosen material as it allows for sufficient rate of alcohol absorption whilst remaining hard at room and mouth temperature[10].

An important aspect of the material is the temperature at which the acrylic enters the rubber phase. This temperature is known as the glass transition temperature, i.e. at this temperature the acrylic remains soft. As the functional impression material is required to remain soft at body temperatures, a plasticizer is used to lower the glass transition temperature in the mouth.

The additional factor that affects the gelling reaction includes amount of alcohol. Initial mixing forms a freely running fluid which after several minutes, develops enough viscosity to be placed into the patient's mouth. Gelation further ensues. Post mixing the material exhibits flow characteristics which are modified over time as the gel sets to a material with an increased plastic like behaviour.

The polyethyl methacylate beads that part constitute the powder are of low molecular weight. This is important as the weight, size and amount of acrylate that they contain can be reduced to increase the rate of set. Ethanol's effect is to cause the polymethacrylate chains to disentangle thereby allowing the plasticizer to ingress. As the gel forms a homogenous mass of plasticizer, polymer chains and ethanol results. The gel sets by entanglement of polymer chains and not by a polymerisation reaction[11]. Many of these materials progress from a plastic stage to an elastic stage before hardening.

The rate of material "hardening" is non-linear and is as follows. Initially the rate of loss of ethanol is greater than the rate of uptake of water leading to an initial increase in hardness of the material. Subsequently, the rate of loss of ethanol declines to less than the rate of water uptake causing the material to soften. Later, eventual loss of plasticizer and ethanol manifests increased hardness. Therefore materials with increased concentration of ethanol tend to lead to final product with increased hardness. This varies from material to material[10].

The process described above can take up to several days and is of great use to the clinician. During the plastic stage the impression material responds to functional stresses, whilst the elastic phase allows the removal of the impression without permanent distortion.

A review of various aspects of functional impression materials has yielded the following characteristics deemed to be integral to the effective clinical use of these materials.

The effect of the *powder to liquid ratio* (P/L) for tissue conditioners may be altered to vary the viscolelastic properties. This is often carried out by practitioners to improve the handling of the material for a certain clinical purpose. The P/L ratio affects the flow properties prior to gelation and the viscoelastic properties after gelation. There exists a wide range of P/L ratios that can be employed for tissue conditioners whilst maintaining acceptable performance. The gelation times using the manufactures recommended P/L ratio is shown in Table 1. As the P/L ratio increases the gelation time reduces. The acceptable P/L ratio for these materials shows variation to differing extents. Fit Soft has a P/L ratio that can be varied between 0.54-2.22 which is the widest range. However, some materials have a very narrow range whilst still retaining the ability to produce an acceptable impression. GC Soft Liner and Hi Soft are good examples with P/L ratios of 0.6 –1.33 and 1-1.78 respectively. A narrow range such as this can make the material difficult to control (Table 2). Hi soft cannot have its P/L ratio reduced much below the manufacturers recommended P/L ratio. On the other hand Hydro Cast and SR Ivoseal cannot be used with a P/L ratio above the manufacturer's recommended P/L ratio. Hydro-Cast, Softone, Shofu and Visco-gel can be used with a P/L ratio above and below the manufacturer's recommendations[12].

The effects of impression materials on the *surface hardness of dental stone* was evaluated by assessing cast surface hardness in contact with hydrophilic impression materials (hydrocolloid alginate, polyethers and tissue conditioners) and hydrophobic impression materials (silicone - condensation and addition). This revealed tissue conditioners to yield both the highest (Hydro-cast) and the lowest (Coe-comfort) surface hardness when cast in dental stone (Table 3). Surface hardness of dental stone increased over time for all materials tested under the above categories [14].

As a point of interest there is a difference of the density of the distribution of crystals at the surface of the dental stone when

Table 1. *Gelation times of various tissue conditioners.*

	Hi soft	*Viscogel*	*Hydro Cast*	*GC Soft liner*	*Fitt*
Time taken to reach gelation (minutes)	18.87	9.5	4.21	2.5	1.59

Table 2. *Manufacturers recommended powder to liquid ratio and clinically acceptable range.*

Material	*Powder liquid ratio (P/L ratio) to the nearest 0.1*	
	Manufacturers recommended ratio	*Acceptable range of ratio*
COE Comfort	0.9	0.7 - 2.2
FITT	2.0	0.7 - 2.0
Fit Softer	1.2	0.5 - 2.2
GC Soft liner	1.2	0.6 - 1.3
Hydro Cast	0.9	0.6 - 1.7
Hi-Soft	1.1	1.0 - 1.8
Softone	1.2	0.6 - 1.6
SR-Ivoseal	1.5	0.6 - 1.5
Shofu Tissue conditioner	1.2	0.6 - 1.9
Visco-gel	1.2	1.0 - 1.8

Table 3. *The relative hardness of models when tissue conditioners are cast using dental stone, the relative elastic recovery of different tissue conditioners at day 10 after the initial mix and the relative compressibility of various tissue conditioners.*

Surface hardness	*Elastic recovery*	*Compressibility*	
Coe Comfort	Visco-gel	Fitt 2/1	Lowest
Fitt	Coe Comfort	Ivo seal	
Visco-gel	Fitt 1.5/1	Fitt 1.5/1	
Hydro cast	Ivo seal	Coe Comfort	
	Fitt 2/1	Visco-gel	Highest

Table 4. *The relative shrinkage (change in linear dimension) of various tissue conditioners 24 hours and 7 days after mixing. SR Ivoseal showed signs of expansion$^{\alpha}$.*

Shrinkage		
Materials 24 hours after mixing	*Materials 7 days after mixing*	
SR Ivoseal	SR Ivoseal$^{\alpha}$	Lowest
Coe Comfort	Fitt	
Hydro cast	Visco-gel	
GC soft liner	GC sot liner	
Fitt	Hydro cast	
Visco-gel	Coe Comfort	Highest

Table 5. *Time after mixing and placement of the material within which it reproduced acceptable surface detail.*

Time (hours) after mixing	Material
1-24	Hydro cast
Up to 48	Tempo
Up to 72	Visco-gel and Fitt

cast between the tissue conditioners. This has been attributed to the differing percentage of water sorption between the materials[15]. The setting reaction is a dynamic process where ethanol and water are exchanged. The literature suggests that tissue conditioners can create casts with surface hardness comparable to elastomeric impression materials enabling laboratory manipulation and appliance construction.

Impression materials have to reproduce an array of clinical information required to produce an accurate working model. *Undercut reproduction* is seen as a *sine non qua* for any impression material. There exists a strong relationship between material thickness and accuracy of undercut reproduction. Difference in aging time also creates variations in accuracy[17]. A material must be elastic to record the presence of undercuts and not distort after removal. Demot et al [18] reported upon elastic recovery and the resistance to compressibility at day 10 after initial mix (Table 3). Fitt was tested at two different P/L ratios as shown. The authors suggested Visco-gel would be more suitable as a functional impression material, based on leaving the impression material in the mouth during the period in which it flows i.e. 1-2 hours. This is due to the fact that Visco-gel's elasticity and compressibility is relatively high during this time.

Dimensional stability is partly related to the volume of ethanol dissolution. However this process is advanced after 1-2 days. Dimensional change after this time period suggests other factors such as the particle size in the powder play a role. As mentioned earlier, tissue conditioners undergo dimensional changes as a function of time with differing brands demonstrating wide variation. In a study by Pissoitis et al [19] all materials tested showed shrinkage 30 minutes post mixing. The smallest amount of shrinkage occurred 3-6 hours after mixing still increasing up to 72 hour later. Different tissue conditioners retain accuracy for differing periods of time (Table 4). Clinically, one is unable to utilize the window of greatest dimensional stability, 3-6 hours where the smallest amount of shrinkage was noted, as tissue conditioners at this point lack the elasticity for impression purposes due to the high degree of distortion upon handling. However, differences in accuracy in the context of dimensional stability between the two time periods are small and not clinically significant[19]. Shrinkage varies between materials, a study by H. Marata showed shrinkage is related to weight loss and that this relationship is linear but different for each material[20] (Table 4). After 7 days, a greater degree of shrinkage was noted (Table 4). The lone exception to the rule was SR Ivoseal, which showed signs of expansion. Marata concluded [20] that due to a wide variation of dimensional changes within the tissue conditioner group of materials not all should be used to generate functional impressions. He recommended Fitt, GC Soft Liner, Hydro cast and Visco-gel were adequate for the use as a functional impression. A further suggestion was that a functional impression material should be left in the mouth for 24 hours. If taken out before this the material may distort during handling and casting. Durations greater than 24 hours caused more significant dimensional changes which in his view became unacceptable for use as an accurate impression material.

Pissiotis et al[19] examined the *reproducibility of surface detail*, found that despite various tissue conditioning materials producing an inferior level of surface detail when compared with elastomeric impression materials, they still produce clinically acceptable results when applied to the American Dental Association (A.D.A) specifications for irreversible impression materials. This study suggested the following materials could reproduce surface detail in compliance with the ADA specification at the following times (Table 5)

CONCLUSIONS

The composition of tissue conditioners has been reported upon extensively in previous years within the dental literature. Many studies have examined the setting reaction of different brands of tissue conditioners. There seems a general consensus that tissue conditioners can be used as an effective functional impression material if used appropriately. Different brands describe a range of characteristics, some are less favourable than others. One interesting aspect of these materials is the range of clinical performance generated by alteration of their P/L ratios. As stated previously, interbrand variations can be considerable and this should be taken into consideration when departing from the manufacturers recommendations.

This review of the literature has not yielded a consensus opinion for technique or material which would support tissue conditioners as functional materials. What is suggested however is that certain tissue conditioners can be used as functional impression materials.

Relatively recently an alcohol free tissue conditioner has become available and early testing shows promising results.

This article highlights properties required of functional materials which are different to those of a tissue conditioner.

MANUFACTURERS DETAILS

- COE Comfort. Coe Laboratories Inc, Chicago, Ill, USA.
- FITT. Sybron / Kerr, Romulus, Mich, USA.
- Fit Softer. Sankin Industry Co., Ltd., Osaka, Japan.
- GC Soft Liner. G-C Dental Industrial Co., Kansas City, Mo., USA.
- High Soft. Shofu Inc., Kyoto, Japan.
- Hydro cast. Kay-See Dental Manufacturing Co., Kansas City, Missouri, USA.
- Softone. Harry J Bosworth Co., Chicago, Ill., USA.
- SR Ivoseal. Ivoclar AG, Schaan, Liechtenstein.
- Shofu Tissue Conditioner. Shofu Inc., Kyoto, Japan.
- Visco-gel De Trey Division Dentsply Ltd., Weybridge, Surrey, United Kingdom

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