Effect of silica layer on bonding strength of thermoplastic nylon to cold cure acrylic resin

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ABSTRACT

Background: The combination of thermoplastic nylon resin materials and auto polymerizing resin is necessary in some situation for repair and adjustment. This study evaluated shear bond strength between thermoplastic nylon material (flexible) and auto polymerizing acrylic resin subjected to holes and silica coated layer.

Materials and Method: Forty five (45) specimens were prepared from flexible acrylic bonded to auto-polymerizing acrylic resin and divided into three groups according to the surface treatments as follows:

Group A: 15 specimens of flexible acrylic bonded with cold-cure acrylic by holes.

Group B: 15 specimens of flexible acrylic bonded with cold-cure acrylic by silica coated layer.

Group C: 15 specimens of flexible acrylic bonded with cold-cure acrylic by combination of holes and silica coated layer. All specimens were analyzed by using Instron testing machine.

Results: The result of this study showed that high mean values were obtained from group C (combination) while low mean values were obtained from B (silica coated layer).

Conclusion: It can be concluded that combination of mechanical surface treatment resulted in significant improvement in shear bond strength of flexible acrylic bonded with cold cure acrylic

Key words: Thermoplastic nylon, silica, shear bond, hole. (J Bagh Coll Dentistry 2013; 25(3):24-27).

INTRODUCTION

In recent years, nylon polymer has been attracting attention as a denture base material because of a host of advantages: favorable esthetic outcome, toxological safety to patients allergic to conventional metals and resin monomers [1], higher elasticity than conventional heat-polymerizing resin, sufficient strength for use as a denture base material [2,3], and use of heat-molding instead of chemical polymerization to ease conventional challenges such as deformation during the polymerization process and the presence of non-polymerized residual monomer [4,5]. Furthermore, it is advantages characteristics such as higher elasticity and higher molding precision than heat-polymerizing base resins facilitate denture retention by utilizing the undercut of abutment teeth in the denture base design. This meant that metal clasps can be eliminated from denture base, which also meant that problems resulting from metal clasps such as excessive stress allergy towards metallic denture clasps can be eliminated [6,7].

However, while all the above mentioned advantages are laudable, the nylon polymer does not provide adequate bonding strength to auto polymerizing resins, which are often used for the repair and adjustment of fractured nylon denture bases and failed artificial teeth. As these corrective procedures are common chair side procedures in the dental clinic, various surface treatment methods have emerged and been proven effective for bonding conventional heat-polymerizing denture base resins to auto polymerizing resins for repair and adjustment [8].

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In contrast, research efforts are scanty with regard to surface treatment methods effective for bonding flexible denture base polymer to auto polymerizing repair resins. This lack of coordinated and concerted research effort could thus account for the lack of general acceptance of flexible denture base polymer in clinical dentistry. In the study, a flexible denture base polymer was first subjected to surface treatment with holes, silica layer and combination between them to assess the effect of these surface treatment on the bonding strength to auto polymerizing resin used for repair of dentures.

MATERIALS AND METHODS

Specimens grouping: Forty five (45) specimens were constructed from thermoplastic nylon (flexible acrylic Valplast-Japan) bonded with auto-polymerizing acrylic (Pan Acrylic) and were divided into three groups according to the mechanical surface treatment as follows:

- **Group A:** 15 specimens of flexible acrylic bonded with auto polymerizing acrylic by holes (control).
- **Group B**: 15 specimens of flexible acrylic bonded with auto polymerizing acrylic by silica coating layer.
- **Group C**: 15 specimens of flexible acrylic bonded with auto polymerizing acrylic by combination of holes and silica.

General preparation of flexible part of specimen

Wax pattern preparation: A cube of wax constructed with a dimension of (1cm x) to be used in shear bond strength test [9] according to the device instruction.

Mold preparation: The conventional flasking technique for complete denture was followed in the mold preparation. Each five wax pattern cube were invested them in the lower half of the flask which contained stone mixed according to the manufacturer instruction (100gm/31 ml); (p/w), and allowed to be set. The wax patterns were inserted into one half of its depth Fig (1). Then Sprue wax gage 5mm was attached to the wax pattern at 45º angle and attached to each other Fig.(2). The stone and wax pattern was coated with separating medium and allowed to be dried and then the upper half of the flask was assembled and filled with stone mixtures and allowed to be hardened for 60 minutes before the flask was opened.

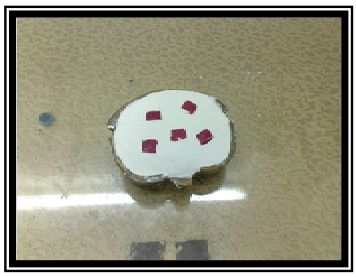

Figure 1. Wax pattern in the dental flask

Figure 2. Spruing the wax pattern

Wax elimination: The flask was put in the boiling water for 15 minute and then opened it carefully and cleaned it with wax solvent and tap water and allows to be dried then the separating medium applied to the stone mold on both halves and allowed it to dry.

Injection the mold by thermoplastic nylon: The flask was closed and inserted to the plastic injection device clamp and make sure that the central hole of the clamp directly to the hole of the flask Fig. (3,4). Then the clamp was attached into the plastic injection device and put the sufficient number of ingot in the device mold (4 ingot) then the thermostat of the device allowed it to reach at temperature of 287 Cº for 15 minute at this time the ingot was completely molten and ready to inject into the mold. After Injected the ingot inside the mold and pressed it by the hydraulic press placed into device and pressed it approximately about 5 minute, allowed it to be harden again in the mold .Then remove the clamp with the injected flask from the device and leaved it for 30 minutes to be cool at room temperature .

Figure 3. Thermoplastic injection device

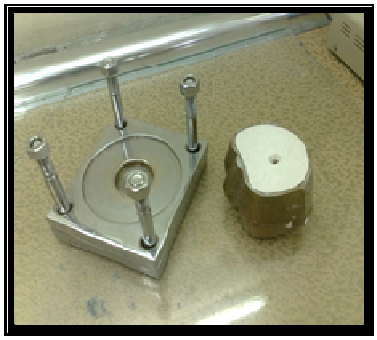

Figure 4. Plastic injection device clamp

Finishing and polishing the thermoplastic part of the specimens: All specimens were removed from the flask, cleaned it from stone particles by using acrylic bur and stone bur. Then cut the sprue by using separating disk and finished the specimens by using (acrylic bur stone bur and rubber point bur).

Preparation of the thermoplastic acrylic specimens with different surface treatment:

A. Holes: A hole of 2mm in diameter and 6mm in length was made in the surface of flexible part by using round bur no.5 with 1500 rpm. For 2 minutes. Each specimen has 5 holes.
B. Silica: All specimens were coated with silica layer in concentration of 25 um by soft brush on the surface twice until dry.
C. Combination of hole and silica: The same procedures of making a hole and coating with silica layer but combination of them.

Preparation the self-cure part of the specimens

-Preparation the wax pattern: A rectangular of wax was constructed with a dimension (2cm x, 1cm x, 1cm x) length, width and thickness to be used in shear bond strength [9] according to the

device instruction. After wax patterns was completed each flexible part specimens was attached to one rectangular wax specimens in L-shape manner so the flexible part will occupied a 1cm of the length of the rectangular wax.

Mold preparation: In this step cold-cure part and flexible part were flasked together in the same time to prevent any error occur during working procedures, the same flasking procedures, wax elimination procedures of flexible part of specimens were fallowed.

Bonding with auto polymerizing resin: The bonding was occurred after surface treatment for all specimens of all groups (holes, silica and combination of them).

A-Holes: All holes present in flexible part of the specimens were filled with cold cure acrylic during packing procedures of cold cure to provide mechanical attachment.

B- Silica: adherence was occurred during polymerization process of cold-cure acrylic after silica coated layer were applied.

C-Combination group: During packing the cold-cure acrylic holes were filled and the surface area between the holes that coated with silica layer will provide adherence with flexible specimens Fig. (5).

Testing: The process of measuring the shear bond strength by using Instron testing machine to determine the force required separating samples in shear. The samples were attached to special clamps for holding samples. The speed of testing machine was 10mm/minute Fig. (6)

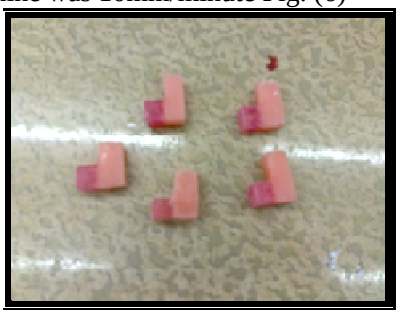

Figure 5. Final specimens

Figure 6. Instron testing machine

RESULTS

The result of shear bond strength of flexible specimens bonded with auto polymerizing acrylic resin specimens received with holes (control) were (23.3 N), silica coating layer (14.6 N) and combination of (holes and silica coated layer) (24.9 N) as shown in table (1).

Table 1. Descriptive statistics of experimental groups

	Group A(control) with holes	Group B (silica)	Group C (holes and silica)
Mean	23.3	14.6	24.9
SD	0.96	1.66	2.37
Max.	25.1	16.7	28.7
Min.	22	12	20.6

ANOVA test showed that highly significant differences between experimental groups $p<0.01$ as shown in table (2).

Table 2. ANOVA test between groups

	F-test	P-value	Sig
Between groups	82.86	P<0.01	HS

To confirm the result of this study paired samples student t-test were used. The result showed highly significant differences between control group (A) and group (B) thermoplastic specimens coated with silica layer, also highly significant difference between group (B) and group (C) thermoplastic specimens received holes and silica coated layer while significant difference between group (A) control and group (B) thermoplastic denture base coated with silica layer as shown in table (3), Fig. (7).

Table 3. t-test between groups

	F-test	P-value	Sig
Group A & Group B	14.105	P<0.01	HS
Group A & Group C	2.17	0.049*	S
Group B & Group C	9.02	P<0.01	HS

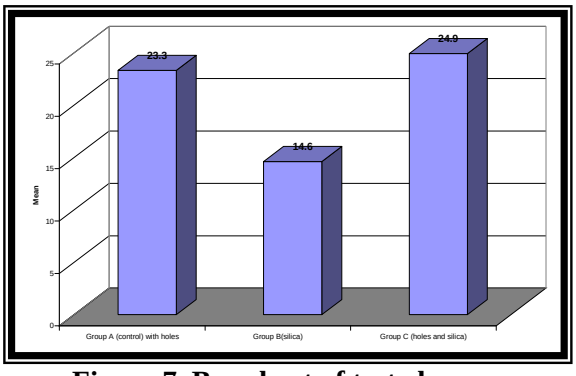

Figure 7. Bar chart of tested group

DISCUSSION

Due to the rapid growth of ageing population worldwide, the concomitant increase of denture wearers has fueled the search for new polymers as alternatives to conventional acrylic resin denture with metal clasps. The search for new denture base materials has arisen with a view to circumventing current problems associated with the use of metal clasps such as poor esthetics resulting from metal exposure and the risk of metal allergy. Besides, nylon denture base polymers are gaining popularity and acceptance in clinical practice as denture base materials because of a diverse range of advantageous characteristics: their high elasticity helps to overcome problems stemming from dimensional changes during polymerization and the use of chemical polymerization averts the problem of non-polymerized, residual monomers [10].

To elucidate the characteristics of nylon polymers as denture base materials, we have investigated the mechanical properties, color stability, and water sorption property of a nylon polymer, we have since reported that, despite a slightly lower color stability when compared with conventional denture base materials, nylon polymer could adequately provide the strength required for denture bases while maintaining high elasticity [11].

Having clarified the inherent characteristics of nylon polymers, the next logical step was to investigate if nylon dentures can be repaired and/or adjusted using auto polymerizing resins. Therefore, the objective of this study was to investigate the bonding strength of nylon polymer to auto polymerizing resin. This was achieved by means of shear bond strength test [12].

In the present study thermoplastic resin specimens bonded with auto polymerizing acrylic specimens by mechanical holes were highly significant increase in shear bond strength when compared with specimens coated with silica layer, this due to better bond strength was attributed to greater surface area and better penetration between repair mattered and resin holes. This result is in agreement with the work of Minami et al [13] who concluded that mechanical retention in the form of a groove or hole placed in acrylic surface increased the bond strength. The lowest mean values were obtained from specimens coated with silica layer this may be low concentration were used in this study also technique used was different when compared with other studies such as coated with silica layer and then treated with silane coupling agent [9].

On the other hand high mean values were obtained in specimens treated with combination of (silica and holes) this may be due to increase surface roughness were obtained from making holes by using round bur that result highly mechanical bonded between thermoplastic and auto polymerizing resin [14]. This result is in agreement with work of Kern and Wenger [15]. Moreover thermoplastic is easily affected by heat, this frictional heat caused by collision energy during silica coating procedure partially softened the thermoplastic surface, such that the adhering silica particles were cut and embedded into the thermoplastic polymer surface holes [5,16].

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