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Active components delivery rate from acrylic resin maxillary surgical obturator: Part I

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Abstract. The purpose of this study was to observe the trend of compounds release from acrylic resin oral prosthesis when used for drug delivery as well as a restoration. In this study, 10 specimens of heat-cured polymethylmethacrylate material were prepared and loaded with methylene blue biological stain. The specimens were then submerged in vials with 5 ml distilled water for 24 hours. The extraction procedure continued for 4 days, each day the specimens were immersed in another 5 ml distilled water vial. All extracted solutions were analyzed by visible light spectroscopy for absorbance comparison. The statistical results showed that the absorbance values were significantly different in the first day of extraction than the following days. However, there was no statistical difference among the 2nd, 3rd and 4th days of extraction. Biological stain loading to acrylic resin at the mixing stage, and then after extraction in distilled water, showed a burst release during the first day followed by a constant release during the following few days.

Keywords: acrylic resin; drug delivery; maxillary obturator; methylene blue

1. Introduction

Acrylic resin has long been extensively used in medical and dental applications (Kati and Al-Kaabi 2016, Al-Kheraif 2014, Qazi *et al*. 2015, Gandhi *et al*. 2015). It has been the material of choice for such applications due to its high biocompatibility and some optimum mechanical and physical properties (Ajay *et al*. 2019). There were several applications involving drug incorporation with the polymethylmethacrylate material to locally deliver active compounds while being used as a restoration (Letchmanan *et al*. 2017, Anagnostakos 2017, Al Thaher *et al*. 2018, Haseeb *et al*. 2019). Maxillary obturator is a custom made intraoral restoration that functions as a closure for a congenital or acquired maxillary tissue defect (Kar and Tripathi 2016). There are three types of maxillary obtutrator the patient will receive during the treatment; surgical obturator, interim obturator, and definitive obturator and they are usually made of acrylic resin polymer (Tasopoulos *et al*. 2019). Surgical reconstruction by itself is not always enough for treatment of maxillay tissues and restoring their functionality, especially if the defect area is significantly large (Minsely *et al*. 1987, Chalian *et al*. 1972). Therefore, surgical obturator with drug delivery capability could be of great importance. The post-surgical healing phase is quite critical that requires special treatments to ensure proper

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healing process. The process of drug elution from acrylic resin is still incompletely understood with certain types of compounds. Thus, the aim of this study was to outline the pattern of compound migration from acrylic resin material with time in a qualitative manner. A suitable biological dye material was selected for this purpose which was Methylene Blue due to its hydrophilic properties and the visibility in terms of optical analysis.

2. Materials and methods

In this study, 10 specimens of PMMA resin (Veracril, Colombia) materials were prepared with dimensions of about 10×10×2 mm, Fig. 1. The specimens were loaded with Methylene Blue die material (Xilong Chemical Industry Incorporation, China) at the acrylic resin mixing stage where all the specimens were made from the same mix and the same die concentration. The powder-liquid ratio was 0.5 g of methylene blue that was mixed with 10 ml of monomer, and the powder-monomer was mixed according to the manufacturer ratio.

After specimen preparation and finishing, they were dry air-cleaned and submerged in 5 ml distilled water, Fig. 2. Each specimen was transferred into a new vial of 5 ml distilled water every 24 hours for 4 days. The extracted solutions were analyzed by Visible Light Spectroscopy, Fig. 3. The wavelength was set to 500 nm and the absorbance values were recorded for each solution.

Fig. 1 Study specimens

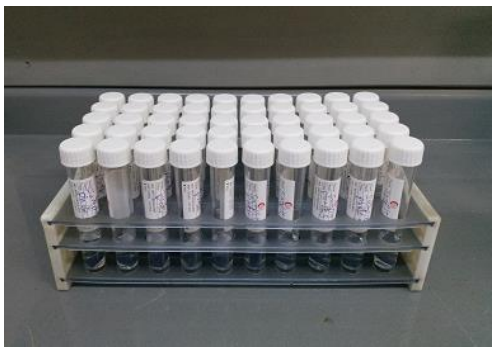

Fig. 2 Study samples

Fig. 3 Visible Light Spectroscopy

Table 1 Descriptive statistics for the study groups in absorbance units

	N	Mean	Std. Deviation	Std. Error	Minimum	Maximum
Day 1	10	0.01780	0.005514	0.001744	0.012	.027
Day 2	10	0.00780	0.001687	0.000533	0.005	.010
Day 3	10	0.00720	0.001989	0.000629	0.005	.010
Day 4	10	0.00630	0.001160	0.000367	0.005	.008
Total	40	0.00978	0.005586	0.000883	0.005	.027

Table 2 ANOVA test for the groups in absorbance unit

	Sum of squares	df	Mean Square	F	Sig.
Between groups	0.001	3	< 0.001		
Within groups	< 0.001	36	< 0.001	30.098	< 0.001
Total	0.001	39			

3. Results

The study descriptive statistics are illustrated in Table 1 with absorbance means higher during the first day of extraction and a lower rate during the following days.

The ANOVA test of variance showed a high statistically significant difference among the groups, Table 2. The Tukey HSD for multiple comparisons showed that the first day of extraction was significantly different than the following days while the 2nd, 3rd, and 4th days showed no statistical difference, Table 3 and Fig. 4.

4. Discussion

The purpose of this study was to examine the drug release trend from heat-cured acrylic resin material, since this material has been used more frequently in dental and medical applications such as maxillary surgical obturator, which is an intra-oral restoration warn by the patient following

Table 3 Tukey HSD for multiple comparison

Groups	N	Subset for alpha = 0.05	
		1	2
Day 4	10	0.00630	
Day 3	10	0.00720	
Day 2	10	0.00780	
Day 1	10		0.01780
Sig.		0.703	1.000

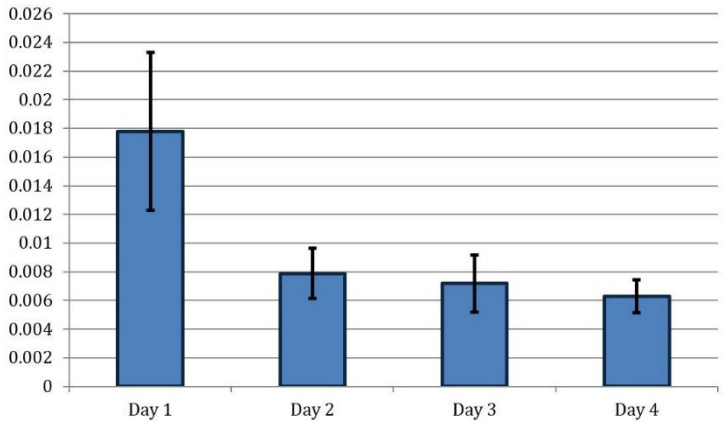

Fig. 4 Absorbance means for the study groups

maxillary surgical procedures for the purpose of protecting the tissues during the initial healing process. Instead of using active drug, a biological stain was used to visually and optically indicate the traffic of release into the extracting solution. Methylene blue stain was selected for this experiment because of its hydrophilic property that can be mixed and dissolved in water and incorporate homogenously with acrylic resin material during mixing stage. It has been introduced as a biological drug for malarial treatment at the end of the nineteenth century, which later on has been used in combination with other drugs for some cases (Shanks 2012). Its chemical formula is ($C_{16}H_{18}ClN_3S$), which is an antioxidant organic salt (PubChem 2020). Nowadays, methylene blue has a wide variety of applications in terms of tissue staining and mapping (Li *et al*. 2018), and for that reason, it was selected for this study observation to determine drug elution from acrylic resin into water solution.

The statistical analysis of the extracted solution showed that after 24 hours of specimen immersion, the largest amount of drug was released into the distilled water that can be vividly observed. The elution rate became more constant and at a lower concentration during the 2nd, 3rd, and 4th days of extraction, which indicates the distilled water have extracted the stain from the bulk of the material rather than the adsorbed stain on the surface as was noticed in the first day of extraction. Stain adsorption after sample preparation was a probable reason since samples were not washed before extraction procedure but rather air-cleaned.

This study results appeared to be in agreement with a study conducted by Bettencourt and associates (Bettencourt *et al*. 2016), when they found that chlorhexidine is delivered from hard

acrylic resin denture liner material in water and artificial saliva. However, elution to water was quantitatively higher than elution to mimetic saliva.

Methylene blue may not perfectly indicate the traffic of elution from the acrylic resin material to the surrounding watery tissues. However, it was used in this study for visual evaluation and to ensure that the stain was not involved in the acrylic polymerization reaction. Using active drug would be highly recommended for *in vivo* studies to observe the pharmacokinetics as well as drug elution.

5. Conclusions

The study showed that methylene blue loading to acrylic resin at the mixing stage would result in a significant delivery rate during the first day of usage, and the release rate takes a somewhat constant pattern during the few following days. It is recommended when incorporating hydrophilic drugs, with similar properties to methylene blue stain, into acrylic resin surgical obturator to submerge the prosthesis in water for 24 hours before being used by the patient. Drug elution studies are highly recommended.

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