CHAPTER 5

DISCUSSION AND CONCLUSION

5.1 Materials, method of specimen preparation, relining procedure and testing procedure

In this study, two different types of denture base materials were used. Heat-polymerized PMMA-based polymer which is the most commonly material used for fabrication of denture bases was chosen as a control group. Eclipse resin which has a different chemical composition and mode of polymerization from the conventional PMMA denture base polymer was investigated as it was considered a relatively new material in the market. Eclipse is based on urethane dimethacrylate and polymerized by heat and light. So far there had been very few studies on mechanical and physical properties of the material. The physical properties of the material were shown to be superior to the conventional heat- and chemical-polymerized polymers (Ali et al., 2008). Some information provided by the manufacturer also revealed an improved strength over the earlier version of light-polymerized urethane (Triad). The manufacturer did not reveal the formulation. However, a different initiator was used and the mode of polymerization was not exactly the same as for Triad. Both heat and light are required for the conversion; the light triggered the polymerization process and the maximum temperature of 129°C attained during the process ensures complete conversion (Lichkus et al., 2005). To date, no study has been documented on the bond strength of this heat- and light-polymerized denture base polymer to reline materials.

For Eclipse denture base specimen preparation, 10 minutes curing time was employed as recommended by the manufacturer. It had also been shown that 10 minutes irradiation resulted in complete polymerization of the exposed and non-exposed surfaces of the resin specimen (Ali et al., 2008). One of the advantages of this system was that it eliminated investing, de-waxing and packing in a flask as in conventional method of denture processing. At the same time it shortened the curing time as compared to overnight cure for heat-polymerized PMMA resin. For the PMMA group

(Meliodent), polymerization was undertaken in water bath using the curing cycle of 7 hours at 70°C followed by 1 hour at 100°C as recommended by Harrison and Huggett, (1992). It was demonstrated that with this curing cycle the strength was increased compared when using other curing mode. As little as 0.54 % to 1.08 % residual MMA monomer was observed using this curing cycle (Harrison and Huggett, 1992).

The purpose of this study was to evaluate the shear bond strengths of UDMA and PMMA denture base polymers when they were relined with various relining materials. The reline materials chosen were representatives of intra-oral and laboratory reline materials. Secure and Kooliner materials were both intra-oral reline materials with different chemical compositions; Secure material was a hydroxyethyl methacrylate (HEMA)-based with benzoyl peroxide as catalyst while Kooliner material was a polyethyl methacrylate (PEMA)-based with isobutyl methacrylate as the monomer and dimethyl-p-toluidine as the activator. No adhesive was advocated by the manufacturer when relining with Kooliner material. However for Secure material dichloromethane adhesive was supplied with the material. Meliodent RR was a laboratory reline material based on polymethyl methacrylate and its chemical composition is similar to Meliodent denture base material except for its mode of activation. Eclipse base plate material was based on urethane dimethacrylate and the reline material used was same material used for the denture base. It was mentioned by the manufacturer that the same base material could be used for relining as the mode of polymerization was similar.

In this study, denture base specimens were immersed in water for 30 days before relining. This was to ensure water saturation as it has been shown that most denture base polymers became saturated within 4 weeks in water (Valittu, 2000). This simulated the condition of the denture after it has been in the mouth for some time. After relining, the specimens were stored in water for 24 hours before they were tested for shear bond strength. This followed the ISO specification no 11405:2003 for testing of adhesion to

tooth structure (type 1-short term test) since there was no ISO specification for evaluating the bond strength of relined denture base polymer. According to the specification, 24 hours storage was sufficient to discriminate between materials that cannot and those that can withstand a wet environment. Following that, in this study the specimens were stored in water for 24 hours before testing for initial reline bond strength evaluation. Similar procedure had been described by Sarac et al, (2005) when they evaluated the shear bond strength of auto-polymerized repair resin to denture base polymers.

The strength of a bond is related to the size of the bonding area and it is therefore, important to control this area and to quantify its dimension in order to allow calculation of the bond strength (Oilo, 1993). For this reason, a customized brass ring with a known diameter of 6 mm was used to confine the reline material to the prepared denture base specimen surfaces. The same method was employed by Minami et al, (2004) and Sarac et al, (2005) when they investigated the bond strengths of auto-polymerizing resin to denture base resin.

The test of bond strength between denture base and reline polymers has been performed with a transverse method by some workers (Arena et al., 1993, Lewinstein et al., 1995, Cucci et al., 1998). However, the validity of the transverse loading method of testing bond strength has been questioned because a bar-shaped specimen is subjected to predominantly bending stresses when loaded under such three-point bending mode (Takahashi et al., 2001a). Tensile test had also been used in evaluating bond strength of denture base and reline polymers (Bunch et al., 1987, Razavi et al., 1990, Smith and Powers, 1991). However this test condition may not stimulate the clinical situation, as the test specimens had double adhesive surfaces and in actual clinical situation a single adhesive surface is present between the fitting surface of the denture and the reline layer.

It has also been stated that the forces that the lining material is clinically exposed to are more closely related to shear and tear tests (Mc Mordie and King, 1989). On the other hand, Retief (1991) argued that shear bond testing provides a more predictive test when compared to the tensile test, although the stresses that exist during clinical function are very complex. Thus, shear bond strength test was used in this study to evaluate the bonding between two denture base polymers and various hard relining materials. This testing method had been employed by many when investigating the bond strength of reline or repair resins (Curtis et al., 1989; Takahashi and Chai, 2001a,b; Sarac et al., 2005; Mutluay and Ruyter, 2005). The advantage of using shear bond test was that it applied a shear load directly to the junction between the denture base and reline materials (Curtis et al., 1989) and as a result the bond will be broken by a force working parallel to the interface. As the knife-edge blade was closely approximated to the denture base-reline polymer interface, a bending moment would least likely to be created. The creation of bending moment would have caused some deviation of the bond strength values (Kitasako et al., 1995).

In this study, the surface of the mounted denture base specimen were fixed flush to the surface of the solid block and the knife-edge blade was closely approximated to the denture base-reline polymer interface before testing. In this way the knife edge blade would apply shear load directly at the denture base-reline polymer interface. Shear bond test does not really simulate the oral environment during function because of the multidirectional intra-oral forces. However, the results from these mechanical testing provided some information regarding the initial bond strength after relining procedure.

5.2 Result

In this study, heat-polymerized PMMA presented the highest bond strength to auto-polymerized PMMA reline material (14.5±0.5 MPa). Sarac et al. (2005) also obtained a high value of 16.7±0.5 MPa for PMMA base when relined with auto-polymerized PMMA material. This was expected, as both materials were of similar chemical composition except for the method of activation. The monomer of Meliodent RR is a small methyl methacrylate molecule which has the ability to swell and penetrate into the denture base polymer (Vallitu and Ruyter, 1997). The formation of interpenetrating polymer network improved the shear bond strength of relined specimen. This phenomenon could have also contributed to the observation of 100% cohesive failures within denture base material observed in PMMA specimens that were relined with auto-polymerized PMMA reline material (Meliodent RR). Cohesive failure indicates better bonding between the denture base and reline material hence higher bond strength at the interface (Chai et al., 1998).

A comparison between the two intra-oral reline materials (Secure and Kooliner) showed higher reline bond strength of PMMA base to Secure material (9.9±1.0 MPa). The use of dichloromethane adhesive with Secure reline material could have improved its bond strength to the denture base. Dichloromethane is a solvent and its action, as explained by Arima et al, (1996) was to dissolve the surface layer of the denture base polymer. Dichloromethane has also been shown by Takahashi et al. (2000) to significantly increase the bond strength between denture teeth and denture base resin. In their study, the SEM views of denture teeth surfaces treated with dichloromethane revealed surface pores and channels of about 1 um in diameter on the denture tooth surface. This could have improved the mechanical retention as there was an increased surface area for bonding (Takahashi et al., 2000). In the present study, the SEM view of PMMA denture base surface treated with dichloromethane revealed a smooth surface

with uniformly scattered depressions. This could have increased the surface area for bonding and as a result improved the bond strength of Secure reline to PMMA denture base material. At higher magnification (x 3000), there was evidence of Secure material remnants attached to PMMA denture base indicating favourable cohesive bond at the reline interface (Fig. 4.4b)

Mutluay & Ruyter, (2005) related the improved bond strength with the formation of swollen layers by the solvent. In this study the swelling process on PMMA denture base surface could have enhanced the penetration of monomer from the reline material into the polymer to form an interwoven polymer network.

In this study, when relining using Kooliner material, adhesive or bonding agent was not utilized, since it was not advocated by the manufacturer. This could have resulted in the low bond strength observed for PMMA-Kooliner (4.5±0.5 MPa). The weak bond strength could also be due to the greater molecular weight of isobutyl methacrylate monomer of Kooliner material that might have limited its penetration into the denture base polymer (Arima et al., 1996). It was also observed that all the Kooliner relined-specimens failed adhesively indicating a weak bond to both PMMA and UDMA denture base polymers. Previous study by Takahashi and Chai, (2001b) had shown an improvement in shear bond strength of denture base to Kooliner reline when the base surface was treated with dichloromethane prior to relining (5.6±2.9 MPa). However no attempt was made in the present study to investigate the effect of dichloromethane since it was not advocated by the manufacturer of Kooliner material. A comparison of shear bond strength of PMMA denture base to Kooliner reline material obtained in this study (4.5±0.5 MPa) was significantly higher to that obtained by Takahashi and Chai, (2001b) which was 2.2±1.4 MPa. One explanation could be that in their study the relined specimens were thermocycled before testing, therefore resulted in a lower value.

For UDMA denture base group, a different pattern was observed when the specimens were relined with Kooliner, Secure or Meliodent RR materials. The higher shear bond strength observed in this study for Secure (8.1±0.7 MPa) compared to Meliodent RR (4.6±0.7 MPa) and Kooliner (2.4±0.5 MPa) materials may be explained by the action of dichloromethane adhesive on the UDMA denture base surface. SEM view of UDMA denture base surface after treatment with dichloromethane, showed the roughening effect of the denture base surface. The roughening action of dichloromethane solvent could have increased the area for bonding, therefore increased the bond strength of Secure material to UDMA denture base material. Within the UDMA group, the highest bond strength was observed when similar Eclipse material was used for relining (11.4±0.6 MPa). Since they are of the same material, there should be some form of chemical bonding between them. This finding was in agreement with the study of Takahashi and Chai (2001a), where they found that Triad denture base material exhibited higher bond strength to Triad reline material as compared to its strength when relined with PMMA and PEMA-based reline materials.

All relined UDMA base specimens showed adhesive failures even for Eclipse base-Eclipse reline combination. The most likely explanation for this could be the highly cross-linked nature of urethane dimethacrylate which might have restricted the penetration of monomers to the high density polymer network (Takahashi et al., 2000). The SEM view of the failed interface of UDMA-Eclipse specimen after shear test showed similar scratches as shown by the SEM view before reline. Adhesive failures observed in UDMA base that was relined with Eclipse material might also be a result of the high viscosity of the reline material that did not allow proper adaptation onto the denture base.

5.3 Clinical implications

The result of the study may be of clinical relevance when selecting a reline material that would provide adequate bond to the denture base polymer. A weak bond could result in delamination of the two materials and poor mechanical strength of the relined denture (Takahashi et al., 1997). For intra-oral chairside relining, Secure material is a better choice compared to Kooliner material for relining to both UDMA and PMMA denture bases in terms of the initial bond strength. The relatively low shear bond strength showed by Kooliner material to UDMA in this study is also a matter of concern. For laboratory relining, UDMA possesed the highest bond strength when relined with Eclipse material and PMMA possessed the highest bond strength when relined with Meliodent RR. However, laboratory reline requires the patient to be without the denture during the time necessary to perform the laboratory procedure.

5.4 Limitation of study

1. This study design did not simulate the actual clinical situation ideally as only one type of force was applied at a time, compared to the various masticatory forces that the relined dentures are subjected to during mastication.
2. Interfacial degradation will be affected by specimen configuration; however the test specimens prepared in this study did not physically simulate an actual denture configuration.
3. The effect of aging or thermocycling on the bond strength of denture base polymers to reline materials was not investigated therefore this may not simulate the condition in the oral environment. However, it was the intention of study to investigate the initial bond strength of the relined denture base polymers.

5.5 Conclusion

1) There was a statistically significant difference in the shear bond strength values among denture base-reline material combinations ($p<0.05$) except for PMMA-Kooliner and UDMA-Meliodent RR denture base-reline combinations ($p>0.05$).
2) When Eclipse relining was excluded, there were statistically significant differences on the shear bond strength values because of the type of denture base polymer ($p<0.05$), reline material ($p<0.05$), and their interaction ($p<0.05$). The type of denture base polymer, reline material and their interaction affected the bond strength between them.
3) UDMA denture base polymer (Eclipse) showed the highest mean shear bond strength when relined using similar base material (11.4±0.6 MPa) while PMMA denture base polymer (Meliodent) showed the highest mean shear bond strength (14.5±0.5 MPa) when relined with auto-polymerized PMMA reline material (Meliodent RR).
4) All PMMA specimens relined with Meliodent RR showed cohesive failures (100%), while those relined with Secure showed mixed failures (100%) and those relined with Kooliner showed adhesive failures (100%). UDMA specimens showed adhesive failures (100%) for all reline materials.