



Potential Therapeutic and Effective Properties of Soft Tissue Liners

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ABSTRACT

Soft tissue liners are polymer materials between the oral tissue and the surface of the denture. They have an essential role in reducing the effect of the masticatory force on the oral mucosa. This short review gleaned data on soft tissue liners to highlight their potential therapeutic importance in the management of denture-related stomatitis and their comparison to other materials. Published articles in many databases were collected using keywords with soft liner properties, viscoelastic, dental materials, impression technique, and additive liner materials. The soft liners were compared to the viscoelastic oral mucosa, and their influences on the control of denture plaque were highlighted too. Their application in the treatment of denture-related stomatitis, as well as adhesion and biofilm formation, was highlighted. The result showed that soft tissue liners have high therapeutic efficacy and effective properties in treating denture stomatitis due to the incorporation of chlorhexidine, antifungal, and antimicrobial agents. The use of soft liners improved ridge resorption and had a crucial effect on the loss of denture fit and stability. In addition, soft tissue liners in combination with additive materials recovered the effect of saliva on the formation and adhesion of biofilm. Uniquely, the application of soft liners in the functional impression technique was ideal, due to their extensive physical properties, their viscoelasticity, and the immediate poured impression. Therefore, soft liners are highly recommended in many dental conditions such as dentures opposing natural dentition, resorption of irregular bone, immediate implant placement, tooth undercuts, oral mucosa atrophy, bruxism, and xerostomia.

Keywords: *Soft liners, stomatitis, denture, viscoelasticity, biopolymer, impression*

1.INTRODUCTION

Soft tissue liners are polymer materials between the oral tissue and the surface of denture which are used temporarily, or for a long period. It is widely used to reduce masticatory forces effect on the oral mucosa [1]. The use of dentures is still preferred to replace lost or missing teeth, since dental implant could face failure, or it might not be suitable to all types of patients

[2,3]. Thus, those soft liners are still needed, since it is always used with dentures. Soft tissue liners are viscoelastic gels which form a cushioning effect between the oral mucosa and the hard denture base. These soft liners are either made of silicone polymers materials or plasticized acrylic resin, where it is modified to achieve the required resilience and elastic properties [4].

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In recent years, soft tissue liners have been developed and widely used in clinical prosthetics. It is considered as a very essential material in prosthodontics treatment [5]. Many studies have been done to evaluate its uses and significant importance in dentistry. Recent studies have shown that these soft tissue liners can improve the health of the oral soft tissues, improve function of an ill-fitting denture, and increase the denture fit [5]. Also, it is considered as a significant adjunct or alternative methods to antifungal medications in the treatment of denture stomatitis [7, 8]. In addition, it has a remarkable capability to resist the stress of the denture bearing mucosa and to offer a cushioning layer made it suitable for a verities range of applications in prosthetic dentistry [5]. Therefore, the objective of this research is to study and evaluate the soft tissue liners stability to accommodate the oral soft tissue for denture placement. Thus, this study will cover some of the related studies about soft tissue liners. In addition, its classification, uses, incorporation, and its physical and chemical properties will be highlighted.

2. METHOD

Several databases, including PubMed, Scopus, Google Scholar, Science Direct, Wiley, Tayler & Francis, Hindawi, and Web of Science, were used to search published publications for this study. To study the pharmacological characteristics of soft liners, and underpinning its usage, published literature on soft tissue liners were searched till 2021. The search was conducted using keywords such as classification of soft liners properties, disadvantages and advantages of soft tissue liners, viscoelastic, dental materials, impression technique using soft liners, additives liners materials, soft liners compared to the viscoelastic oral mucosa, and the influences of soft liners on the control of denture plaque. The search did not include publications that were not published in English, dissertations, online sources, literature reviews, or molecular docking articles. The information gleaned from these articles was highlighted in text format.

3. RESULT AND DISCUSSION

3.1. Classifications of Soft Tissue Liners

Soft tissue liners are resilient denture lining material of two types based on their composition. The two main types of soft tissue lining materials were classified by the International Organization for Standardization [ISO]. The first type is materials acrylic resin-based material, and the second type is silicone-based materials [9]. The acrylic resin-based liner is made of a powder, liquid, and plasticizer, where the powder is the polymers (PEMA copolymer), and the liquid is an aromatic ester (dibutyl phthalate) with ethanol. However, the silicone-based lining material is made of dimethylsiloxane and thus has good elastic properties without the need for plasticizer [10, 11, 12]. The soft liners are also classified into short-term materials that last for 30 days, and long-term material (ISO 10139-2:1999) that can be used for up to one year [13]. The short-term liners called tissue conditioners, while the plasticized acrylic resins and silicone elastomers are called long-term resilient liners [6]. The soft tissue liners also can also be classified based on their curative properties into different categories such as self-cured (soften, viscogel), heat cure (supersoft, molloplast B, Lucisoft, Flexor, Permaflex), and light cured resin (clearfitLC - polyisoprene based material) [14]. Some studies recommended the silicone-based material hence it has better roughness values and smoother surface which promote less biofilm buildup over the acrylic resin material [15]. Apart from that, studies showed that the acrylic resilient have problems of durability as they become rigid due to water absorption and the leaching out of some components [7]. However, this problem can be solved by the addition of some additive's compounds such as citrate ester-based plasticizer. The citrate ester-based plasticizer has significant properties in improving the durability of dental soft polymer materials [16]. On the other hand, the acrylic soft liners were preferred as it makes the dentures less painful compared to the silicone based soft liners. This is due to the lesser stress it causes on the oral mucosa than the silicon soft denture liners [17]. Therefore, each type has its characteristics, preferences, and drawback, thus based on the

required treatment or case the soft-liner type will be used.

3.2. *The potential therapeutic uses of Soft Tissue Liners in Dentistry*

Many studies have shown that soft tissue liners have many uses in prosthodontics. Mainly, it is used in the accommodation of soft tissue for denture placement, functional impressions surgical splints and obturator temporary relining, and to increase the stability of ill-fitting dentures. Also, to avoid distressing injury of the mucosa, act as a cushion between the mucosa and denture, for occlusal forces distribution, and for lessen the mucosal pain under the hard dentures. It has been found that the service life of denture increases when soft liner was used, and the volumetric shrinkage of acrylic resin that are compensated for. Furthermore, the use of soft tissue liners has been proved in clinical use as a material for functional impression as shown in Fig.1 [14, 18, 19]. Soft tissue liners are considered as an economical method to the patient, additionally it helps in increasing the stability and retention of a denture [20]. Soft tissue liners are also used in loose dentures to increase its adaptation to soft tissue. Moreover, edentulous patients are mostly treated by using complete dentures, but these dentures lose their fit over time which causes discomfort to the patient including mastication and speech problems [20]. Thus, the use of soft liners in an essential part that aid comfort and prevents mechanical irritation resulting from denture wearing. Soft liners are also used as a temporary method to treat irritated mucosal tissues beneath the loose prosthodontics denture [21].

In cancer patients, soft tissue liners are used as a therapeutic treatment to simulate the recovery of tissues. Soft liners and flexible soft denture or modified dentures are used for potentially malignant lesions in the oral cavity [22]. Soft tissue liners also provide masticatory stresses distribution by having the ability to remodel itself during the therapeutic period of an injury, while the abused tissues return to their original and healthy shape [23]. Another important usage of soft liners is in implant placement during the healing stage as a relining layer after the implant and other clinical applications [24]. Likewise, the inclusion of antifungal and antibacterial agents in

soft tissue liners material is also beneficial for the therapeutic purposes of the mouth tissue [25]. On the other hand, studies have shown that there are many consequences if these soft liners were not used in dental clinical practice [26]. It has been found that the used lining material plays a vital role in the success treatment rate of deep carious lesions in permanent teeth after partial caries removal (PCR) with composite restorations in permanent molars [27].

3.3. *Physical and Chemical Characteristics of Soft Liners*

Soft tissue liners are required to have high stability and long-lasting viscoelastic behavior to help in relieving the pain and improve the functional and nonfunctional forces. However, there are other significant and essential properties that soft tissue liners are required to have such as [8]:

- Low water sorption,
- Stable color,
- Staining and tearing resistant,
- The strength of bonding to the denture base is good,
- Dimensionally stable,
- Biocompatible,
- Resists the growth of fungi and bacteria,
- Processed easily,
- Good service life,
- Robust,
- Elastic modulus is low,
- Heat and radiation resistant,
- Exceptional electrical isolation, and great value of energy dissipation

Soft tissues display viscoelastic behavior which is dramatically essential in biological materials [16]. In 2011, Lacoste-Ferré et al. conducted a study to show the viscoelastic nature of oral mucosa compared to variety of soft tissue liners mechanical properties. Lacoste-Ferré et al, investigated pig oral mucosa samples and six commercialized samples of soft tissue liner. They used creep recovery and dynamic mechanical analysis to find the oral mucosa, and soft tissue liners mechanical modulus. Subsequently, they compared the shear modulus of mucosa bulk and the soft tissue liner by using the Poisson ratio.

Their study highlighted the influence of water absorption plasticization on the mechanical properties of the underlying tissue. They proposed that the biomechanical theory of the conventional complete dentures is in need for a serious change of dynamic mechanical resistance between the denture base and the oral mucosa [28]. In another recent *in vitro* study, Hong et al., [16] suggested that the addition of citrate ester-based plasticizer can improve the viscoelastic properties and expand the sturdiness of soft liners. In addition, oral mucosa has demonstrated referent biopolymer viscoelastic mechanical property *in vitro* which is comparable to soft liners [16, 29].

3.4. Disadvantages and Advantages of Soft Tissue Liners

The major disadvantage of soft tissue liners is the lack of long-lasting bond to denture surface. The elastic strength of materials affects the strength of the bond of the resilient material [1]. Several factors affect the bond between the acrylic and the liners such as: the bonding surface geometry if it is roughened or clinically etched; bonding agent usage; the bonding strength inherent in the material; varied compliance; tear strength; and the lining material thickness. Moreover, when failure of the bond between soft tissue liners and denture base occurs, the growth of bacteria is facilitated, and the longevity of soft tissue liner material is reduced. Therefore, the lack of bonding ability of silicon to acrylic without an adhesive is considered as one of the main drawbacks of this material [1, 14]. In fact, the most substantial problem with soft lining materials is that the softness of denture base might get reduced and separated from the denture when used over long time periods (Table.1) [30]. In addition, phthalate esters, which is a plasticizer that is used in dental soft polymer, have been found to have estrogenic effects which is considered as environmental hormones [16]. Thus, this problem should be considered, and the phthalate esters material should be replaced with an ecofriendly substance. On the other hand, soft tissue liners have significant advantages in prosthodontics dentistry. One of the most known advantages of soft tissue liners is that it lacks taste, odor and has a long setting time that

allowing the practitioner to perform all the functional movements within an adequate time [29]. Soft tissue liners have been found to have the ability to remodel itself during the therapeutic period of an injury resulting in providing masticatory stresses distribution. Thus, it helps the injured tissues to return to their original and healthy shape. It can also improve retention of the denture base and increases the denture fit. Moreover, soft tissue liner material is also beneficial for therapeutic purposes due to the incorporation of the antifungal and antibacterial agents in it [23, 31]. These advantages of soft liners, despite its drawbacks, has made those resilient liners good candidates to be used in dental materials.

3.5. Additives of Soft Tissue Liners

Soft tissue liners have been proven to be more effective with the addition of antifungal agents with little or no effects on the physical and mechanical properties of soft tissue liners [32]. In generally, the control of plaque of soft tissue liners is mainly done by chemical cleaning. The most known used compound for denture cleaning is the Eugenol due to its effective antimicrobial properties [33, 34]. Murata et al., [35] conducted a study to assess denture cleanser effects on the quality of soft tissue liners surface based on porosity and roughness of the surface. In terms of surface quality, it has been found that the enzyme type of denture cleaners is the most appropriate for soft tissue liners. This enzyme cleaner is mainly effective when applied at a range from 3 to 7 days. However, poorly cleaned dentures commonly show palatal inflammation. The optimum time to assess the used of chlorhexidine gluconate mouthwash combined with soft tissue liner by complete denture wearing for patients with palatal erythema [36]. Generally, both are used regularly in daily clinical practice. The result showed no differences in the inflammation levels and the result was statistically significant among all groups. On the other hand, a reduced palatal inflammation was perceived when soft tissue liner was combined with 0.2% of chlorhexidine gluconate mouthwash [36]. Apart from that, the addition of antimicrobial agents to soft tissue liners was thought to be a potentially significant method to be used for the treatment of

denture stomatitis. Kadkhoda et al [37] compared the use of soft tissue liners alone versus soft tissue liners with chlorhexidine for the treatment of denture stomatitis. Results showed that both were effective in the treatment of denture stomatitis. However, there were slightly statistically significant positive effects of adding chlorhexidine to soft tissue liners, particularly seen in the size and color of the lesion when compared to soft tissue liners alone [37]. In fact, denture-related stomatitis affects about 75% of denture wearers. It is well known that this condition can be reduced by instructing patients to not wear the denture at night, and the use of soft tissue liners or antifungal agents. However, a study has been done to compare the effect of management of denture related stomatitis by soft tissue liner and hard auto-polymerizing reline material. The results of their study confirmed that both soft tissue liner and auto-polymerizing reline material was effective in the management of denture stomatitis. However, their results showed that significant differences were found in the time needed for denture stomatitis resolution ($p < 0.001$), where it took longer time for the soft tissue liner than auto-polymerizing reline material [38]. On the other hand, the adhesion between the soft tissue liner and the denture were studied by many researchers. In one study, the soft denture liners incorporated with 5% AgVO₃ showed an effective control of *P. aeruginosa*, *E. faecalis*, and *C. albicans*. Also, it improved the adhesion between the soft tissue liner and the denture base material by 2.5 and 10%. The results of the study confirmed that roughness was not affected while the hardness properties of a soft material were maintained by the 1% concentration [39]. Apart from that, the formation and adhesion of biofilm were found to be decreased on the acrylic-based soft tissue liners while increased in silicone-based soft tissue liners by the saliva presence. Likewise, the biofilm adhesion and formation of MRSA and *C. glabrata* were favored on a rough surface. In fact, the irritation of the oral mucosa may result when microorganisms were present on the soft liners, and this may expose the patients to an increased risk of infection especially in immunocompromised patients. The presence of these microorganisms is more likely due to the

denture base material and lack of bioactive response to the oral condition [40]. Hence, the combination of soft tissue liners surface characteristics and saliva, and their effect on oral biofilm and adhesion formation have a significant advantage when investigated [41, 42].

3.6. Effect of Soft Liners on Denture Surface

Recently, many studies have been done to investigate those effects of the uses of soft tissue liners on denture surfaces. Despite of the many advantages of soft tissue liners, still, it uses were found to a great effect on the denture surface. A study was conducted to highlight the effect of leached out solvent contents of soft tissue liners on the surface roughness of heat-polymerized acrylic and visible light-activated denture bases materials. The result of the study showed that with soft tissue liners usage, a change was seen in the polished denture base material surface. Nevertheless, the result also showed that denture base material made of heat-cured acrylic resin was more resistant to the solvent contents of soft tissue liners by comparison than the visible light-cured acrylic resin material [43]. On the other hand, the conservation of surface texture and softness after mechanical cycling is greatly affected by the chemical composition of the soft lining materials [44, 45]. Moreover, the surface degradation process of soft liners was found to be affected by mechanical cycling, which will lead to surface texture change. In addition, the softness, surface quality, and smoothness of the surface were better preserved by Polysiloxane-based materials when compared with acrylic resin-based plasticized materials under cyclic loading [44].

3.7. Impression Technique Using Soft Tissue Liners

Successful treatment of resorbed alveolar ridge depends on denture teeth position and external denture contours. Subsequently, following resorption, the tissues under the denture will lack support and become easily displaced. Hence, a distorted impression will result when conventional impression methods are used. Soft liners of various consistencies, border molding and final impression materials were tested, to

modify the complete denture impression techniques, and resolve the disadvantages of conventional methods. Therefore, an impression technique has been designated by Smutko for resorbed alveolar ridge by using different consistencies of soft tissue liners. A modification of Smutko's technique was introduced by Wang and Hong for further thickening and improvement of denture border fit. Hence, the overall retention of the complete dentures was improved [19]. Fig. 2 shows the functional and mandibular impression technique using soft tissue liners and bite rims [19].

Soft tissue liners as a functional impression material have been successful proved. Unlike impression compound, which is a muco-compressive material, soft liner has the advantage of being mucostatic, thus, the soft tissue is not compressed, and no pressure is exerted on the tissues, when the impression is being taken [43]. Moreover, soft tissue liner would be in its plastic stage within few hours, where it reacts to functional strains to enhance fit and adaptation [19]. While, within a few days, recovery of tissue occurs following the cushioning of total stresses. Nevertheless, after 1 to 2 weeks, where the material is in the firm stage, dimensional stability of soft tissue liner can be achieved. Furthermore, no distortion is encountered upon removal of the material from the mouth. In fact, the pouring of the impression is the most important stage when using the soft tissue liner as an impression material [19]. This resilient material appears to have stress rate-dependent plastic feature. Therefore, it is essential to pour it immediately. In another dental case study of a 78-year-old patient, soft liners were assessed when he visited for new dentures [46]. It was found that the satisfactory retention and function were achieved when the edentulous patient was treated by a functional impression using provisional dentures, which were previously lined by soft tissue liners. The use of soft liners was used to adjust pressured maxillary and mandibular edentulous ridge [46]. The technique of functional impression is used as soon as the dental stone is poured, and immediately once the impression is taken using soft tissue liners, due to its viscoelasticity. Therefore, the use of soft tissue liners in

functional impression technique were more favored due to its effective characteristics, viscoelasticity and the immediately poured impression.

3.8. *Hardness Changes of Soft Tissue Liners*

Hardness is considered as one of the factors that can affect the quality of soft liners. An experiment was done to investigate the stability of denture liners materials [47]. The result of the study showed an increase in the hardness of all the robust denture liners when placed in artificial saliva (Fig.3). It was also found that the hardest material was GC Reline Soft, while the least change was Elite Soft Relining. Whereas some materials such as Megabase and Mucopren were found to be softer initially than the other materials. However, after the first 7 days, the hardness values of those materials increased more rapidly reaching close to that of Elite Soft Relining [47]. Araújo & Basting [48] investigated and evaluated the application of material after 7 days. They found a reduction in the surface roughness of acrylic resin-based and silicone-based denture soft liner, creating a smoother surface with time. Thus, they recommend that when selecting appropriate material, the silicone-based material is preferred. This is due to its low affinity of biofilm build-up, owing to its smoother surface compared to acrylic resin-based material. In another study, the surface roughness change of dental stone casts was evaluated and compared, when using chair-side soft tissue liners as functional impression [13]. Silicone based soft liner showed a consistent increment of surface roughness over time, compared to acrylic-based soft liner, when used as a functional impression material. Many other studies have investigated the hardness of soft tissue liners; however, the silicone resilient denture liners were considered more stable in hardness than the robust acrylic resin denture liners [49]. The bottom line, these soft tissue liners despite of its based material are highly recommended in many dental conditions such as: denture opposing natural dentition, resorption of irregular bone, immediate implant, implant placement, tooth undercuts, oral mucosa atrophy, and for patients with bruxism and xerostomia [1, 50, 51, 52].

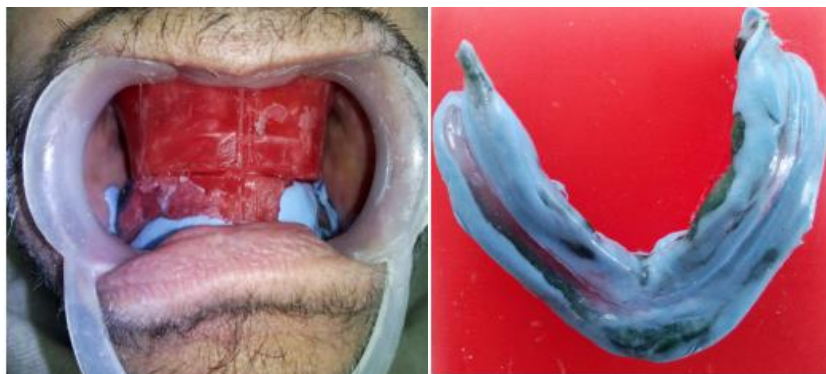


FIGURE 1: Shows the functional and mandibular impression technique using soft tissue liners and bite rims adopted .



FIGURE 2: Shows the final impression taking using tissue soft liner.

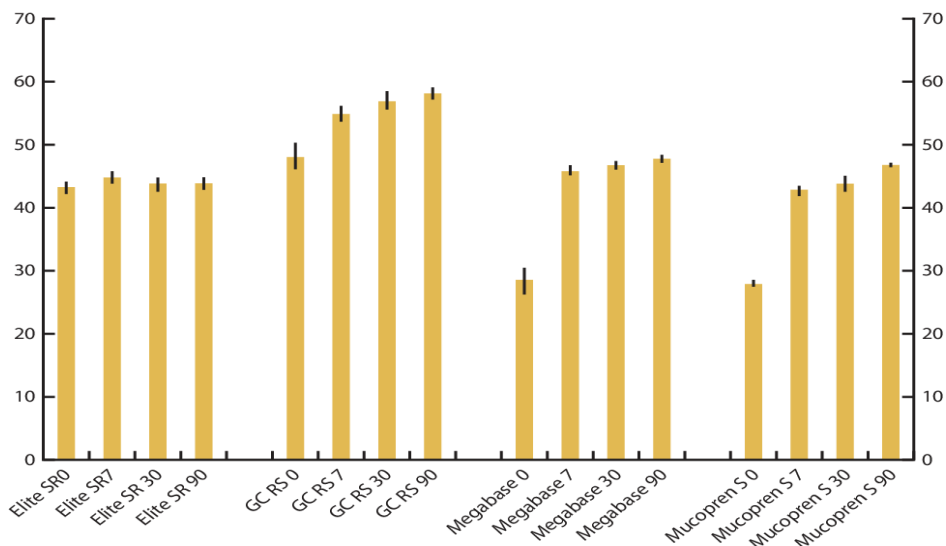


FIGURE 3: Shows a comparison of the hardness changes of some tested materials (Shore A degrees) adopted.

TABLE 1: Shows the results of durometer (Shore A hardness test N¹/₄3), the result shows the softness of denture base changes over time

Product Type	Materials	24 h		28 d	
		Mean	SD	Mean	SD
Acrylic resin-based	Durabase (A)	29.27 ^b	1.64	39.47 ^b	1.68
Silicone-based	Dentusil (A)	28.90 ^b	0.14	42.80 ^c	0.43
	GC Reline Soft (A)	50.13 ^f	0.48	57.20 ^e	0.28
	GC Reline Ultrasoft (B)	21.30 ^a	0.29	34.73 ^a	0.47
	Mucopren Soft (A)	33.06 ^c	0.62	46.47 ^d	0.09
	Mucosoft (A)	37.93 ^e	0.25	39.93 ^b	0.09
	Sofreliner Tough (A)	35.13 ^d	0.09	43.73 ^c	0.19

Within same column, means with same letter are not significantly different ($P > .05$).

4. CONCLUSION

The importance and significant use of soft liners are continuous, despite the tremendous advancement in the fields of dentistry and implantology, as it offers a better option for treatment with fewer problems. Soft liners form an essential part of denture rehabilitation. It aids to accommodate the soft tissues for denture placement, increases the fit of the denture, records functional impressions, as well as in temporary relining of surgical splints and obturators. It also can be used as a temporary method to treat irritated mucosal tissues beneath the loose prosthodontics denture. In addition, it prevents mechanical irritation resulting from denture wearing and provides masticatory stress distribution. The additions of antifungal and antibacterial agents to the soft tissue liners are also beneficial for therapeutic purposes. In terms of types of soft liners, the silicone resilient denture liners were more preferred than the robust acrylic resin denture liners, due to their stability in hardness and composition of materials. The hardness of the soft lining materials increases over time, while its usage decreased its softness over time. Therefore, soft liners are considered an efficient, economic, practical, and accessible alternative that can be used in the management of denture-related stomatitis and oral infection treatment.

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