

Recent advances in tissue conditioners for prosthetic treatment: A review

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Advances in Clinical and Experimental Medicine, ISSN 1899-5276 (print), ISSN 2451-2680 (online)

Adv Clin Exp Med. 2017;26(4):723–728

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Funding sources

None declared

Conflict of interest

None declared

Received on November 20, 2015

Revised on March 8, 2016

Accepted on April 12, 2016

Abstract

Tissue conditioners (TCs) are short-term soft liners, formed in situ from a mixture of a polymer powder and a liquid plasticizer. This article reviews the recent advances in the composition, functions, clinical use, gelation process, and physical properties of TCs and their effects on denture bases and oral mucosa. TCs are used to improve the fit and function of an ill-fitting denture. They can also be used to treat abused mucosal tissues underlying ill-fitting acrylic dentures as temporary expedients. TCs are recommended as provisional liners to maintain the fit of removable dentures and to prevent mechanical irritation from the denture. TCs may also be used to rehabilitate cancer patients. The polymer powder, used in the formulation of TCs generally consists of polyethyl methacrylate (PEMA) and the liquid plasticizer is ester-based in ethyl alcohol solution without an acrylic monomer. The plasticizers are low molecular weight aromatic esters. Mixing of the powder and liquid results in polymer chain entanglement and the formation of a coherent gel characterized by viscoelastic behavior appropriate to its intended clinical use. The loss of surface integrity and surface roughness of TCs are regarded as the main problems in the denture bearing oral mucosa conditions resulting in inflammation of oral mucosa of the denture-bearing area - denture stomatitis. TCs provide an even distribution of masticatory force, accurately modeling itself to the changes which occur during the healing of lesion of substrate and can act therapeutically by incorporating antifungal or antibacterial agents.

Key words: dentistry, candida, acrylic resins, denture soft liner

DOI

10.17219/acem/62634

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Tissue conditioners (TCs) are short-term soft liners made from amorphous polymers, formed in situ from a mixture of a polymer powder and a liquid plasticizer.^{1,2} They are routinely used to improve the fit and function of an ill-fitting denture prior to replacement. They can also be used to treat abused mucosal tissues underlying ill-fitting acrylic dentures as temporary expedients. Additionally, these materials are recommended for making functional impressions.³⁻⁵ The following preparations are among the wide range of available commercial products: Visco-gel (De Trey), Coe-Comfort (GC America), FITT (Kerr), GC Soft-Liner (GC Europe NV), SR-Ivoseal (Ivoclar), Tissue Conditioner (Shofu), Hydro-Cast (Sultan Chemists).

The loss of resilience, water sorption, support of bacteria and yeasts growth, color change, and loss of adhesion to the denture base resin are the main problems during the clinical use of TCs. As a result, the materials require regular replacement at short intervals.^{2,3}

This article reviews the recent advances in composition, functions, clinical use, gelation process, and physical properties of TCs and their effects on denture bases and oral mucosa.

Composition of TCs

The polymer powder, used in the formulation of TCs, generally consists of polyethyl methacrylate (PEMA) of molecular weights ranging between 1.79×10^5 and 3.25×10^5 . The liquid plasticizer is ester-based in ethyl alcohol solution without an acrylic monomer. The plasticizers are low molecular weight aromatic esters, such as dibutyl phthalate, butyl phthalyl butyl glycolate, butyl benzyl phthalate, and benzyl benzoate.⁵⁻⁷ Their role is to lower the polymer glass transition temperature of the acrylic polymer, softening the otherwise rigid polymer.^{2,3} Mixing of the powder and liquid results in a polymer chain entanglement and the formation of a coherent gel characterized by viscoelastic behavior appropriate to its intended clinical use.^{8,9} The PEMA particles are slowly penetrated by the large molecules of the ester-based plasticizer, while the alcohol swells the polymer and hence accelerates plasticizer penetration to produce a clinically acceptable gelation time. Polymethyl methacrylate (PMMA), a commonly used acrylic polymer, is unsuitable in this application, because it is insoluble in ethanol.^{2,10,11}

Plasticizers, in the absence of ethanol, do not produce clinically acceptable gelation time because of the slow penetration of polymer particles by large plasticizer molecules.^{2,3} It has been shown that the molecular weight of polymer powder, plasticizer type, ethanol content and powder liquid ratio can affect the viscoelastic properties of the TC as determined by a dynamic mechanical test. In addition, the gelation of a PEMA based system can be controlled over a wide range by varying the polymer molecular weight and in particular, the ethanol content.^{6,8}

Other factors also impact the gelation process such as: molecular weight and the size of polymer powder particles, the proportion of liquid and powder, the plasticizer content and the temperature in which the process occurs.^{8,10} It was shown that the gelation time is reduced with the increase in polymer molecular weight and with the increase in the powder/liquid ratio as well as the increase ethanol content in the liquid component. A reduction in the average size of the polymer molecule also reduces the time of the gelation.^{2,3,8,10} It has been stated that the increase in temperature reduces the gelation time; hence, the process is faster at the temperature of the mouth cavity compared to normal room temperature.⁸ The type and the amount of softeners also have an impact on the time of the gelation.⁹ Parker et al. showed that the higher degree of polymer comminution, the more rapid the gelation.¹⁰ The ethanol in the liquid component, which acts as the softener, is an important factor in the process of the gelation. However, within the mouth cavity, its rapid evaporation and removal by rinsing, leads to hardening and increased porosity of the TC, which limits its useful life in the mouth cavity due to the loss of its desirable flexible and plastic state. As a result, a change in the relining layer is required every 3-5 days.^{10,11} The high content of ethanol has an impact on the weight loss and on the material shrinkage in the mouth cavity.¹⁰ It has been demonstrated that the greatest amount of ethanol is released from the surface of the tissue conditioner in the first 12 h after prosthetic relining.¹² It has been stated that a high ethanol content in the TC increases the material plasticity and flexibility after gelation. Whereas the type of the softener used impacts the plasticity, it does not change the material flexibility during the period of usage. Murata et al. claimed that the application of the right proportion of powder and liquid enhances the flexibility of the TC after the gelation.¹¹ Because of the differences in the physical properties and the chemical composition of various TCs, the authors recommend choosing materials according to the intended use and desirable flexible properties.

Physical properties of TCs

The limitations of TCs result from the effects of the oral cavity environment on physical properties of TCs which necessitate frequent replacement of the material. The ethanol and plasticizers leach into the saliva, which is then absorbed by the polymeric phase of the gel.¹³⁻¹⁵ It has been shown that over a period of 1 week, water sorption increased from 0.2 to 5.6 mg/cm, and solubility ranged from 0.03 to 0.40 mg/cm for various commercial products.¹⁶⁻¹⁸

One of the main problems with silicone-based TCs concerns bonding to the denture base surface. It has been shown that "adhesion" between the lining mate-

rial and base of the denture is the most common source of failure of a resilient-lined denture. As a result, this creates a potential space for denture plaque and calculus formation and leads to micro leakage.^{2,19,20} Therefore, effective bonding is important for the longevity of resilient-lined dentures, and long-term bonding can be achieved only by preventing leakage of fluids between the liner and denture base.²⁰ Bonding can be improved by providing a rough surface acrylic denture base. Adhesion to a roughened surface has been reported to be approximately double that of a smooth surface while a slightly irregular surface provided improved mechanical retention for a soft material. The bond strength can also be improved with airborne particle abrasion or laser treatment of the denture base which provide an irregular surface and enhanced mechanical retention.^{2,3,21-23} Such treatments, when implemented before the application of a resilient liner, result in lower peel strengths than in an untreated resin surface.² However, the denture lining layer must be of sufficient bulk (a thickness of 2-mm is recommended) to be clinically acceptable.^{2,15} Glantz et al. evaluated the effects of TC on the deformation of maxillary complete dentures during maximum force delivery and chewing food test specimens.²⁴ They reported that the deformation of relined dentures under masticatory function was larger than that of unrelined dentures with the deflection increasing as the thickness of the lining layer increased.^{2,3} It was found that microwave post-polymerization treatment on the flexural strength improves the longevity of the denture bases relined with TC.^{2,3}

Worth noting is the dimensional instability and the weight of TC layer. These features change with time, because of water absorption and the solubility of the material in the mouth cavity. When a polymer has a high capacity for water absorption, this leads to an increase in the volume of the TC, whereas the loss of ethanol and softeners results in material shrinkage. These processes impact not only the susceptibility, flexibility, and surface roughness but also the relative stability of relining material.^{3,25} Murata et al.¹³ compared the linear dimensional stability of: Coe-Comfort, FITT, GC Soft-Liner, Hydro-Cast, SR-Ivoseal and Visco-gel. Samples of the above conditioners were kept in distilled water for 21 days. With the exception of Ivoseal, all the products experienced shrinkage and weight loss. The lowest shrinkage (1.16–1.61%) occurred in the first 24 h after preparation. The authors suggested that the time of forming the functional impression in oral cavity should not exceed 24 h when using the above materials. It is also essential to provide the laboratory with the impression within a short period of time in order to create a plaster model. The impact of the TC hardness on the molding plaster models was assessed. The results showed that there was no detrimental effect of the TC on the surface of molding plaster model, compared to silicone impression models.²⁵

Due to the loss of elastic properties required for the therapy, the usable period of TCs in the mouth cavity should be accordingly short. Surface-coated TCs may provide an extended period of resiliency and a longer life under clinical conditions. The rationale for using surface-coated TCs was based on a longer retention of softness, which may be attributed to reduction in plasticizer leaching, as well as the penetrant (alcohol). It is also possible that surface-coated TCs prevent the absorption of salivary inorganic salts, which may contribute to the hardening process.^{12,26}

The advantages of protective preparations, such as Monopoly and Permaseal, has been demonstrated with the layer material Coe-Comfort.²⁷ Permaseal and, to a lesser extent Monopoly, which maintains its softness for longer periods, and hence extends the useful life of the conditioner in the mouth cavity. The effects of the above preparations may result from a reduction in leaching of the softeners and alcohol as well as the reduction of water absorption through the surface of the TC.^{27,28} The layer also protects the surface of the TC from the absorption of salt in saliva, which may lead to hardening of the material.¹²

It was reported that coating the surface of a TC with Monopoly increases the life of the resilient up to 1 year. The smooth surface of coating also reduced the incidence of bacterial and fungal growth. In a similar way Monopoly has also been applied to the surface of an acrylic resin nasal obturator to achieve a smooth polished surface.^{2,29} Additionally, it was found that TCs coated with Monopoly may lose alcohol but did not absorb water in vitro and there was no loss of plasticizer over a 30-day test period.^{2,28,29}

When using a TC on the acrylic dental base surface, it is recommended that the prosthesis base be of an appropriate thickness, as plasticizers released from the TC's surface can diffuse into the acrylic material, changing its properties. This can lead to deformation and fracture of the dental base, particularly after prolonged use.^{3,13}

TC and denture stomatitis

The loss of surface integrity and surface roughness of TCs are regarded as the main problems in denture bearing oral mucosa conditions, resulting in the inflammation of oral mucosa of the denture-bearing area – denture stomatitis.^{30,31} The frequency of this ailment, which may also be caused by mechanical irritation from the denture, is rated as 40–65% among the acrylic denture wearers.^{32,33} TCs provide an even distribution of masticatory force, accurately modeling itself to the changes which occur during the healing of lesion of substrate and can act therapeutically by the incorporation of an antifungal or antibacterial drugs. Conditioners provide a particularly useful alternative for patients who do not wear dentures during the healing period of prosthetic substrate before relining the old denture.^{34–36}

Okita et al.³⁷ found that the preparations Coe-Comfort, FITT, Soft-Liner and Visco-gel, exhibit cytotoxic activity *in vitro*. The cytotoxicity of the above conditioners is higher than the cytotoxicity of acrylic resin. An adverse effect on tissues can be seen in releasing the softeners from the conditioner surface (phthalates) from the TC surface. Moreover, it has been shown *in vitro* that certain phthalate esters exhibit estrogenic activity and *in vitro* proliferation of estrogen-dependent MCF-7 cells.²⁶ Hence, new compounds, such as dibutyl citrate or dibutyl sebacate, are sought as replacements for toxic phthalates. This may lead to the creation of a new generation of TCs, free from cytotoxic phthalic acid esters.^{38,39} In addition, it has been shown that some plasticizers have the ability to slow the *in vitro* growth of *Candida albicans*. Microscopic examinations have revealed that the form of fungal growth, on the sample surface of TCs, also depends on the type of plasticizer used.²⁶

Through the loss of ethanol and plasticizers, the TC surface becomes hard and porous which enhances sedimentation of the denture base. At the same time, the acrylic denture base which is lined with a TC layer may become a rich reservoir for bacteria and fungi.^{3,35} Hence, during treatment, there is a need to replace the TC layer within a strictly specified time.

The efficacy of adding antibacterial and antifungal drug to TCs has been assessed. One of the evaluated products was Zeomic (Sinanen Zeomic Co.) – crystalline aluminum silicate containing silver ions acting as an antiseptic. It has been demonstrated that this formulation slows the growth of *Candida albicans*, *Staphylococcus aureus* and *Pseudomonas aeruginosa* *in vitro*^{39,40} as well as improving the elastic properties of some TCs. This has been explained by the fact that Zeomic increases the penetration of the plasticizer within the polymer chain.⁴¹ Although the release of silver ions leads to a cytotoxic effect, but because it has a short-term effect, the health risk seems to be insignificant.

Chow et al.⁴² showed that 5% of itraconazole added to Coe Soft or FITT materials maintains the highest activity in the first 3 days, after which the relining material must be replaced to ensure a good therapeutic effect.

It has also been shown that the rough surfaces of the denture base may facilitate bacterial and fungal growth by enhancing the adhesion of microorganisms onto resilient lining materials and may expose the patients to infections and could cause *Candida*-associated denture stomatitis.^{43–45}

Fungal growth on TC surfaces can cause irritation of the oral mucosa. Adhesion of *Candida albicans* to the surface of TCs is a result of cell proliferation and matrix production.^{32,31,45} Radnai et al. found that chlorhexidine digluconate gel added to TC had no inhibitory effect on the growth of *Candida albicans*, but the incorporation of miconazole gave a dose-related inhibitory effect on candidal growth *in vitro*. Moreover, Gebremedhin et al.⁴⁵ demonstrated that miconazole exhibits high antifungal

activity against biofilms of various *Candida* species developed on heat-cured poly(methyl methacrylate) discs *in vitro*.⁴⁶ Schneid⁴⁷ demonstrated that a sustained release delivery system incorporating antifungal agents – nystatin, chlorhexidine, clotrimazole and fluconazole into a number of TCs significantly inhibited the growth of *Candida albicans*, although the hardness of the material increased. On the other hand, Toda et al. found that incorporating an antimicrobial polymer – 10% poly (2-tert-butylaminoethyl) methacrylate (PTBAEMA) into one TC – Coe Soft increases the wettability and roughness of the TC surface and decreases the adhesion of *Streptococcus mutans* and *Staphylococcus aureus* to the surface.³⁵ No anti-microbial effect was observed against *Candida albicans*. It has also been suggested that anti-microbial agents, such as silver zeolite, be incorporated into the TC powder, since a TC containing Ag-zeolite showed a dose-dependent inhibitory effect on *Candida albicans*.⁴⁰

Clinical applications of TCs

The soft resilient nature of TCs on the acrylic denture surface facilitates a whole range of diagnostic and treatment modalities. They are used to restore the condition of inflamed denture bearing oral mucosa, and in taking functional impressions. They may also be used as provisional liners to improve the fit of the acrylic dentures, to prevent mechanical irritation from the denture plate, and for trial evaluation of border extensions. TCs may also be used to modify dentures during implant surgery and rehabilitate cancer patients requiring obturation. Their physical properties of TCs, such as viscoelastic properties and dimensional stability, vary depending on the materials used.^{13,15,19} Thus, a single type of TC may not be capable of fulfilling all of the applications adequately. The ideal resilient denture liners should possess higher elasticity during mastication and then behave viscously to distribute the functional and nonfunctional forces and relieve the pain.^{2,3,48} When used for interim relining, the material should be dimensionally stable to prevent changes in the vertical dimension of occlusion. It should also be compatible with the dental stones.^{15,23}

The essential issue is to maintain denture hygiene with the relining material on the fitting surface of the denture. Prostheses should be thoroughly cleaned before relining and patients should be informed about the necessity of ensuring regular hygiene of the oral cavity during the treatment. An adverse impact of liquid cleaners for prosthesis and certain antiseptic drugs on TC surface has been observed. These accelerate the leaching of the components from the conditioner.^{14,21} Materials for biological tissue regeneration are susceptible to mechanical damage. Therefore, gentle cleaning of relining prosthesis using a cotton cloth or gauze is recommended as well as disinfection in a 0.2% solution of chlorhexidine.

In conclusion, it should be emphasized that biological materials for tissue regeneration lose their beneficial denture physical properties in a short period of time; hence, they are designed only for short-term denture relining. It is worth mentioning that in the case of prolonged use, the materials are mechanically irritating on the mucosa, causing the accumulation of denture plaque on the surface and an increase of denture stomatitis symptoms.

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