Original Article

Effect of Cynoacrylate as Surface Hardener on Gypsum Die Material

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ABSTRACT

OBJECTIVES: To determine the effect of cynoacrylate on surface hardness of type IV dental stone.

MATERIAL AND METHODS: This comparative observational study was conducted at Prosthodontics department; Lahore Medical and Dental College, Lahore, during August 2009 to February 2010. A total of 60 specimens were included in this study to compare the effects of surface hardener (cynoacrylate coated group) with control group. The dimension of the specimen: 5 acrylic sheet (Perspex) dies were made having dimensions 5×5×1.25-cm3. The die comprises of three compartments upper, middle and lower compartments, which were secured with the help of screw and bolts. Type IV die stone was mixed with tap water and was left in the dies for 45minutes. The specimens were weighed first on a digital balance and then abrasion test was carried out on abrasion testing machine. The wear produced was again analyzed by weighing the specimen on the digital balance and the wear loss was calculated.The increase in abrasion resistance was measured by calculating weight reduction of specimen with relation to pre-abrasion weight.

RESULTS: Pre and post abrasion of mean weight reduction was 4.47(0.94) grams in group A, average weight of specimen was 54.03 ± 1.47 grams while in group B 54.07 ± 1.66 grams before abrasion test significant difference was not observed between groups. After abrasion of test average weight of the specimen was 49.46 ± 1.52 grams in group A and 54.02 ± 1.66 grams in group B. Significant difference was observed between the groups after abrasion of test (p=0.0005).

CONCLUSION: Surface hardness of type IV dental stone can be increased by surface coating its surface with cyanoacrylate resin.

KEYWORDS: Gypsum Die Material, Type IV die stone, Cynoacrylate Surface hardeners.

INTRODUCTION

Gypsum is one of the most commonly used materials in dentistry.[1] Chemically it is Calcium SulphateDihydrate ($CaSO_4.2H_2O$). According to American Dental Association (ADA) gypsum products has been classified in to five types (ADA type I-V). These include impression plaster, model plaster, dental stone, high-strength dental stone and high-strength & high-expansion dental stone.[1,2] All these products are chemically identical. The difference occurs in particle size used, powder water ratio and manipulation.[3] Gypsum materials are preferred as a die material because of easy manipulation, economic disposition, and compatibility with most impression materials.[4] Inadequate compressive strength, dimensional instability, technique sensitivity and susceptibility to abrasion, are some of the shortcomings of gypsum products.[5]

In dentistry gypsum materials must be able to reproduce fine details in impressions so that the gypsum models will be as accurate as possible. For high-strength die materials, reproduction of detail is especially critical because a precision casting will be fabricated on the gypsum die.[6] Dies used to fabricate dental prostheses are often cast in Type IV or Type V gypsum material to produce a hard, accurate surface on which to make the wax pattern for the prosthesis. These materials are often thought to differ significantly in their hardness and other characteristics. Increased hardness and abrasion resistance is especially important for die materials, where extreme accuracy is needed to ensure the proper fit of crowns and inlays.[7,8]

Ideally a model and die material should neither expand nor contract so that the size of the oral structure captured in the impression is reproduced accurately. Water/powder ratio, water temperature, mixing procedure, mixing time, moisture and expansion affect the gypsum body in different ways.[9,10] Increased water in the water/powder mix tends to increase inter crystalline space which weakens the gypsum strength.[11,12] While low W/P ratio (thick mix) leaves less residual water in the set mass and so decreases the amount of the porosity.[13] Apart from that a low W/P ratio increases the effect of crystal growth during setting, because available nucleation centers are concentrated

in a smaller total volume of mix; interaction of growing gypsum crystals occurs earlier and is more effective so the amount of the porosity is increased. At any W/P ratio, the total proportion of inherent porosity in the set mass is the sum of above types.[14]

Weak gypsum can decrease cast hardness and abrasion resistance.[15] The reduction in the W/P ratio increases the hygroscopic setting expansion and the normal setting expansion in the same manner increased spatulation results in increased hygroscopic expansion.The addition of water to gypsum materials after the initial mixing can also increase setting expansion. This type of expansion is called hygroscopic expansion. The hygroscopic expansion obtained during the setting of the dental stone or plaster is generally small in magnitude. A dental stone used in making casts may exhibit a normal linear setting expansion of 0.15% with a maximum hygroscopic expansion of not more than 0.30%. This difference may be sufficient to cause the misfit of a denture or similar device made on cast.[15]

To increase surface hardness, surface coatings or various treatments have been recommended to improve the stone's hardness or abrasion resistance.[16] Several methods have been employed to improve surface hardness and abrasion resistance. Substitution of colloidal silica or soluble resin solution for water has been attempted. This technique may lead to increase setting expansion.[1] Surface coating has also been employed to increase surface hardness. Materials such as cynoacrylate, die sealants and resins, have been found to increase surface hardness and reduce surface fracture at critical marginal areas of dies.[2,3] Though some investigators are of the opinion that surface hardeners are of little use rather they decrease surface microhardness.[2] This contradiction regarding die hardener coatings may be due to use of different gauging techniques. Standardized scales for hardness measurement such as Knoop, Brinnell, Vickers and surface hardness changes measured through Vicat or Gillmore needles.[1,2] These conventional testing methods generate heavy loads which may penetrate deeper in thin coating but with nano- indentation method accurate forces are generated on thin surface die hardener which produce accurate results.[17] Results of nano-indentation methods showed higher efficacy of die coatings. Since there is divided opinion on the effectiveness of cyanoacrylate as die hardener even on conventional testing methods, to some investigators it provides satisfactory results beside this material is economical and user friendly.[1]

Therefore; the objective of this study was to observe the effects of surface hardener (cynoacrylate) on abrasion resistance and the strength of final cast in type IV gypsum die material, as this may help the clinicians and laboratory personnel to fabricate more precise dies/casts and accurately fitting prostheses.

MATERIALS AND METHODS

This comparative observational study was conducted during August 2009 to February 2010, at Prosthodontics department of Lahore Medical and Dental College, Lahore. A total 60 samples (specimens) were fabricated by using type IV dental stone. These specimens were divided into two subgroups with 30 samples each. Group A: (Control group) 30 samples strictly according to manufacturer's instruction without any modification i.e. 23ml of water with 100g of type IV plaster. Group B: (cynoacrylate coated group) 30 samples with the coating of cyanoarylate. Material was mixed as per manufacturer's instructions and after drying, was coated with cyanoacrylate.

In this study term hardness is used for resistance of a Cynoacrylate material to plastic deformation typically measured under a load[18] as it was hypothesized that surface coating of commercially available type IV die stone with cynoacrylate will increase its surface hardness. The increase in abrasion resistance will be determined by calculating weight loss of specimen before and after abrasion testing on digital balance.

Type IV die stone material with trade name of "Silky Rock" (High-Strength, Die Stone - Whip Mix Corporation) was used in this study. Powder was measured in grams (gm) using digital balance (HR-200 &Corporation). Water for mixing was measured in milliliters (ml) using graduated laboratory cylinder. Five acrylic sheet (Perspex) dies were made with dimensions of 5×5×1.25-cm^3.

The die material type IV die stone was mixed with tap water at room temperature. Each mixture was hand mixed for five seconds and then vacuum mix in a vacuum mixer (Carlo Corp Italy) for 20seconds. This mix was emptied in to the dies on a vibrator to avoid air bubbles (PRODENT-Hi-Power Extra system) extra vibration for another 10seconds was employed. The material was left in the dies for 45minutes and then it was released from the dies and put in the plastic bags to set over night. These specimens were kept for 14 days to ensure dryness. The 60 samples were obtained by mixing 100 grams of powder with 23 ml of water. The specimens were weighed on a digital balance and then abrasion test was carried out on abrasion testing machine provided by the Department of Chemical Mineral and Metallurgy Engineering University of Engineering and Technology, Lahore (CMME – UET). Before mounting on the machine the specimen was made completely flat. Following securing the specimen in a jig the stylus was adjusted such that the position of the chisel was perpendicular to the surface.

After wards 50gm weight was placed on the stylus and then the reciprocating table was driven manually 80 times over a 10mm length of the specimen. For Group B, 30 samples were coated with cyanoacrylate and abrasion test was carried out of both groups on abrasion testing machine & again weighed.

Statistical analysis:

Data was entered and analyzed in Statistical program S.P.S.S version 16.0. Numerical variable (abraded material of Group A and B) is presented as Mean and ± Standard Deviation. The comparison between cyanoacrylate group was made with respect to the control group. The qualitative data was presented as n(%) and chi square test was applied to compare the proportions between the groups. The significance of difference of abrasion resistance was tested through student t – test. $P \leq 0.05$ was taken as a significant.

FIGURE I: DIE USED TO MAKE SPECIMENS

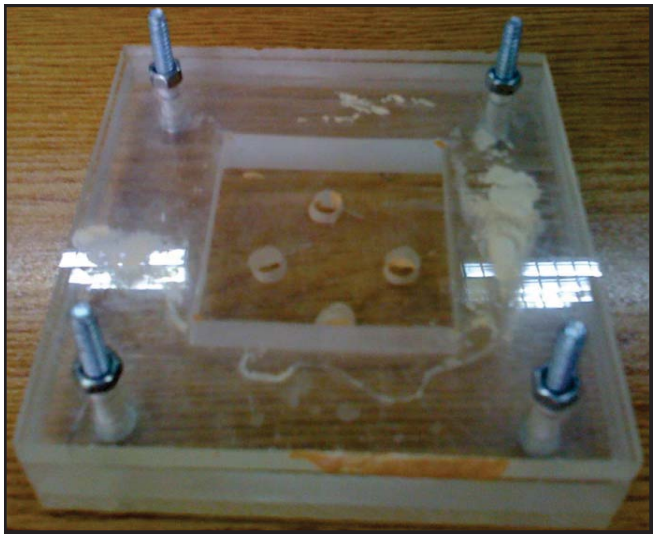


FIGURE II: ABRASION TESTING MACHINE, THE SPECIMEN IS BEING TESTED

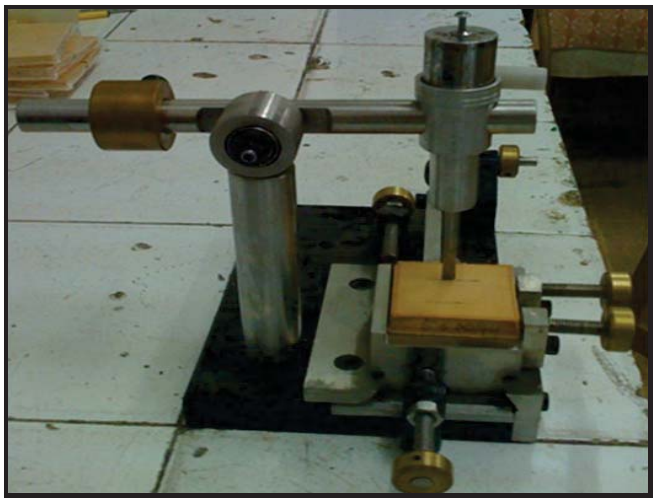
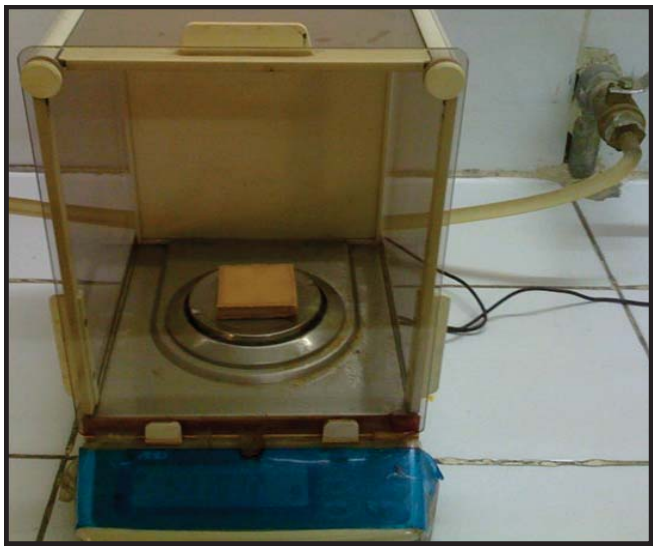


FIGURE III: SHOWING THE DIGITAL BALANCE WEIGHING THE SPECIMEN



RESULTS

A total of 60 specimens were included in this study to examine the effects of surface hardener (cynoacrylate) on the strength of final cast in type IV gypsum die material. The sample were divided into two groups, Group A (Control group) 30 samples strictly according to manufacturer's instruction without any modification i.e. 23ml of water with 100g of type IV plaster and group B (Cynoacrylate coated group) 30 samples. Material was mixed accordingly and after drying was coated with cyanoacrylate.

Surface coating of commercially available type IV die stone with cynoacrylate was increased its surface hardness. The increase in abrasion resistance was measured by calculating weight reduction of specimen. In group A (control group), average weight of specimen was 54.03 ± 1.47 gm while in group B 54.07 ± 1.66 gm before abrasion test significant difference was not observed between groups. After abrasion of test average weight of the specimen was 49.46 ± 1.52 gm in group A and 54.02 ± 1.66 gm in group B. Significant difference was observed between the groups after abrasion of test (p=0.0005). Pre and post abrasion of mean weight reduction was 4.47(0.94) gm in group A and 0.05(0.041) gm in group B. Difference of average weight reduction between groups was 4.42 (95%: 4.17 to 4.86) its mean average weight lose was significantly high in group A as compared to group B (p=0.0001).

TABLE I: COMPARISON OF SPECIMEN WEIGHT BETWEEN GROUPS FOR BEFORE AND AFTER ABRASION TESTING

Weight	Group A	Group B	P-Value
Before Abrasion Test	54.03 ± 1.47	54.07 ± 1.66	0.92
After Abrasion Test	49.46 ± 1.52	54.02 ± 1.66	0.0005*

* P value is statistically significant calculated by Independent sample t test

TABLE II: WEIGHT REDUCTION FROM BASELINE WITH AND WITHOUT CYNOACRYLATE COATING

Abrasion Test	weight reduction mean(SD)		Difference of the reduction (95%CI)	P-Value
	Group A	Group B		
Before (Baseline)	-	-	-	-
After	4.47 (0.94)	0.05 (0.041)	4.42(4.17 to 4.86)	0.0001*

* P value is statistically significant calculated by chi square test

DISCUSSION

In this study type IV dental stone was tested for the abrasion resistance. Factors like mixing time, water temperature and storage conditions were kept same as they might influence the hardness of a final gypsum body as indicated by Chan et al. and Anusavice.[19,20]
We witnessed that by coating the die stone surface with cynoacrylate surface hardener the weight loss was less with increased abrasion resistance as compared with control group. A number of authors have found an improvement of gypsum abrasion properties with the application of a surface treatment of various surface hardeners,[1,17,21]while others have demonstrated no influence and still others have shown a reduction in hardness.[2,3]This may be due part to differences in measurement technique since hardness is an operationally defined physical property of materials. The evaluation of wear is difficult because it occurs in various ways and because there is a lack of consensus about which physical properties are the most predictive of material wear.[3] The mechanisms underlying the wear of gypsum and related materials, some investigators (Lindquist and Stanford) fabricatedcustom reciprocal device,[3] same devicewas used for this study also.
For abrasion resistance we coated die surface with cyanoacrylate, while some researchers employed supportive resin which binds to the gypsum matrix, filling subsurface voids and sealing the gypsum surface. Impact fracture and loss of surface material is thereby reduced by having reinforcement, both at the surface and within the material, due to surface penetration of the resin and there may be an increase in the micro hardness. Though impregnating set gypsum with resin increases abrasion resistance, but generally it decreases compressive strength and not user friendly and economical as compare to cyanoacrylate.[3,4,22]
Although inconstant outcomes were documented when conventional microhardness scales were employed to test surface hardeners, but when nanoindentation & micro scratch methods were used to test film die hardener they showed increased abrasive resistance. He et al. used Methyl Ethyl Ketone with active ingredient of cyanoacrylate or resins as surface hardener & concluded that it resist the abrasion.[17] Findings of above study are not suggestive of efficacy of cynoacrylate but one may infer that film surface hardeners generally do provide abrasive resistance which justifies our observation. Contrary to our observation Harris et al.[2] failed to notice any improvement instead they observed decrease in hardness. Our findings are in agreement with the study of Ghahremannezhadet al.[23]Lindquist et al. also found significant die abrasion resistance with cyanoacrylate film application.[1]
The statistically significant result of this study proved our hypothesis that by coating the surface of commercially available type IV gypsum dies material the abrasion resistance of the material is increased. Thus the clinical implication of the study is that the cast made form type IV and type III can be made more abrasion resistant by the application of surface hardener cyanoacrylate to obtain more accurate dental prosthesis like crown, bridges, partial and complete dentures with additional advantages of low cost and easy application.

CONCLUSION

Surface hardness of type IV dental stone can be increased by surface coating.
Cyanoacrylate coating is cheaper option as surface die hardener for construction of accurate prosthesis.

LIMITATIONS

The power of the study is not very high because sample size was kept 60 due to cost effectiveness and ease to handle it. Large sample size will be quite expensive because of high cost of material involved.

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