TENSILE BOND STRENGTH BETWEEN UDMA PROCESSED RECORD BASE AND HEAT CURED PMMA

by

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CERTIFICATE OF APPROVAL

MASTER'S THESIS

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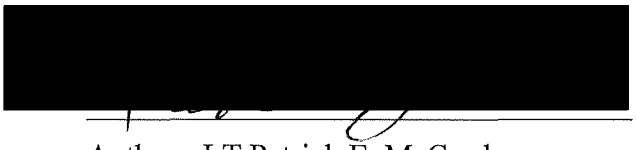

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Abstract:

Introduction: Record bases are used to capture interocclusal records, set prosthetic teeth and have been shown to reduce overall error in the fabrication of removable complete dentures (RCD's). Record bases can be processed in poly-methyl methacrylate (PMMA) or urethane di-methacrylate (UDMA). Subsequently, teeth are attached to the record base using PMMA. UDMA has mechanical properties superior to PMMA but its chemical structure may preclude forming a reliable bond to PMMA. **Objective**: To compare the tensile bond strength (TBS) of UDMA to PMMA and PMMA to PMMA for RCD record base fabrication. **Methods**: Two groups consisted of 12 molded and light-cured half-dumbbell shaped UDMA specimens and 12 molded and heat processed half-dumbbell shaped PMMA specimens. Surface treatment consisted of a solvent called wax remover for UDMA specimens and liquid monomer for PMMA specimens. All half specimens were placed in a plaster mold and PMMA was packed and heat processed to fabricate full-dumbbell shaped specimens (n=12). All manufacturer's instructions were followed for specimen fabrication. Static load testing was conducted following International Organization for Standardization 11405 for TBS using a custom titanium jig on an MTS universal testing machine (5kN load/0.5mm/min crosshead speed). TBS was calculated over bonding surface area. Student's t-test was used to compared the TBS between UDMA to PMMA group and PMMA to PMMA group. **Results**: Mean TBS for the UDMA to PMMA group was 20.38±6.48 MPa and PMMA to PMMA group was 55.51 ± 7.74 MPa ($p<0.001$). **Conclusion**: PMMA had a significantly greater TBS compared to UDMA when bonded to processed PMMA.

Key Words: PMMA, UDMA, hybrid technique, record base, shear bond strength

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LIST OF ABBREVIATIONS

PMMA: Polymethy-methacrylate
UDMA: Urethane Di-methacrylate
RCD: Removable Complete Denture
CR: Centric Relation

I. Introduction

The record base and occlusal rim are used to capture interocclusal and facebow records used for removable complete denture (RCD) fabrication. Record bases can be made in two ways from many types of materials. In the first method, the master cast is "blocked out" with wax to fill any undercuts to facilitate removal on and off the cast and prevent damage. This is referred to as a trial base[1]. This record base is poorly adapted to the mouth and can have reduced retention and stability. A second method eliminates the blockout stage. Record base material is adapted directly to the master cast and processed to the final form.

In 1981 Langer compared the accuracy of interocclusal records using a trial and processed record base. He found significantly more occlusal discrepancies using a trial base[1]. He noted the advantage of the processed record base was the same base was used for recording, transferring and adjusting occlusion. Error caused by trial base instability was reduced[1]. Schoen and Stewart compared centric relation (CR) records with these record bases in 1967. They reported more repeatable and accurate CR records using a processed record base[2]. Syclora explored the same topic in 1995. He looked at the dimensional changes of finished dentures after one (trial base) or two (processed base) stages of curing. He found that changes in pin position, percentage of centric contacts and adaptation of the posterior palatal seal were all more favorable with two stages of curing[3].

Eclipse (Dentsply) is a UDMA denture base material released in 2007. It is advertised for use in nocturnal occlusal orthotics, partial removable dental prostheses, RCDs and as processed record bases combined with a processed poly methyl methacrylate (Lucitone 199) denture superstructure. According the manufacturer, the material is methyl methacrylate free and safe for patients with an allergy to this chemical. It is also

stated that material properties surpass traditional heat cured poly methyl methacrylate (PMMA). A literature review was completed using key phrases; "eclipse denture," "processed record base," "bond strength UDMA," and "bond strength lucitone 199." A total of 94 articles were found and filtered for relevance to material properties comparing UDMA to PMMA and clinical advantages of using a processed record base. Eleven articles were selected for the review and there were no results that mentioned the bond strength of Eclipse to Lucitone 199 which has been recommended by the manufacturer.
Literature review specific to these PMMA and UDMA materials revealed a higher transverse strength of Eclipse[4,5,6,7], but Eclipse was more brittle than Lucitone 199[5]. Looking at biocompatibility, neither material was found cytotoxic[9], water sorption of Eclipse was less than PMMA (Meliodent) at the 3 and 6 month storage, and[9] Eclipse showed more candida adherence than PMMA at both 24 and 196 hours[10]. There was no published data on the bond strength between Lucitone 199 and Eclipse, but there was some literature comparing different PMMA liners to an Eclipse base. Among the materials tested, heat processed PMMA had a stronger bond to autopolymerizing PMMA than did Eclipse, however Eclipse performed comparably when used with chairside liners[11]. Eclipse has a higher bond strength to resilient liners, but lower with hard PMMA liners and of all the liners tested, those with a bonding agent had higher shear bond strengths[11,12].

The literature review reveals UDMA has material properties superior to PMMA but is more brittle, so the combination of the two materials may produce a hybid with improved properties. The traditional manner of using a processed record base uses the same resin for the base and the resin processed to the teeth. There is no research that provides the shear bond strength between Lucitone 199 – Lucitone 199 or Eclipse –

Lucitone 199. The bond strength between the two materials in the final RCD influences the longevity of the prosthesis and prevention of potential microbial infiltration into a weak junction. If the bond strength of the Eclipse to Lucitone 199 is significantly less than Lucitone199 to itself then the technique of combining the two different material may not be worth the mechanical advantage. The purpose of this study is to test the interface between Eclipse and Lucitone 199 by testing the shear bond strength. The null hypothesis is that there will be no difference in the bond strength of Lucitone 199 to Eclipse or Lucitone 199 to itself.

II. Materials and Methods

Computer aided design and manufacturing was used to design titanium grips and printed samples with molds to fabricate test samples (Fig 1.). Overall design was a dumbell shape to be pulled apart in a tensile bond strength test. Samples were duplicated with silicone (Regisil Rigid, Dentsply) using the printed molds. Duplicates were then flasked in denture flasks using dental die stone (SilkyRock, WhipMix) to create stone molds (Fig 2.).

Fig 1. Printed molds designed to fit in titanium grip

Fig 2. Silicone duplicates in stone mold

Cut duplicate samples in half then divided into 2 groups of 12 samples. The PMMA-PMMA group: set into stone molds then processed heat cure PMMA (Lucitone 199, Dentsply) against the half silicone duplicate. Mixed monomer and polymer according to manufacturer's instructions. Allowed 9 minutes of setting time then packed acrylic into second half of stone mold. Trial pack at 1500 psi, removed flash and then final pack of 2500 psi. Cured in long cycle of 10 hours.

Fig 3. Half dumbell after surface treatment ready for processing of second half

PMMA-UDMA group: Fabricated stent of full sample dimensions by placing duplicate samples into stone mold then made a clear pressure formed matrix over the duplicate samples and the stone mold. Replaced the half duplicate samples. Heated Eclipse to 49◦C and hand packed into stone mold then shaped Eclipse with matrix and cured for 10 minutes in Eclipse curing oven.

Retrieved half samples, removed excess PMMA (Lucitone 199, Dentsply) or UDMA (Eclipse, Dentsply). Roughened surfaces with 60 grit sandpaper to a flat edge.

Chemical treatment of half samples. PMMA-PMMA group: Surface treated with monomer then second half was processed in the same manner as above. PMMA-UDMA group: placed samples in metal flask and boiled for 6 minutes to replicate wax burnout. Cleaned samples with boiling water. While hot but not steaming, applied "wax remover" onto surface with 3 applications each sample. Closed metal flask and allowed to bench set for 10 minutes. Processed second half with heat processed PMMA (Lucitone 199, Dentsply) in same manner as above

Removed all excess material and made sure there was no overlapping material at material interface. Measured diameter of the interface at 3 locations with digital calipers and calculated average diameter. Tested samples in an MTS universal testing machine for ISO standard tensile bond strength test with cross head speed of 0.5mm/min until failure (Fig 4).

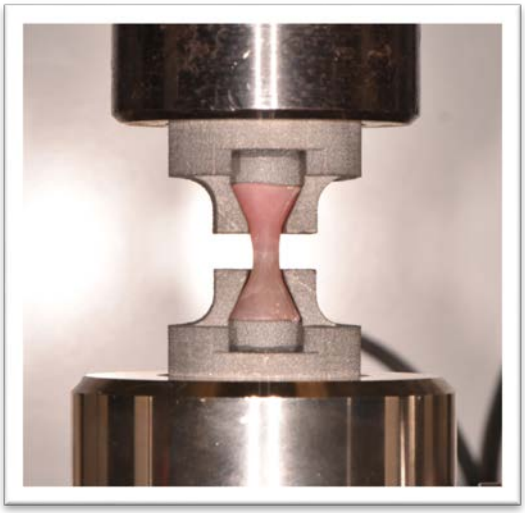

Fig 4. Sample in printed titanium grips ready for testing

Calculated tensile bond strength using calculated surface area and peak load in Newtons. Statistical analysis was completed using Student t-Test.

Failure mode was determined under light microscopy at 100x magnification.

III. Results

There were no pre-test failures in either group. Mean TBS for PMMA-PMMA was 55.51MpA with a standard deviation of 7.74 and for PMMA-UDMA the TBS was 20.38 MpA with a standard deviation of 6.48. Statistical analysis showed a significant difference between the groups ($p < 0.001$). Failure mode of the PMMA-UDMA was adhesive while the PMMA-PMMA group had 3 cohesive and 4 mixed fractures.

IV. Discussion

A reliable bond of different materials is desired to combine favorable mechanical properties of both materials. Due to the difference in chemical structure, the bond between UDMA and PMMA is uncertain. There was no previous research on the tensile bond

strength of these materials. This study investigated the immediate bond strength of UDMA (Eclipse, Dentsply) and PMMA (Lucitone 199, Dentsply). The null hypothesis was rejected. The bond between PMMM-PMMA was statistically significantly higher than PMMA-UDMA.

In proportion to the average, the standard deviation of the UDMA group was higher than the PMMA group. The surface treatments of the two workflows were different due to the treatment of UDMA. The treatment is technique sensitive and can be varied by the heat of the stone during exposure. Furthermore, there could be moisture contamination from the steam produced. The UDMA is also formed under finger pressure instead of being packed under mechanical pressure. This could contribute to inconsistency in sample fabrication. These variables could have contributed to the standard deviation.

The tensile bond strength of PMMA-PMMA is more than double that of PMMA-UDMA. This calls to question the reliability of the latter. Literature review found one article that tested the combination of UDMA with PMMA but it was with intraoral liners. They also found a significant difference when PMMA was relined with more PMMA than when combined with UDMA[8]. To relate the bond strengths to clinical use, they can be compared to research on dental cement bond strength. Some researchers in this field determined acceptable or sufficient clinical bond strength to be at least10 MPa[13]. The bond strength of UDMA-PMMA was double that amount. Based on this comparison, despite being statistically lower bond strength, the bond between PMMA and UDMA is clinically acceptable.

The failure mode of the PMMA-UDMA and the PMMA-PMMA specimens were consistent with previous studies[8,11]. The presence of cohesive fractures in the PMMA-PMMA group suggests bond strength equal to or stronger than the material itself. The

cohesive failures may also be from some material overlapping of the second PMMA addition at the interface.

The procedure of combining a UDMA processed record base with PMMA surrounding the teeth has initial data that suggest it is a clinically acceptable technique. Future studies should investigate the bond strengths after thermocycling and ways to improve the bond strength. Also of interest is the potential for bacterial growth between the two layers of material. The study design produced results with minimal standard deviation and a normal distribution. It is a valid design that can be used for future research.

V. Conclusion

Within the limitations of this in-vitro study, the following conclusions can be drawn. The tensile bond strength of PMMA-PMMA is statistically higher than PMMA-UDMA. Comparisons to other research show clinically acceptable bond strengths for both testing groups.

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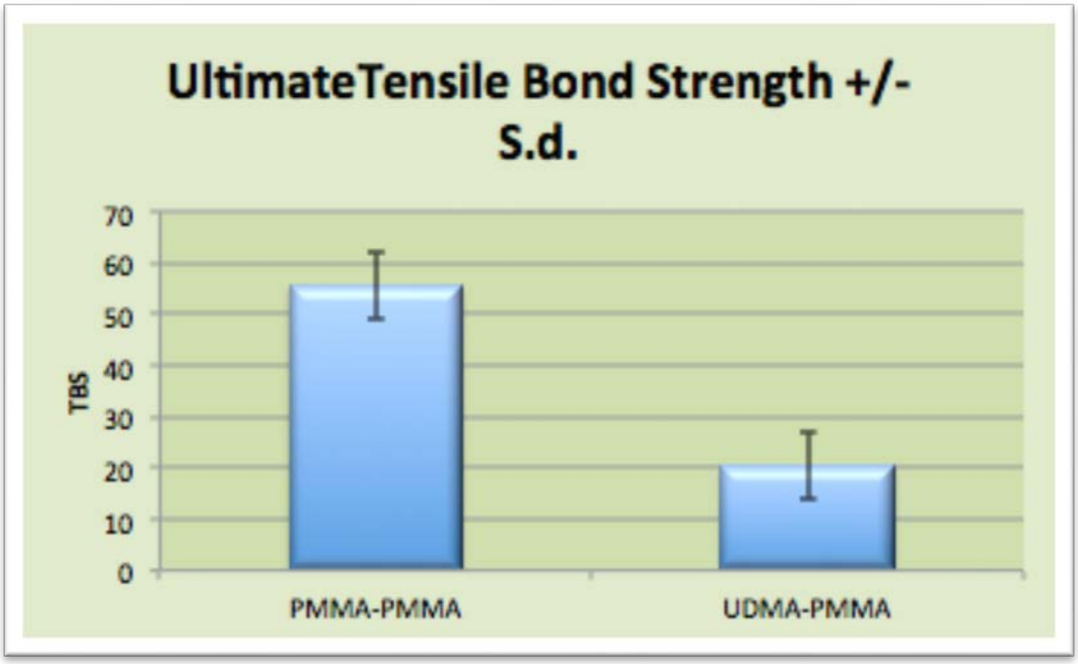

Table 1. Mean TBS of PMMA-PMMA 55.1 ±7.64. Mean TBS UDMA-PMMA 20.38 ± 6.48 ($P<0.001$)