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Research Article / Araştırma Makalesi

The Bonding of Soft Lining Materials to the Denture Base: Meta-Analysis

Yumuşak Astar Materyallerinin Dental Kaide ile Olan Bağlantısı: Meta Analizi

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ABSTRACT

Background: One of the biggest disadvantages of soft lining materials is that they deform over time and cause ruptures and fractures in the bonding with the denture base. To overcome these problems, the factors that weaken the bonding should be determined and measures should be taken accordingly. The aim of this study is to elucidate the factors affecting the bonding of soft lining materials to the denture base, in terms of dental base and soft lining materials, surface treatments and retention agents.

Methods: The keywords 'soft lining materials, dental base, bond strength' were written and searched using PubMed/Medline databases, and as a result, 54 research articles related to the current study were evaluated. Each article was classified in terms of the type of denture base and soft lining material, methods of surface treatment, retention agents, and bond strength.

Results: While retention in saliva and water bathing decreased the shear bond strength compared to the group without any retention agent, the application of cleaning agents increased the shear bond strength. The tensile bond strength varied according to the surface treatments, and the laser application showed the highest tensile bond strength. In terms of peel strength, the heat-treated group and the laser with chemical treatment applied group showed lower bond strength than the mechanical treatment and soaked group.

Conclusion: It was concluded that cleaning agents, laser application and mechanical treatments increased the tensile, shear and peel strength.

Keywords: Bond Strength, Soft Lining Materials, Surface Treatments

ÖZ

Amaç: Geniş bir kullanım endikasyonu bulunan yumuşak astar materyallerinin en büyük dezavantajlarından biri zamanla deforme olması ve protez kaidesi ile olan bağlantıda kopma ve kırılmalara yol açmasıdır. Bağlantıdaki bu kopma ve kırılmalar klinik açıdan sorun teşkil etmektedir. Bu sorunların üstesinden gelebilmek için yumuşak astar materyalleri ve protetik kaide arasındaki bağlantıyı zayıflatan faktörler belirlenmeli ve buna göre önlemler alınmalıdır. Bu çalışmanın amacı, yumuşak astar materyallerinin protez kaidesine bağlantısını etkileyen faktörleri, dental kaide ve yumuşak astar materyallerinin çeşidi, yüzey işlemleri ve retansiyon ajanları açısından aydınlatmaktır.

Gereç ve Yöntemler: 'Yumuşak astar materyalleri, dental kaide, bağlanma dayanımı' anahtar sözcükleri yazılarak Pubmed/Medline veri tabanları kullanılarak tarama yapılmış ve bunun sonucunda mevcut çalışma ile alakalı 54 araştırma makalesi değerlendirilmiştir. Her bir makale dental kaide ve yumuşak astar materyalinin çeşidi, yüzey işlemleri, retansiyon ajanları ve bağlanma dayanımı türü bakımından sınıflandırıldı. Bağlanma dayanımı ise kendi arasında kesme, çekme ve soyulma bağlanma dayanımı olarak 3 gruba ayrıldı.

Bulgular: Tükürük ve su banyosunda bekletme, herhangi bir retansiyon ajanı uygulanmayan grup ile karşılaştırıldığında kesme bağlanma dayanımını azaltırken, temizleme ajanlarının uygulanması kesme bağlanma dayanımını arttırmıştır. Çekme bağlanma dayanımı, yüzey işlemlerine göre değişiklik göstermiş olup lazer uygulaması en yüksek çekme bağlanma dayanımı sergilemiştir. Soyulma dayanımı bakımından ise, ısıl işlem uygulanan grup ile lazer ve kimyasal maddeler uygulanan grup, mekanik işlem ve suda bekletilen gruba göre daha düşük bağlanma dayanımı göstermiştir.

Sonuç: Temizleyici ajanların, lazer uygulamasının ve mekanik işlemlerin çekme, kesme ve soyulma dayanımını artırdığı sonucuna ulaşılmıştır.

Anahtar Kelimeler: Bağlanma Dayanımı, Yumuşak Astar Materyalleri, Yüzey İşlemleri

Introduction

Soft lining materials are defined as the soft polymers applicable on the bond surface of the denture to lower occlusal loads on mucosa tissues and spread the load more evenly.[1] They can be suitable for permanent and temporary usages. Soft lining materials used for temporary purposes are prepared at room temperature, allowing the old prosthesis to be adapted and used more comfortably until the prosthesis is renewed or the patient's permanent prosthesis is made. Soft lining materials, which are used for permanent purposes, are polymerized with heat and their usage periods vary between 6 months and 5 years.[2]

The basic properties and utilization

Soft lining materials must establish a good bond with denture base, be free from any dimensional change, preserve its softness, not absorb water, demonstrate no porosity so that microorganisms are repelled, be resistant against abrasion, be easy to clean and form, have a stabile color, be biocompatible, finishing and polishing on it must be easy to perform, be easy to repair, have a fine taste and smell, disallow proliferation of bacteria and fungus, and be non-toxic and non-irritant.[3]

Soft lining materials exert several benefits in versatile cases. These include aging and pathologic changes, local relief of the pressure, lowering the occlusal load, gripping the undercuts, allowing denture retention, patients with a maxillofacial defect, radiotherapy patients, dryness of the mouth, presence of hyperemic loose mucosa, in bruxism cases, preventing any bone resorption caused by extreme pressure, in cases with hard middle palatal raphe, resettling denture retention via correcting the resultant imbalance, after periodontal surgeries, to be used as the functional measurement material, to prepare sinus and plaques, maxillofacial dentures, surgical defects, epithesis and obturator preparation, decreasing the pain emerging on thin and non-resilient mucosa due to heavy chewing force and helping the patient adapt to his/her denture.[4,5]

The classification

Overall, soft lining materials are various and can be classified

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according to processing, usage, and chemical structure. Soft lining materials polymerized under room temperature or by heat. Those hardened under room temperature are either acrylic or silicon. They are mostly used for temporary purposes for a few weeks to a few months and may require renewal occasionally. Until the time denture is renewed or permanent lining is applied, they allow using old dentures comfortably. Their advantages are being able to be used inside the patient's mouth, cost effective, easy to apply, compared to polymerized ones they are better compatible with the tissue. Moreover, they raise blood circulation via massaging lower tissue. The disadvantages are that it loses its softness and dimensional stability over time, absorbs water, changes color, can fail in the bonding with the denture base. This failure can cause fungal and microorganism accumulation as a result of leakage.[3] Soft lining materials polymerized by heat (through applying conventional muffling and compression molding method) are more durable and remains soft for a longer period. Soft lining materials polymerized by heat are also silicon and acrylic. They are relatively long-lasting (6 months to 5 years). In terms of chemical structure, soft lining materials are various. Acyrilic-based soft linings are formed by polymethyl methacrylate polymer and n-butyl ester monomer.[6] With respect to their polymerization types they are hardened either under room temperature or by heat.[7]

Silicon based soft linings neither wear down easily nor undergo physical and chemical change. They are tasteless, not allergenic, odorless and colorless. Compared to acrylic forms, silicon based soft linings absorb less water due to having no plasticizers. Since silicone-based soft lining materials have a chemical composition similar to silicone-containing impression materials, they can maintain their elasticity for a long time without the need for any plasticizer. [8] Because of the porous structure, the color may darken in due time. Hard to cut and polish. Their bond with base plaque may derail in due time. Fungus proliferation such as Candida albicans is among its greatest disadvantages. [9-11] The loss of the connection with the prosthesis base over time is seen as the biggest disadvantage of soft lining materials containing silicone. [12]

Polivinyl resins are 2 types: polyvinyl chloride and polyvinyl acetate. Vinyl copolimers are synthetic resins used in the clinic for the first time.[13] Polyvinyl chloride is a brittle material that requires polymerization heat above 1000 C, which adversely affects the structure of acrylic base. On the other hand, alternatively developed polyvinyl acetate is extremely flexible. Its bond with poly (methyl methacrylate) (PMMA) base is the greatest disadvantage. [14]

Elastomer/Methacrylate system is formed by the combination of methacrylate monomer and elastomer. It has a single pad system and is highly resistant with an elastic quality. It has a good bond with PMMA denture base hence the final product is quite a resistant material. [15]

Fluoroethylene copolymers are chemically stabile, and they have strong resistance to water, solvents, and abrasion, but hardens with light. Despite that they are not fit to be used for denture applications since they are hard, they have weak bond with denture base with lacking the essential viscoelastic features. That is why this new soft denture lining with a fluorinated copolymer base to stick strongly on the acrylic denture base and exhibiting notable mechanical features is recommended. It has a good bond with PMMA base, low water absorption quality, low ratios of waste monomer, low resolution, and high wettability. [14]

Polyurethanes are formed by the reaction of hydroxyl components with isocyanate and successfully used in maxillofacial dentures. Their bond with denture base is weak. They are colored (darkened) in a short time. [13] Another disadvantage is that isocyanates may have toxicity. [14]

Natural tires/PMMA graft copolymers have an increased the graft adhesion onto the denture, with satisfactory mechanical test results. Since dithiocarbame in its composition leads to mucosal reactions, it is not deemed fit for clinical usage. [14]

Advantages and Disadvantages

Soft lining materials lower the occlusal load on mucosa, increase denture retention, help prevent bone resorptions due to extreme pressure in bruxism cases, decrease the pain emerging on thin and no resilient mucosa due to heavy chewing force, and can help the patient adapt to his/her denture. They stimulate blood circulation through massaging effect on tissue, thereby enable supporting tissues to gain health.

Soft lining materials are complex and costly. It is applied to thin denture base that could lead to weakening and breaking of denture, and possibly disconnections in bonding to denture base. Over time, they lose elasticity. They may be deformed in terms of softness, porosity, rupture, color, and shape change. [4] The rough surfaces formed as a result of this deformation lead to the accumulation of plaque and tartar, and prepare a suitable environment for the reproduction of yeast and similar organisms. The difficulty of cleaning the materials further increases the accumulation in the environment.[10] Due to these disadvantages, deterioration in its bonding to the denture base can be observed and this situation causes a clinical problem. To overcome these problems, factors that weaken the bonding should be identified and measures should be taken accordingly. [16] The aim of this study was to elucidate the factors affecting the bonding of soft lining materials on denture base with respect to base, type of soft lining materials, surface treatments, and retention agents.

Material and Methods

Systematic Literature Review

A systematic literature review was conducted for the search of key words ('soft liner bond strength', 'soft lining material bond strength', and 'soft liner denture base bond strength') on PubMed/Medline sites. The categorical factors were surface treatments, retention agents, and test methods and materials that affect bonding of soft lining materials on denture base. The response variables were the bonding strengths as assessed by the shear, tensile, and peel strengths.

Studies that provided not any numerical value for bond strength or presented no details on the subjects were excluded from the database. Data for this study was compiled from 54 relevant articles. The base types (n=3) were acrylic, metal, and polyamide bases. The soft lining materials (n=4) were acrylic, composite, polyvinyl acetate, and silicon. Surface treatments were categorized into 10 groups: no surface treatment and those subjected only to one of polymerization, water bathing, thermal, chemical, mechanical, and laser treatments and those subjected to both mechanical and chemical treatments and both mechanical and laser treatments. Retention agents (n=5) were no agent, food simulation agents, saliva, water bathing, and cleansing agents.

Thermocycle application and autoclave retention were categorized within the thermal treatment. Applications of adhesive, antifungal, antimicrobial, gas, food simulating agents, retaining in chemical solvent, monomer, cleansing agents, and retaining in salivate were considered chemical treatment. The mechanical treatments covered sanding and application of dissimilar lining diam.

Data were subjected to the PROC FREQ procedure of SAS to determine category of the factors mentioned previously. After determining mean differences against their control in original studies using the Cohen method (>10) and the Hedges method (n<10), relative improvement and/or regression in response variables were determined. Finally, the linear model was established to determine the main effects of the factors and hierarchical interactions on response variables. Insignificant model terms were omitted in order to avoid artefactual factors. Statistical significance was declared at $P < 0.05$.

Results

Data of consisted of 351 observations in 54 previously published research papers. According to the base type, acrylic, metal, and polyamide constituted 97.15, 1.14, and %1.71, respectively (**Table 1**). Soft lining materials were comprised of mostly of silicon (69.52%) and followed by acrylic (%27.92) (**Table I**).

Table I. The type distributions of the bases and soft lining materials in the database.

Factors	N (%)
Base	
Acrylic	341 (97.15)
Metal	4 (1.14)
Polyamide	6 (1.71)
Soft Lining Material	
Acrylic	98 (27.92)
Silicon	244 (69.52)
Composite	2 (0.57)
Polyvinyl acetate	7 (1.99)

In few cases, there were dual surface treatments (**Table II**). Chemical treatment and thermal processing were two most comment treatments, constituted % 34.48 of the treatments. Mostly utilized retention agents (% 6.55) were water bathing and cleansing agents (% 5.41) (**Table II**).

Table II. The distributions of surface treatments and retention agents in the database.

Factors	N (%)
Surface Treatment	
No Treatment	135 (38.46)
Water Bathing	23 (6.55)
Polymerization	9 (2.56)
Thermal Processing	41 (11.68)
Mechanical Treatment	26 (7.41)
Chemical Treatment	80 (22.80)
Laser Application	26 (7.41)
Mechanical Treatment + Chemical Treatment	4 (1.14)
Mechanical Treatment + Laser Application	5 (1.42)
Chemical Treatment + Laser Application	2 (0.57)
Retention Agents	
None	304 (86.61)
Water Bathing	23 (6.55)
Saliva	2 (0.57)
Food Stimulation	3 (0.85)
Cleansing Agent	19 (5.41)

The effects of the base type, soft lining material type, surface treatment, and retention agent on the shear bond strength are shown in **Table III**. There was only adequate the number of observations for acrylic base. Thus, comparisons could not be computed to elucidate the base type effect on the shear bond strength. Soft lining materials made of acrylic and silicon were in sufficient number of observations but they were not significantly different. The surface treatment effect on the shear bond strength was insignificant. There were significant differences among retention agents on the shear bond strength (P<0.001). Compared to the group that received not any retention agent retention in saliva and water bathing diminished the shear bond strength, whereas retention in cleansing agents empowered the shear bond strength (**Table III**).

Table III. The effects of the base type, soft lining material type, surface treatment, and retention agent on the shear bond strength.

Factors	P <
Base Type	Not detected
Soft Lining Material Type	0.712
Surface Treatment	0.832
Retention Agent	<0.001
Retention Agent	Mean±SD
None	12.50±29.28^{b}
Water Bathing	1.06±0.29^{c}
Cleansing Agent	127.99±42.79^{a}
Saliva	0.69±0.21^{c}

Different superscripts among retention agents significantly differ (P<0.05).

Among the category of the base type, soft lining material type, surface treatment, and retention agent, the tensile bond strength was varied by the surface treatment (**Table IV**).

Table IV. The effects of the base type, soft lining material type, surface treatment, and retention agent on the tensile bond strength.

Factors	P <
Base Type	0.955
Soft Lining Material Type	0.105
Surface Treatment	0.001
Retention Agent	0.391
Surface Treatment	LS Mean
No Treatment	5.55^{bs}
Water Bathing	3.81^{bc}
Polymerization	0.46^{c}
Thermal Processing	3.69^{bc}
Mechanical Treatment	2.02^{c}
Chemical Treatment	8.76^{bc}
Laser Application	20.87^{a}
Mechanical Treatment + Chemical Treatment	0.13^{c}
Mechanical Treatment + Laser Application	12.21^{ab}

Different superscripts among surface treatments significantly differ (P<0.05).

The laser application was superior to other treatments to enhance the tensile bond strength. Combining laser application with mechanical treatment numerically reduced its effectiveness. Polymerization and mechanical treatment were inferior to improve the tensile bond strength.

The peel strength was affected by the surface treatment (**Table V**). Thermal processing and chemical treatment lowered the peel strength, whereas laser application, mechanical treatment, and water bathing increased the peel strength.

Table V. The effects of the base type, soft lining material type, surface treatment, and retention agent on the peel strength.

Factors	P <
Base Type	0.505
Soft Lining Material Type	0.201
Surface Treatment	<0.001
Retention Agent	Not detected
Surface Treatment	LS Mean
No Treatment	4.55^{ab}
Water Bathing	6.16^{a}
Thermal Processing	1.38^{b}
Mechanical Treatment	6.49^{a}
Chemical Treatment	0.47^{b}
Laser Application	7.16^{a}

Different superscripts among surface treatments significantly differ (P<0.05).

Discussion

Failure of the soft lining materials to bond with denture base is one of the most salient problems that limits their usages. [17] A weak bond between the base and lining material can lead to potential sites to accumulate microbial activity, plaque, and tartar. [18] Different surface treatments are applied to enhance the bond between soft lining and denture base. The surface treatment effects in the literature are controversial and hard draw conclusion.

Al-Athel et al. [19] divided samples into 3 groups to not wetted and wetted at 37 and 50oC in distilled water for 7 days prior to measuring the shear and tensile bond strength. Soaking at 37oC for 1 week did not alter the shear and tensile bond strength. However, extending soaking up to 6 months considerably decreased the bond strengths. The adverse effect of soaking at 50oC for 1 week was notable. Salloum et al. [20] reported that keeping silicon lining material within 37oC distilled water and salivate decreased the shear bond strength. However, Mahboub et al. [21] kept inside cleansing agent and % 2.5 sodium hypochlorite for 15 minutes and reported that acid caused deterioration in the shear bond strength measured 20 days later. In soaking, absorbed water could directly swell lining material and tensile concentration in bond interface which could diminish bond strength or absorbed water could indirectly alter visco-elastic features of lining material. In the literature, different findings could be related to variance in the soaking time, the soft lining materials type, the sample shape, and the application procedure. [18] The data of the present study reveal that soaking in distilled water, retention in inorganic artificial salivate and cleansing agents impacted the bond strength of soft lining materials with denture base.

To evaluate the tensile bond strength, Akın et al. [22] performed Er-YAG, Nd-YAG and KTP laser application, and administered sanding processing to some of the groups both before laser application and before lining application. They reported that Er-YAG laser achieved the highest tensile bond and that Nd-YAG and KTP laser were not effective. Moreover, exposure to sanding processing before lining application weakened that base. This finding can be attributed to the high energy of Er: YAG laser. The effect of high energy causes immediate vaporization of water due to a great volume expansion. This expansion in effect causes the abrasion of ambiance material [23] thereby shrinking the surface area. Therefore, soft lining materials penetrate into the irregularities or holes caused by Er: YAG laser and empowers the strength of the bond. In agreement with results of current study, Tugut et al. [24] also reported that Er-YAG laser improved the base. In another study, Akın et al. [25] reported superiority of laser to bonding agent to achieve higher base level.

Alcantra et al. 26 examined various antimicrobial agents' effect on peel bond strength. In accordance with present study they reported that although type and concentration of chemical agent application was changed it did not alter the bond between denture base and soft lining material. Sanchez-Aliaga et al. 27 applied dissimilar antifungal agents on 2 different types of soft lining material and measured the peel strength. After keeping inside 37°C distilled water, the treatment of soft lining material with Nystatin, Ketoconazole and Chlorhexidine did not alter the peel test results and rupture modes. However, treatment with Miconazole improved the peel strength.

When the studies were examined, it was seen that the type of soft lining material, type of denture base and surface treatments had a significant effect on the bond strength between soft lining materials and denture base. According to the results of present study, there was no significant effect of the type of soft lining materials on the shear, tensile and peel bond strength. Therefore, clinicians may prefer acrylic lining materials as well as silicone lining materials.

Conclusion

Despite having a wide range of usage indications, one of the greatest disadvantages of soft lining materials is being deformed in the course of time; thereby causing rupture and fractures in the denture base bond. This meta-analysis evaluated the base type, the soft lining material type, the surface treatment, and retention agent effects on the bond strengths. The shear bod strength was responsive to the retention agent, being the highest for cleansing agent. On the other hand, retaining in saliva and water bathing diminished the shear bond strength. Both the tensile bond strength and the peel strength were responsive to the surface treatment, laser application had the highest value on tensile and peel bond strengths whereas thermal processing and chemical treatment lowered the peel strength.

Therefore, based on these results, clinicians may apply laser application and mechanical treatments to increase the bond strength between soft lining materials and the denture base, while they may avoid applying thermal and chemical surface treatments, as they adversely affect shear bond strength and reduce peel strength by retaining in saliva and water bathing.

Değerlendirme / Peer-Review

İki Dış Hakem / Çift Taraflı Körleme

Etik Beyan / Ethical statement

Bu çalışmanın hazırlanma sürecinde bilimsel ve etik ilkelere uyulduğu ve yararlanılan tüm çalışmaların kaynakçada belirtildiği beyan olunur.

It is declared that during the preparation process of this study, scientific and ethical principles were followed and all the studies benefited are stated in the bibliography.

Benzerlik Taraması / Similarity scan

Yapıldı – ithenticate

Etik Bildirim / Ethical statement

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Çıkar Çatışması / Conflict of Interest

Yazarlar çıkar çatışması bildirmemiştir. | The authors have no conflict of interest to declare.

Yazar Katkıları / Author Contributions

Çalışmanın Tasarlanması | Design of Study: BT(%60), NY (%40)
Veri Toplanması | Data Acquisition: BT (%70), NY (%30)
Veri Analizi | Data Analysis: BT (%65), NY (%35)
Makalenin Yazımı | Writing up: BT (%70), NY (%30)
Makale Gönderimi ve Revizyonu | Submission and Revision: BT (%65), NY (%35)

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