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Original Article

Comparison of tensile bond strength of resilient soft liners to denture base resins

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Purpose of the study: To determine the tensile bond strength of three commercially available soft liners to a polymethyl methacrylate denture base resin, to help the clinicians to select the liner for their patients, and to provide a comparative database when new materials are introduced.

Basic procedures: In this study, tensile bond test was considered a good method of investigating and comparing the bond strength of three resilient lining materials, because it gives information on the strength of the bond in comparison to the tensile strength of the material.

Main findings: The tensile bond strength of SuperSoft (acrylic-based liner) was better compared to Molloplast B (silicone-based liner) and Mucopren (silicone-based liner).

Principle conclusion: The tensile test used in this study was effective in evaluating and comparing the tensile bond strength of the three liners. Factors such as processing methods, water sorption, bonding agents, changes in compliance, changes in the bond strength in the harsh oral environment, and chemistry of the material need further investigations to increase the serviceable life of the material.

Key words: soft resilient liner; tensile bond strength.

The impression surface of a denture base that is lined with a resilient material should partially absorb, and provide for a more advantageous distribution of imposed stresses to its basal seat.

Soft denture liners have several problems; one of the more serious problems with soft liners is the failure of adhesion between the soft denture liner and the denture base. Bond failure also creates a potential surface for bacterial growth, plaque and calculus formation. Therefore, frequent clinical evaluation and periodic replacement of the soft denture liner is required.

Tests developed to evaluate adhesive strength of materials include tensile, shear, fatigue, creep, impact, and cleavage. The most commonly used methods to measure the bond strength of resilient lining materials to denture base materials have been peel, tensile, and shear tests. In this study, tensile bone strength is used to study the bond of the liner to the resin.

- **Soft denture liners used**
  1. SuperSoft (GC America Inc., USA)
  2. Molloplast B (Detax Gmbh & Co., KG, Germany)
  3. Mucopren (Kettenbach, Germany)
- **Heat cure acrylic resin**
  1. DPI – heat cure material
  2. Tensile testing machine
  3. Materials and equipment used for denture base acrylization procedure.

METHODOLOGY

Preparation of acrylic test specimen by standardized processing conditions

A rectangular brass metal pattern mold was prepared for a test specimen of size 40 mm x 10 mm x 7 mm. Wax blocks were prepared by pouring molten wax into the mold cavity. Two blocks were invested with a brass spacer of dimensions 10 mm x 7 mm x 3 mm in between the wax blocks. Dewaxing was done. Heat-cured PMMA (DPI – heat cure material) was used to fabricate the acrylic blocks. Trial packing was done, and excess

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was trimmed. After packing, the flasks were compressed with the help of hydro press and were processed in a water bath at 75°C for 1½ hour, followed by 100°C for 1 hour.

Lining the acrylic test specimen

After polymerization of acrylic blocks, the metal spacer was retrieved. The required soft liner was manipulated, trial packed, and cured according to the manufacturer's instructions.

Curing cycles

DPI – heat cure material: Immerse the flask in cold water. Bring gradually to the boil in not less than 30 min. Boil for 30 min.Total time 1 hour.

Super soft: Curing in the acrylizer for 6 h at 165°C

Molloplast B: Place flask in cold water and heat up slowly to 100°C/212°F. Polymerization in boiling water at 100°C/212°F for approximately 2 hour.

Mucopren: Cured with water heated to 40–45°C for at least 20 min.

Testing the bond strength

The specimen [Figure 1] was fixed to the grip of the machine and pulled in either way. The maximum load, which the specimen can take till the break point, was noted. The bond strength was calculated by

$$\frac{\text{The stress at failure (kg)}}{\text{Cross sectional area of the sample (cm}^2\text{)}}$$

Means and standard deviations were calculated for all three materials. The bond strengths were compared using one-way analysis of variance [Table 1]. Later the values were compared with each other.

RESULTS

SuperSoft S. No.	Bond strength (kg/cm²)	Molloplast B S. No.	Bond strength (kg/cm²)	Mucopren S. No.	Bond strength (kg/cm²)
1	25.0	1	15.0	1	12.5
2	26.0	2	14.5	2	11.5
3	25.0	3	13.0	3	13.0
4	24.5	4	13.5	4	12.5
5	24.5	5	14.5	5	12.0
6	24.5	6	14.5	6	12.5
7	25.0	7	15.0	7	11.5
8	24.5	8	13.5	8	12.5
9	25.0	9	14.5	9	12.5
10	24.5	10	13.5	10	11.5

SuperSoft: Mean, -24.85; SD, -0.4743; *t* value, -39.6629.
Molloplast B: Mean, -14.5; SD, -0.7091; *t* value, -6.9305.
Mucopren: Mean, -12.2; SD, -0.5375; *t* value, -55.8028.

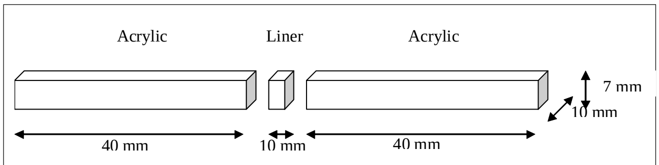

Figure 1: Specimen

DISCUSSION

After analyzing the results obtained, the previous literature and opinions from engineering experts, the following interpretations can be made.

The tensile bond strength of Supersoft was better compared to Molloplast B, which was in turn, better than Mucopren.

Type of test for measuring the bond strength

The tests developed to estimate the adhesive bond strength are tensile, shear, fatigue, creep, impact, and cleavage. The most commonly used methods to measure the bond strength have been peel, tensile and shear tests.

In peel bond test, the values at which resilient liners fail cohesively compared favorably with the original tear strength values of these materials as there would be in a tear specimen. If the resilient liner reveals low-tear strength values when the adhesive peel strength of the resilient liner resists stresses approaching the elastic modulus without debonding, more cohesive failure may occur with a peel test than with a tensile bond test. This finding is significant for liners that show relatively low-tensile strength and tear strength. In general, because silicone-based resilient liners have lower tear strengths than the other types of resilient liners, the adhesive strength of such materials would best be characterized by the use of tensile bond test.

Liner thickness of the specimen

In the present study, the liner thickness was 3 mm. Athel et al.[1] had done a tensile bond test where he compared the bond values with increase of the liner thickness, that is, 3, 4.5, and 6 mm. The strength decreased significantly when a thick layer of Molloplast B denture lining material was applied, possibly because of the increased possibility of the presence of voids and internal imperfections in the thicker layer. These voids and imperfections would weaken the joints by concentrating the stress at the bond site when load is applied. However, increasing the thickness beyond 4.5 mm had no effect on the tensile bond strength.

Processing against polymerized or unpolymerized PMMA

In this study, the liner was processed against polymerized PMMA. Kawano has compared the

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difference in strength when processed against polymerized and unpolymerized PMMA. All liners demonstrated increased bond strength when processed against polymerized PMMA, with the exception of Novus, which had no significant difference and Vinasoft, which decreased. Supersoft has the potential of forming an interpenetrating molecular network across the interface through the two chemically similar polymers. However, the bond strength of Supersoft decreased when processed against the unpolymerized PMMA.

Processing factors and storage

According to Aydin et al.,[2] the bond strength of soft liners behaved differently when stored in water (0, 15, 30 and 90 days). No change was observed by storing in water. Craig and Gibbons stated that the strength increased by storage in water. Water may percolate directly into the bond site, leading to swelling and consequent increase in stress at the liner denture base interface and reduce the bond strength. The water may indirectly decrease the bond strength by causing the plasticizers from the body to leach out.

Craig reported that roughening the denture base surface improved the bond strength, whereas Amin et al.[3] stated that roughening decreased the bond strength.

Factors in testing procedure

Studies revealed a highly significant increase ($P < 0.001$) in the tensile strength when specimens were deformed at a rate of 40 mm / min when compared with a deformation rate of 20 mm / min. However, the tensile strength decreased significantly when specimens were deformed at a higher rate of 60 mm / min. Failure is more cohesive in specimens deformed at rates of 20–40 mm / min. The decrease in the tensile strength specimens deformed at a rate of 60 mm / min was associated with an increased tendency towards adhesive failure.

Composition of the liner

To achieve adequate softness, the tensile strength of the elastomer may suffer. However, it must be pointed out that the bond strength will likely be lower when old dentures are relined, because the denture base may be contaminated by micro-organisms and other materials absorbed from food or cleansing agents.

Leaching of the plasticizers is a major problem. Diatomaceous earth was used as filler. This shows a high rate of water absorption. As the water content increases, the filler particles rapidly swell in size. This results in a marked change in both the physical properties and the dimensions of the polymer and a loss of adhesion from the acrylic, to which the soft denture material is bonded. A plasticizer, which itself undergoes polymerization and, therefore, would not readily leach from the set polymer should be used. Possible materials of this type include the alkyl maleates and itaconates. The liquid phase might be modified so that the monomer contains a high percentage of catalyst.

The results of this study will serve as a benchmark for studying new materials and other variables that can affect bond strength. Factors such as processing methods, water sorption, bonding agents, changes in compliance, changes in the bond strength in the harsh oral environment and chemistry of the material need further investigations to increase the serviceable life of the material.

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88 CMYK