Assessment of some mechanical properties of Imprelon® and Duran® thermoplastic Biostar machine sheets in comparison with some types of acrylic resins

Mustafa F. Mohammed, B.D.S. [(1)]
Salah A. Mohammad, B.D.S., M.S.D. [(2)]

ABSTRACT

Background: Imprelon® Biostar foils are new alternative tray material that has become increasingly popular because oftheir several advantages. Also, (Duran®) is another type of Biostar foils which is used in splint therapy. This study assessed some mechanical properties of these two types Biostar sheets in comparison with some types of acrylic resins used for construction of trays and splints.

Materials and Methods: A total of 150 specimens were prepared, 30 specimens for each test, 10 for each group material in order to assess some mechanical properties of the Imprelon® Biostar foil (dimension stability, surface roughness and shear bond strength of Imprelon® materialto zinc oxide impression material) and compare them to that of the other tray materials (autopolymerized and VLC) resin materials. Also to assess the mechanical properties (wear rate and transverse strength) of the Duran® Biostar Foil and compared them with that of the other splints materials (heat-cure acrylic and VLC) resins.

Results:The results showed highly significant differences at P<0.01 between all studied groups except the in dimensional changes of Imprelon® and VLC, and in wear rate of heat cure acrylic and VLC resins, no significant differences obtained between their studied groups.

Conclusions: Imprelon® is dimensionally stable, so it can be used directly after fabrication, also it has a good shear bond to zinc oxide eugenol impression material but it may not provide mechanical retention to other elastomeric impression materials and their adhesives since it has a low value of surface roughness (Ra).Duran® is recommended for short time use in patients with acute pain and/or dysfunction symptoms.

Keywords: Imprelon® Biostar foils, Duran® Biostar foils, Acrylic resins, mechanical properties. (J Bagh Coll Dentistry 2013; 25(1):34-37).

INTRODUCTION

Accurate registration of oral structures requires an accurate impression material, an accurate impression tray to support the material and a means of bonding or attaching the set material to the tray [(1)]. (Imprelon®) is a thermoplastic material made from Polystyrol (PS) used temporarily in mouth as a special tray, as a substitution to the cold cure acrylic trays or light cure acrylic. While (Duran®) is another hard-elastic, abrasion resistant, unbreakable material used for all indications in the splint therapy as a substitution to the heat cure acrylic [(2)], A bite splint is a removable appliance, usually fabricated of acrylic or composite, most often designed to cover all the occlusal and incisal surfaces of the teeth in the upper or lower jaw Most splints are now made using heat-cured acrylic, splints can also be made from soft acrylic or using light cured composite[(3,4)].

The molding of these two materials can be achieved with positive pressure molding machine which is called “Biostar”machine.

(1)M.Sc. Student, department of prosthodontics, college of dentistry, university of Baghdad.
(2)Assistant professor, department of prosthodontics, college of dentistry, university of Baghdad.

MATERIALS AND METHODS

Five different materials were used in this study: (heat cure acrylic resin, cold cure acrylic resin, Light cure acrylic resin, Imprelon and Duran Biostar sheets). These different resin materials have different curing methods; they were grouped and used to evaluate, Dimensional stability, Shear bond strength to the zinc oxide eugenol impression material, Surface roughness, Transverse strength, Wear rate.A total of 150 specimens were prepared, 30 specimens for each test, 10 for each material.

Surface roughness: A stainless steel mould was prepared for this test, it consist of two parts (Plate and Frame), the frame of 6mm height and the plate of 3mm thickness and 15*10mm dimensions, figure (1). The Profilometer device was used to study microgeometry of the tested surfaces. It is supplied with surface analyzer (stylus) made from diamond to trace the profile of surface irregularities, and recording all the peaks and recess which characterize the surface.

Shear bond strength: Two metal pattern were constructed with dimensions of (76.2 mm* 12.7mm *4.76mm length, width and depth respectively) with stopper of 3 mm thickness to provide space, and handle thickness of (13mm) figure (2), these metal pattern were used to prepared 30 specimens for shear bond strength. The Zinc oxide impression material has been applied by spatula into space between the blocks and any excess of material was removed using sharp knife, then the specimen was put under weight of 200g [5]for stability and left it for 4-5 minutes at room temperature (25±2C˚) for bench cure. After setting of the impression material the specimens were tested for shear bond strength by Instron testing machine.

Dimensional stability: The same stainless steel mould of surface roughness test was used for this test with the same dimensions, but the metal frame had marked with four grooves about 2 mm away from their borders, in order to mark four (+) signs about 2 mm away from the corners. These signs after preparation would be good defined marks for measurements. A computerized scanning to the specimens was done in two stages: First one directly after separation from the metal mould and the second one after 24 hours (leaving the specimens on the bench at room temperature for 24 hours to resemble the same circumstances of the use of the custom trays). A computerized program (Dino capture) was used to measure the distances between the corners of the selected marks (+).

Transverse strength: Thirty specimens were prepared; ten specimens for each group or material (i.e. Duran®, heat-cure acrylic and VLC), each specimenhad a dimension of (65*10*3 mm) ±0.3mm length, width and height respectively according to ANSI/ADA No.12. The transverse strength of samples was measured by using three points bending test in an Instrun machine.

Wear rate: Thirty specimens were prepared; ten specimens for each group or material (i.e. Duran®, heat-cure acrylic and VLC), each specimenhave a circular shape and dimension of (65*3 mm) ±0.5mm diameter and thickness respectively according to the requirement of the test. The testing machine consisted of pin holder in which the stylus has be enfixed, the pin holder has connected to the horizontal metal arm, aluminum rotary disc of (500 rpm), normal load of (1500g), figure (3), aluminum oxide smoothing paper and electronic balance of accuracy 0.0001g was used to accomplished the test, The measurement of the wear rate was done by a (Weighting method), since it is a simple method and easy to be applied.

Data were translated into computerized database structure. Statistical analysis was done by using SPSS version 16(statistical package for social science).

Figure 1: Metal mold for surface roughness test

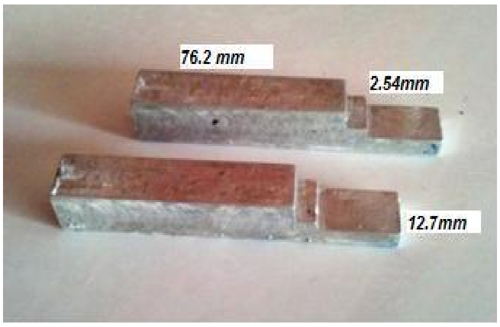

Figure 2: Mettal pattern for shear bond test

Figure 3: Wear rate testing machine

RESULTS

Table 1 showed the results of multiple comparisons by LSD (Least significant difference)method which were represented statistically differences at P<0.01 between Study Shear test at P<0.01 between Cold C.A. group and the leftover groups as well as a highly significant different at P<0.01 between VLC group and Imprelon® group.

With respect to Surface Roughness parameter, the comparisons between the studied groups showed that highly significant results were reported with the all comparisons. Finally, with respect to Dimensional changes, the significant comparisons between the studied groups showed that a highly significant were reported with the all comparisons except between VLC and Imprelon® groups which was reported a non-significant different at P>0.05.Table (2) showed the results of multiple comparisons by LSD method which represented statistically differences with the parameter of Transverse Strength test at P<0.01 between Hot C.A. group and the leftover groups as well as a highly significant different at P<0.01 between VLC group and Duran® group.

With respect of Wear Rate parameter, the comparisons between the studied groups showed that a non-significant at P>0.05 was registered between Hot C.A. group and VLC group, while a highly significant were reported with the leftover comparisons.

The VLC showed the highest mean value of surface roughness(6.382µm) followed by autopolymerized acrylic resin, while the Imprelon® had the lowest mean value of surface roughness. The Imprelon® showed the highest mean value of dimensional stability (0.032mm), followed by VLC, while the autopolymerized acrylic resin was dimensionally unstable.

Table 1: Multiple Comparison (LSD) among all pairs of (Shear bond strength, Dimensional changes and Surface roughness) parameters according to different treated groups

(I) model	(II) model	Sig. Levels (P-value) (*)		
		Shear Bond S.	Surface R.	Dimensional changes
Cold C.A.	VLC	0.000	0.000	0.000
	Imprelon®	0.000	0.000	0.000
VLC	Imprelon®	0.000	0.000	0.928

Table 2: Multiple Comparison (LSD) among all pairs of (Transverse Strength and Wear rate) parameter according to different treated groups

Groups Material	Test of Homogeneity of Variances		ANOVA Equality of means		C. S. (*) P-value
	Levene Statistic	Sig.	F	Sig.	
Transverse S.	4.584	0.019	352.74	0.000	HS
Wear R.	20.927	0.000	448.66	0.000	HS

The Imprelon® had the highest value of shear bond strength to the zinc oxide impression material (0.244N/mm^2) VLC followed the Imprelon® then autopolymerized acrylic resin when used as custom tray (Table 3).

The Duran® showed the highest mean value of transverse strength(160.35N/mm^2) followed by heat-cure acrylic then VLC resins, also the Duran® showed the highest value of wear rate(0.00510 gr/mm) (table 4).

Table 3: Descriptive Statistics for Shear Bond, Surface roughness and Dimensional changes tests in the different of the studied treatment's groups:

Groups	Statistics	Surface R. µm	D. changes mm	Shear B.S. N/mm^2
Cold. C.A	Mean	3.188	0.214	0.142
	Std. Deviation	0.467	0.025	0.012
VLC	Mean	6.382	0.033	0.182
	Std. Deviation	0.600	0.005	0.014
Imprelon	Mean	0.023	0.032	0.244
	Std. Deviation	0.005	0.006	0.027

Table 4: Descriptive Statistics for Strength and Wear tests in the different of the studied treatment's groups:

Groups	Statistics	Transverse S. N/mm^2	Wear R. gr/mm
Hot. C.A	Mean	73.26	0.00008
	Std. Deviation	7.97	0.00001
VLC	Mean	57.77	0.00004
	Std. Deviation	5.19	0.00001
Duran®	Mean	160.35	0.00510
	Std. Deviation	13.02	0.00075

DISCUSSION

Surface roughness: The low value of (Ra) of Imprelon® might because of the already smooth surface of the Imprelon® foil which processed under high temperature and high pressure; also it might due to small particle size of polystyrol.The VLC has showed surface roughness greater than cold-cure acrylic resin, the presence of impurities within VLC structure might contribute to this value Ra [6]**.** Finally this might be due to different size particles of the VLC material components[7].

Dimensional stability: Imprelon®has showed highest value of dimensional stability(after 24 hours on bench side) followed by VLC then cold-cure resin, this can be attributed to that the Imprelon®is thermoplastic material this was in agreement with [8] who stated that an ideal plastic would be one that had no polymerization shrinkage. The autopolymerizing acrylic resin showed the highest value of dimensional changes after 24 hours on bench side and this might be due incomplete polymerization of the acrylic resin since the polymerization process lead to shrinkage of the resin [9].

Shear bond strength: The Imprelon® has showed highest bond strength with zinc oxide impression material, this exceptional increase in ultimate bond strength can be attributed to acetic acid, which is one of the accelerator additives of zinc oxide eugenol impression material, the acetic acid is organic solvents, weak acid, of chemical formula CH_3CO_2H, and would dissolve polymers within its solubility parameter range [10]. The second bond strength value to zinc oxide eugenol impression material was recorded by VLC followed by self-cur acrylic resin. This might because the difference in surface roughness value of these two materials, (the VLC showed highest value of Ra6.382µm).

Transverse strength: The Duran® has showed the highest value of transverse strength followed by heat-cure acrylic and the VLC acrylic resins, and this might be due to the modification of the poly (ethylene terephthalate) which is the main component of the Duran by Glycol, which lead to improvement of mechanical properties[11]. Also the differences of transverse strength values between the VLC and heat-cure acrylic can be attributed to different size particles of the VLC components[7] which might had a direct effect on the flexural strength of the material.

Wear rate: The Duran® has showed highest wear rate followed by the other two types of acrylic resins; the VLC and heat-cure acrylic resin, which showed no significant difference between their wear rate as showed in table 6. The explanation of this might be due that the colorless Polyethylene Terephthalate PET (the main component of Duran®) is semi-crystalline resin, and has a very lightweight (density)when compared with other two types of acrylic resins, also the particles size of PET-G is very fine (particle size < 500 nm).

REFERENCES

1. Abdullah MA, Talic YF. The effect of custom tray material type and fabrication technique on tensile bond strength of impression material adhesive systems. J Oral Rehab 2003; 30: 312-17.
2. Scheu-Dental Gmbh (www.scheu-dental.com) AmBurgberg.
3. Ash MJR. Current concepts in the etiology, diagnosis and treatment of TMJ and muscle dysfunction. J Oral Rehabil1986; 13: 1-20.
4. Boero RP. The physiology of splint therapy: a literature review. Angle Orthod 1989; 59: 165-80.
5. Yousif AA. The effect of disinfection, tray perforation and adhesive usage on the tensile and shear bond strength using two different elastomeric impression materials, (comparative study). A master thesis, prosthetic department, University of Baghdad, 2006.
6. Jin C, Nikawa H, Makihira S, Hamada T, Furukawa M, Murata H. Changes in surface roughness and color stability of soft denture lining materials caused by denture cleaners. J Oral Rehabil 2003; 30,125-30.
7. Martin RJ, Johnson JF, Cooper AR. Mechanical properties of polymers; the influence of molecular weight and molecular weight distribution. 1973; 9: 57-200.
8. Powers JM. Mechanical Properties. In: Craig's Restorative Dental Materials, 12th ed. Philadelphia, 2006:51–91.
9. Philips RW. Skinner's Science of Dental Materials, Chapter11: Denture base resins: Technical considerations, miscellaneous resins and techniques, philadelpphia, PA, Saunders, 1991: p207.
10. Iqbal M Z, Mamoor GM, Tariq B, Irfan M, Manzoor MB. A study on polystyrene-metal powder conductive composites. J Chemical Engin IEB 2010; 25 (1).
11. EMCO industrial plastic: (Poly Ethlene Terephtalate Glycol), 2012.www.emcoplastics.com