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REVIEW ARTICLE

Resilient Liners: A Review

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Abstract Resilient liners when used intelligently are an excellent adjunct in removable prosthodontics. However, currently they have to be best considered as temporary expedients because none of the advocated permanent liners have life expectancy comparable to resin denture base. This article reviews the literature regarding their composition, functions, gelation characteristics, bond strength and influence on denture bases. It also presents their drawbacks and attempts made to extend their longevity. A Medline search was completed for the period from 1986 to 2007, along with a manual search, to identify pertinent English peer-reviewed articles and textbooks.

Keywords Tissue conditioners · Dentistry · Resilient liners · Viscoelastic properties · Denture stomatitis

Introduction

Use of resilient liners in the clinical management of prosthodontic patients is well documented and their adjunctive benefit recognized [1–3]. Since their introduction in the 1950s these viscoelastic compliant materials have undergone some development and improvement, being used to form all or part of the fit surface of a denture and help condition traumatized tissues providing an interim or permanent cushion like effect. Their complete function is debatable, but they serve to distribute the forces of mastication more evenly and to absorb energy [2]. These liners may be classified as provisional or definitive, room-temperature or heat-temperature vulcanized [4–6]. They are also divided into four groups according to chemical structure: plasticized acrylic resins either chemical- or heat-polymerized, vinyl resins, polyurethane, polyphosphazene and silicone rubbers [7]. Clinical experience indicates almost universal tissue tolerance of soft liners and acceptable patient reactions. However, currently the materials have to be considered as temporary expedients because of problems during clinical use including loss of resilience, water sorption, support of bacteria, color change, and loss of adhesion between the liner and denture base resin requiring replacement at short intervals, which is time-consuming and costly for both the dentist and patient. Despite these problems, 26 out of 30 patients in a study preferred resilient denture lining to conventional acrylic dentures and 1–5 % of all mandibular dentures had soft liners incorporated in them [8]. This article reviews the literature regarding their composition, functions, gelation characteristics, bond strength and their influence on denture bases. It also presents their drawbacks and attempts made to extend their longevity.

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Composition and Its Influence on the Gelation Characteristics of Resilient Liners

Resilient liners can be divided into two main types: plasticized acrylic resins and silicone elastomers [9]. Both material types are available in auto- and heat-polymerized forms [7]. Tissue conditioners or short term soft liners are uncross-linked (formed by polymer chain entanglements but not cross-linked), amorphous polymers, formed in situ from the mixture of a polymer powder and a liquid plasticizer [10, 11]. The polymer powder generally consists of polyethyl methacrylate (PEMA) of molecular weights ranging between 1.79×10^5 and 3.25×10^5 with no initiator [8, 10, 11]. The liquid consists of an ester-based plasticizer and 4–50 wt% ethyl alcohol (EtOH) [12] and contains no monomer [10, 12]. The plasticizers (except dibutyl sebacate, which is aliphatic) are aromatic esters such as dibutyl phthalate, butyl phthalyl butyl glycolate, butyl benzyl phthalate, and benzyl benzoate [12]. Plasticizers are liquids that have low molecular weights and that lower polymer glass transition temperature and soften the rigid polymer [7]. Heat polymerized forms also generally consist of powder and liquid components [7]. The composition of the powder and liquid are not well known, but are generally thought to be acrylic polymers and copolymers along with a liquid containing an acrylic monomer and plasticizers (EtOH and/or ethyl acetate) [7, 13, 14]. Silicone resilient lining materials are similar in composition to silicone impression materials. Both are dimethylsiloxane polymers [15]. Polydimethylsiloxane is a viscous liquid that can be cross-linked to form a rubber with good elastic properties [15]. No plasticizer is necessary to produce a softening effect [15]and they retain their resilience throughout their working life.

Mixing of the powder and liquid results in polymer chain entanglement and formation of a coherent gel characterized by viscoelastic behavior appropriate to its intended clinical use [11, 16, 17]. The PEMA particles are slowly penetrated by the large molecules of the ester-based plasticizer. The alcohol accelerates plasticizer penetration into the polymer to produce a clinically acceptable gelation time [10, 16].

Ethanol, a highly polar constituent, facilitates penetration of plasticizers into the polymerized denture base. It is essential to the PEMA based system because ethanol rapidly swells the polymer particles and accelerates penetration of plasticizer into polymer [18]. In contrast, polymethyl methacrylate (PMMA) is not a suitable polymer because its solubility parameters for the strongly bonded solvent is zero and it is not dissolved by ethanol [18]. Plasticizers containing no ethanol do not produce clinically acceptable gelation time because polymer particles are penetrated very slowly by large plasticizer molecules [10, 11]. In a study [18], investigating the influence of molecular weight of polymer powder, plasticizer type, ethanol content and powder liquid ratio on the viscoelastic properties of tissue conditioners using a dynamic mechanical test reported that gelation of a PEMA based system can be controlled over a wide range by varying polymer molecular weight, specially ethanol content.

While gelation time decreased exponentially with increase in ethanol content, a higher molecular weight polymer powder and a higher powder liquid ratio produced a shorter gelation time. This may be explained by the fact that higher molecular weight polymer and powder liquid (P/L) concentration would produce greater polymer chain entanglements thereby resulting in a shorter gelation time. Although the effect of plasticizers was small, gelation times were found to be independent of the solubility parameters and molecular weight of these plasticizers, rather higher molar volume plasticizers (which expresses effect of molecular size) tended to lead to a longer gelation time. This finding is in contrast with reported findings of Jones et al.[8], explained by the fact that previous studies evaluated the viscoelastic properties using a reciprocating rheometer which only provide a comparative evaluation among materials, but do not measure absolute values of elasticity and viscoelasticity.

Resilient Liners and Bond Strength

Limitations of tissue conditioners result from the effects of the oral environment on their physical properties; these effects necessitate frequent replacement of the material [19]. The wet environment of the oral cavity allows the ethanol and ester plasticizers to be leached into saliva, and water is then absorbed by the polymeric phase of the gel [12, 13, 20, 21]. At 1 week, water sorption has been reported to range from 0.2 to 5.6 mg/cm [22], and solubility to range from 0.03 to 0.40 mg/cm [22] for various commercial products [23]. However, Graham et al. [21] showed that the percentage of plasticizer lost from a resilient liner at the end of 14 days of clinical use was 31.1 ± 12.4 %. Differences in the research methodology has been cited as the reason for this difference as these authors advised their patients to rinse the resilient liner under running tap water and not to use denture cleaning agent.

Jepson et al. [24] reported that all reductions in laboratory compliance after immersion in distilled water, saline, or artificial saliva, were significantly less than those seen clinically. Evidence of an increased loss of plasticizer in vivo [21] was suggestive of an enhanced solvent effect from a dietary source acting to effect clinical changes in the viscoelasticity of these materials. Early reductions were greater for materials with higher ethanol content and with immersants with a more powerful solvent action and probably reflect the reported ready loss of ethanol [20] and the influence of a material's ethanol concentration on the rate of this change. Later changes were associated with an increasing influence of solvent type and were more indicative of plasticizer loss [12] with variations between immersion solutions reflecting their differing solvent effects.

The loss of plasticizer and EtOH can alter the bonding surfaces or the viscoelastic properties of resilient materials, which become brittle, changing their bond strength properties [8, 25–28]. When the material swells, stress builds between bonding surfaces and the viscoelastic properties of the resilient liners change [25].The material becomes brittle and transfers the external loads to the bond area [8]. Apart from aging in water, use of a primer with the lining material, and the nature of denture base materials can also affect nature of the bond between the resilient lining material and denture base [29]. According to Wright [6] the most common reason for failure of a soft-lined denture was the failure of "adhesion" between the liner and denture base. Bonding to the denture base surface is a significant problem especially for silicone-based products [7]. Bonding between the denture base resin and silicone-based lining material rely completely on the adhesive, a solvent that dissolves the denture base resin surface, such as acrylic resin monomer. Bond failure between the liner and denture creates a potential interface for micro leakage, plaque and calculus [9]. Therefore, effective bonding is important for the longevity of resilient-lined dentures, and long-term bonding can be realized only by preventing leakage of fluids between the liner and denture base [30].

Craig and Gibbons [31] advocated a roughened surface to improve the adhesive bond. They reported that adhesive values obtained with the roughened surface were approximately double those of the smooth surface. Storer [32] sandblasted the acrylic resin surface before placing a resilient lining material and concluded that a slightly irregular surface provided mechanical locking for the soft material, thereby increasing the strength of the bond. Other investigators tried other means of improving the bond strength including airborne particle abrasion (APA); laser treatment of the denture base preceding placement of a resilient liner providing an irregular surface and mechanical retention [33, 34]. Amin et al. [34] reported that APA roughening of the acrylic resin base preceding resilient liner application could have a weakening effect on the bond of the denture base. Jacobsen et al. [33] concluded that APA or laser treatment of denture base surfaces before resilient liner application provides lower peel strength than an untreated resin surface.

The low mean peel strength of airborne-particle–abraded specimens has been attributed to the stresses that develop at the interface of the PMMA/resilient liner junction and to the insufficient size of irregularities created by laser or by airborne-particle–abrasion medium to allow flow of material into them [33, 34]. Another explanation for low peel strength involved the penetration coefficient of the lining material; because the penetration coefficient is inversely proportioned to viscosity, increased liner viscosity reduces penetration into irregularities on the PMMA surface [34].

Sarac et al. [30] reported wetting the PMMA surface with MMA monomer was significantly more effective than either airborne-particle abrasion with Al_2O_3 particles or resilient liner application without any surface treatment and only adhesive application. The adhesive in silicone resilient liners contains butanone and methacrylates. Therefore, using monomer and adhesive together may effectively increase the dissolution of the PMMA surface prior to resilient liner application. Further they suggested that treating a denture base acrylic resin surface with chemical etchants like methyl methacrylate, methylene chloride, and acetone for 15–30 s prior to adhesive application reduced the micro leakage and increased the bond strength when using silicone-based resilient liners. However, these chemical treatments decreased the flexural strength of the acrylic resin [35]. Nevertheless, the decrease in flexural strength were within the limits of the ISO/FDIS 1567 [36, 37] A notable limitation of this study was the use of only 1 type of silicone-based resilient lining material in their tests. Different results might be obtained with different resilient lining material.

Conflicting results regarding tensile bond strength following storage in water. While some studies reported increase in tensile strength [4, 31, 38–40] on account of less lengthening and increased rigidity of the material others reported decrease in tensile strength [25, 41]. As a result of swelling and stress buildup at the bond interface or of the changed viscoelastic properties of the resilient lining material, which renders the material stiffer and transmits the external loads to the bond site. However, a direct comparison of these studies cannot be made because of the different mechanical tests and research protocols used.

The values found for tensile bond strength can vary from 2.12 ± 0.16 Mpa [42] to 1.64 ± 0.12 Mpa [43] when the materials were evaluated immediately after specimen processing. However, after 12 weeks of water storage the value was 0.74 ± 0.29 Mpa, [44] and after 24 h and 6 months were 1.21 and 2.69 Mpa, respectively [39].

A study [45] used to assess in vitro accelerated aging produced with varying amounts of thermal cycling on bond strength and permanent deformation of 2 commercially available resilient denture liners indicated that thermal cycling significantly affected the bond strength of acrylic resin resilient lining material to PMMA denture base resin after 4,000 cycles but did not affect the bond strength of silicone resilient lining material. It also indicated that failure of silicone resilient lining material was adhesive, which implies that the bond strength for the liner molecules was greater than the bond strength between the liner and PMMA resin. Acrylic resin resilient lining material failed both adhesively and cohesively. Also regardless of thermal cycling, the plasticized acrylic resin resilient lining material) experienced more permanent deformation than the silicone material. It has been reported that resilient denture lining materials with 10 pounds per inch (4.5 kg/$cm^2 = 0.44$ MPa) bond strength are acceptable for clinical use [27, 38, 46]. Most resilient materials have a satisfactory bond strength to polymerized PMMA denture base resin.

Changes in bond strength in the harsh oral environment require further investigation to predict which materials will provide the best clinical service. Most laboratory studies only simulate oral environment, but most appropriate testing environment is intraoral, and consequently clinical studies should supplement laboratory investigations.

Resilient Liners and Denture Base

The relining of a denture base has been shown to significantly decrease its resistance to plastic deformation, and the effect was more pronounced in the reline materials that possessed lower bulk strength [47]. Oral environmental variables such as thermal stress and flexural cyclic loading enhance the degradation and shorten the clinical life of relined denture bases [48]. The plasticizers could leach from the conditioners and diffuse into the polymerized denture base, resulting in alteration of base properties. In addition, the resistance to plastic deformation of the relined denture base generally deteriorated as the proportional thickness of the denture reline material increased [7] and that of the denture base decreased resulting in decreased denture base strength. Furthermore, materials used in conjunction with resilient liners, such as adhesives and monomers, cause partial dissolution of the accompanying denture base with resultant decrease in base strength causing fracture during clinical service [49].

Several studies [50–54] have supported that the strength of relined and repaired specimens depends on the bulk strength of the denture base materials, the strength of the reline materials, and the ability of the polymers to bond to each other.

Clinical studies indicate that the lining layer must be of sufficient bulk (a thickness of 2-mm is recommended) to be clinically efficient [17, 55, 56].

Glantz and Stafford [57] examined maximum functional loading levels and occlusal forces exerted through maxillary complete dentures, demonstrating local high stress levels at the interface between the dentures and the supporting tissues. Glantz et al. [58] evaluated the influence of tissue conditioners on the deformation of maxillary complete dentures during maximum force delivery and chewing of food test specimens. They reported that the deformation of relined dentures under function was larger than that of unrelined dentures. This deflection increased as the thickness of the lining layer increased. Using a tissue conditioner on the denture intaglio surface may reduce the overall denture strength and inevitably increase the tendency of the denture base to fracture. This fracture may result from replacement of part of the hard denture base with a viscoelastic and easily deformable material and the plasticizing effect of the material on the denture base resin. This plasticizing effect would accelerate softening of the denture base with time.

Recent studies report gain in flexural strength of relined denture bases following microwave irradiation [59, 60]. However power/time combinations appropriate for the material used must be known [59]. The favorable effect of microwave post-polymerization treatment on the flexural strength shown in this investigation, suggests that the procedure could improve the longevity of the denture bases relined with these materials. This limited study [59] only evaluated the effect of microwave post-polymerization on the flexural strength of bulk acrylic materials, which were tested in a dry state, clinical conditions and use, were not simulated in this investigation. Longitudinal clinical studies are necessary to corroborate the clinical use of resilient materials polymerized by microwave energy or visible light methods. There is also a need for evaluating other important properties, such as surface hardness, permanent deformation, and shear tensile bond strength.

A recent study suggested that treating a denture base acrylic resin surface with chemical etchants prior to adhesive application reduced the micro leakage and increased the bond strength when using silicone-based resilient liners. Although these chemical treatments decreased the flexural strength of the acrylic resin denture base [35], it was within the limits of the ISO/FDIS 1567 [36, 37].

Resilient Liners and Denture Stomatitis

Changes over time in viscoelastic properties of resilient denture liners are relevant to the liners continued effectiveness. EtOH and the plasticizer leach out and are partially replaced by water accounting for the loss of viscoelastic properties over time. Jepson et al. [24] demonstrated a significant loss of viscoelasticity of Coe-Soft (GC America, Allsip, Ill.) over an 8-week period with particularly rapid reduction during the first week. There are many factors involved with the surface conditions of tissue conditioners, including the effects of saliva, denture cleansers, thermal cycling, and masticatory force. The loss of surface integrity and surface roughness may begin in a matter of 3–4 days [61]. Surface roughness of the resilient liners may differ among materials [62, 63]. It has also been shown that rougher surfaces enhance the adhesion of microorganisms onto resilient lining materials and may allow fungal growth [64–67]. The microorganisms from the plaque on the denture surface may expose patients and dental personnel to infection [68]. In addition, denture plaque containing *Candida albicans* could cause denture-induced stomatitis [69].

Several studies have evaluated methods of enhancing the useful life span of tissue conditioners, including preservation of surface integrity and viscoelasticity [70] and the incorporation of antimicrobial components into the material [77–79]. As well as photo-catalytic agents like Titanium dioxide [80]. Although preserving the surface integrity of tissue conditioners may play an important role in reducing the adhesion of fungal and other microorganisms on dentures, other solutions have been suggested; these include integrating anti-microbial components such as silver zeolite into the tissue conditioner powder [77, 78]. Schneid [79] demonstrated that a sustained release delivery system that incorporated 4 antifungal agents (chlorhexidine, clotrimazole, fluconazole, and nystatin) into a tissue conditioner (Lynal) significantly inhibited *Candida albicans,* although the hardness of the tissue conditioner increased. It is possible that antimicrobial compounds could be combined with surface-coated tissue conditioners, although the surface coating may prevent their release. Further, Akiba et al. [80] suggest that coating agents with TiO2 photo catalyst can be effective for the maintenance of tissue conditioners when dentures are removed during sleep. Denture cleansers used in the daily maintenance regimen of patients must be compatible with the denture lining agents in order to prevent the biofilm formation of fungi on such materials [81, 82] as they can cause significant deterioration on account of the higher ionic concentration (potassium and sodium) of denture cleanser compared to water [21, 28] leading to a higher release of soluble components. Some studies have studied the immersion of resilient denture liners in disinfectant solutions [83–85]. Certain controversial finding with the use of sodium hypochlorite have been reported [84, 86–88]. Yilmaz et.al [83] suggested that immersion of resilient denture liners in disinfectant solution, especially 5.25 % sodium hypochlorite for 5 min effectively reduced the microbial count. However long term immersion effects on the mechanical and physical properties of these materials were uninvestigated [83]. Another study suggested that detrimental effects on long term immersion of denture base material in 0.02 or 0.0125 % was manifested after more than 7 years [84], however, currently available tissue conditioners require replacement at short intervals [24] Other studies have studied the efficacy of microwave irradiation in the elimination of *Candida albicans* and *Staphylococcus aureus* [89, 90]. While the irradiation eliminated most of the microorganisms, immersion in 2 % sodium hypochlorite was found to be more effective than microwave irradiation. The reported gain in flexural strength of relined denture bases following microwave irradiation [59, 60] however suggests that the procedure could improve the longevity of the denture bases relined with these materials.

Surface Sealed Resilient Liners

Resilient denture liners have several problems associated with their use, such as loss of softness, change of permanent deformation characteristics, water absorption, colonization by *Candida albicans*, bond failure between the liner and denture base requiring frequent clinical evaluations and periodic replacement [9, 43, 45, 91–93].

Surface-sealed resilient denture liners may provide an extended period of resiliency and longer life under clinical conditions. The rationale in using surface-coated tissue conditioners was that they retained their softness longer, which may be attributed to reduced leaching out of the plasticizer, as well as the penetrant (alcohol). However, Braden [10] suggests that a more likely cause is the continuing solution of the polymer into the plasticizer. It is also possible that surface-coated tissue conditioners prevent the absorption of salivary inorganic salts, which may be a contributing factor to the hardening process [20].

One product proposed to improve the life-span of tissue conditioners is monopoly, a PMMA syrup made of 1 part clear polymer powder to 10 parts heat-polymerized monomer [70]. Although it may be a cost-effective method of extending the longevity of a tissue conditioner, monopoly is not yet commercially available, perhaps because it is made of materials that most dentists have available for other purposes. Gardner and Parr [70] reported that coating the surface of a tissue conditioner with monopoly increased the life of the material up to 1 year. The coating remained clean and smooth, reduced the incidence of bacterial and fungal growth, and allowed the temporary liner to maintain its resilient characteristics for an extended period. In another study, monopoly was painted on an acrylic resin nasal obturator to achieve a smooth polished surface [71]. Casey and Scheer [72] compared 3 surface treatments of a tissue conditioner and found that surface treatment with monopoly resulted in an improved glassy surface that lasted for 30 days intraorally. Dominguez et al. [73] found that tissue conditioner coated with monopoly may have lost alcohol but did not absorb water in vitro. In addition, there was no loss of plasticizer over the 30-day test period.

Gronet et al. [74] evaluated whether surface coating tissue conditioners with palaseal (Heraeus Kulzer, South Bend, Ind.) or monopoly would improve their resiliency. There was a significant increase in the resiliency of Lynal (LD Caulk, Dentsply International, Milford, Del.) specimens coated with palaseal and Monopoly and visco-gel (DeTrey/Dentsply, Weybridge, England) specimens coated with palaseal. However, no difference between the uncoated and coated specimens of Coe-Soft was demonstrated. Hayakawa et al. [94] found that the fluorinated copolymer coating Kreguard (Kureha, Tokyo, Japan) imparted an improved glossy surface to a tissue conditioner, which may have increased its useful life. Another commercially available tissue conditioner, Permasoft (Austenal Inc, Chicago, Ill.) is packaged with Permaseal (Austenal Inc), a coating that is claimed to prolong the life of the tissue conditioner. There presently are limited scientific data to support this claim [95, 96]. Within the limitations of their study Malmstrom et al. [97] found the application of Permaseal or monopoly coatings significantly reduced the loss of tissue conditioner softness. Permaseal-coated conditioner remained the softest over the length of the study. Limitation of most of these studies is that the level of softness or surface integrity necessary to prolong the lifespan and effectiveness of a tissue conditioner is unknown. Several investigators have suggested that 2–3 mm is an appropriate thickness for tissue conditioners [17, 55, 56, 73, 95, 96]. Another limitation of these studies are that results may not apply to various tissue conditioners treated with the same coatings. Gronet et al. [74] reported that various tissue conditioners may respond differently to coatings, possibly because of the adhesion of the coatings and differences in conditioner composition (such as amount of alcohol and ester plasticizer).

Other studies have evaluated various mixing techniques intended to reduce the porosities that are incorporated into tissue conditioners and hence reduce void formation and microbial adherence. Nimmo et al. [75] vacuum-treated visco-gel tissue conditioner, producing a denser, less porous mix and improved surface texture. Microbial adherence, however, was not affected by vacuum treatment. Corwin and Saunders [76] suggested a modified polymerization technique that would extend the useful clinical life of the tissue conditioner.

In conclusion, surface coatings may allow tissue conditioners to function longer than currently recommended by manufacturers before replacement. However, clinical studies need to be conducted to confirm that less frequently replaced coated tissue conditioners treat inflamed or abused tissues as effectively as uncoated conditioners. In addition, additional research on different brands of surface coated tissue needs to be conducted as different brands may exhibit different softness and surface integrity properties over time.

Uses of Tissue Conditioners

The soft resilient nature of these materials inside the mouth provides them with a whole range of diagnostic, adjunctive and treatment purposes in the management of patients [1].They have been used to restore health of distorted and inflamed denture supporting tissue, make dynamic impressions and to restore traumatized oral mucosa to healthy state. They are used as provisional liners to maintain fit of the dentures, to prevent trauma and for trial evaluation of border extension. Additional uses would include to modify transitional prostheses after stage I and stage II implant surgery and to rehabilitate cancer patients requiring obturation. Their physical properties, such as viscoelastic properties [17] and dimensional stability [13, 56, 98], which make them suitable for these varied purposes, are different from material to material [17]. That is, if the material is near-ideal for one purpose, it may not be ideal for another. Thus, a single type of tissue conditioner may not be capable of fulfilling all of the intended uses equally well. The ideal resilient denture liners would possess higher elasticity during mastication and then behave viscously to designate the functional and nonfunctional forces and relieve the pain [99]. When used for interim relining; the material should be confined to prevent the vertical dimension of occlusion from changing [17]. An ideal tissue conditioner used as a functional impression material should flow and register the mean shape of the denture-bearing mucosa under functional stress, such as mastication, speech, swallowing, and para function, should have high compatibility with the dental stones and a smooth surface equivalent to that of elastomeric impression materials. Furthermore, those properties should be maintained intraorally until a functional impression is formed. It was found that some of the tissue conditioners were not suitable for making a functional impression, because changes in the surface roughness over time varied considerably among the types tested [100]. Moreover, dentists frequently control the P/L ratio of tissue conditioners within acceptable limits to improve handling properties, adjust working time, and vary viscoelastic properties after gelation [17, 55]. By increasing the liquid proportion; the materials with lower flow properties can be changed to have increased flow. However, the lower P/L ratio (larger amount of plasticizer) may produce a greater plasticizing effect on the denture base. From the standpoint of softening of denture bases, the P/L ratio should not be lower than manufacturer-recommended values.

Research and Development

Since it appears that the ideal material does not currently exist, further research and development are needed to develop improved materials that meet the previously mentioned requirements. From the standpoint of gelation and manipulation after mixing, ethanol is considered to be an essential additive of these materials. Since the deterioration of tissue conditioners is a function of leaching of the low weight plasticizer and especially ethanol, tissue conditioners which contain less or no alcohol should be developed or alternatively PEMA with higher molecular weight should be used, or a new type of polymer should be developed. The physical properties of these new materials must be clinically investigated to predict which materials will provide the best clinical service. Murata et al. [100] investigated the properties of a recently developed alcohol-free tissue conditioner based on a n-butyl methacrylate/i-butyl methacrylate copolymer, its surface coated version and three tissue conditioners containing EtOH. Gelation characteristics, dynamic viscoelastic properties and compatibility with dental stones were measured using a displacement rheometer, dynamic viscoelastometer and profilometer, respectively. In addition, weight changes during immersion in water were also determined. They concluded that coated alcohol-free tissue conditioner was superior to the conventional material containing EtOH in view of viscoelastic properties after gelation, compatibility with dental stones and durability.

A study [101] investigated some clinically relevant properties of a newly developed polyisoprene-based light-curing lining material. Its properties were compared with those of other four commercial products. The polyisoprene-based lining material showed low water sorption and solubility, moderate softness, high staining resistance and satisfactory shear bond strength to denture base resin. It also provides clinicians sufficient working time due to its light-curing property. It would be an attractive alternative as a relining material.

Another study [102] evaluated a range of clinically relevant properties of a newly developed, fluoroalkyl-based denture lining material including water sorption and solubility, color change, surface micro hardness, in vitro denture base fit, and shear bond strength and compared it to the properties of 3 commercially available, non–fluorine-containing lining materials. Fluorine atoms produce a low-energy surface, yielding a water- and oil-shedding quality. A reduction in water sorption and solubility might be expected with the fluoroalkyl methacrylate monomer, but deterioration in surface hardness and bond strength may result from fluorine addition. Results showed the lowest water sorption and solubility, and superior stain resistance. In spite of the addition of the fluoride content, this product exhibited no deterioration in physical properties, such as surface hardness, fit of the relined denture, and shear bond strengths to denture base materials tested. The presence of fluorine developed high hydrophobicity thereby reducing the water solubility. Moreover presence of cross linking agent also reduced its solubility [103, 104]. Reduction of solubility increased its bond strength. The high monomer to polymer ratio as well as the presence of cross linking agent and fluorine increased its hardness and stain resistance.

Summary

Clinical experience indicates almost universal tissue tolerance of soft liners and acceptable patient reaction. However currently the materials have to be considered as temporary expedients because none of the advocated permanent liners have a life expectancy comparable to that of the resin denture base. Improved strength, permanent resiliency, improved adhesion to the denture bases, the ability to inhibit growth of microorganisms, and chemical stability continue to be the main focus of ongoing research. These attempts include surface coatings of liners with sealants such as fluorinated copolymers and integration with antifungal components. The ideal resilient denture liners would possess higher elasticity during mastication and then behave viscously to designate the functional and nonfunctional forces and relieve the pain. In addition, their durability in the oral environment is necessary over long periods. Acrylic resin which shows viscoelastic behavior and higher levels of cushioning effect, may best meet the requirements for the resilient denture liners from the point of view of the inherent viscoelastic properties. However, from the standpoint of durability, the silicone would be better. Selection of a particular liner cannot be based on any single property. Material selection is influenced not only by the properties available but also by the particular clinical situation. Laboratory studies simulate an oral environment; however, no simulation is entirely accurate. The most appropriate testing environment is intra oral; consequently, clinical studies should be performed on the materials tested.

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