Influence of the Light Curing Source on the Biological Properties of a Self Etching Adhesive

Received for publication, July 27, 2010
Accepted, February 7, 2011
MONA IONAS ¹, MARIANA SABĂU ¹, TIBERIU IONAS ², ADA DELEAN ³, SEPTIMIU TOADER ⁴
¹Department of Dentistry, Faculty of Medicine, 'Lucian Blaga' University, Sibiu, Sibiu, Romania
²Privat practice, Sibiu, Sibiu, Romania
³Faculty of Dentistry, 'Iuliu Hatieganul' University of Medicine and Farmacy, Cluj-Napoca, Cluj, Romania
⁴Faculty of Medicine, 'Iuliu Hatieganul' University of Medicine and Farmacy, Cluj-Napoca, Cluj, Romania
Corresponding author: Mona Ionas, home address: str. Rahova nr. 14 ap. 11, CP 550340 Sibiu, Sibiu, Romania, phone/fax 0040(0)269210524, e-mail monaionas@yahoo.com

Abstract
Purpose of the study: This study tries to determine whether the light curing source, a halogen lamp or a LED unit, influences the biocompatibility of a self-etching light cured dental adhesive.

Material and method: The local effects of a subcutaneously implanted self-etch adhesive, Adper Prompt L-Pop, were macro and microscopically evaluated over a period of three weeks. The experiment observed the local effect of the implant and was performed according to ISO 10993 standard, part 6.

Results: All animals showed a per primam healing without any vicious cicatrix or implant rejection. The histological examination revealed no differences between the tissue reactions to the adhesive samples cured with the two light curing units.

Conclusions: The type of photopolymerization source has no influence on the biocompatibility of the adhesive used in this experiment. Twenty-one days after the inoculation the samples impregnated with Adper Prompt L-Pop were bioinert and the presence of the adhesive blocked the bioresorption phenomenon observed in the control group.

Key words: experiment, dental adhesive, subcutaneous implant, biocompatibility.

Introduction
In dental medicine the photopolymerizable self-etching adhesives were developed to simplify the work technique (adhesive conditioning, impregnation, and application) (1). The current trend is to raise the hydrophilic character of the last generation adhesives, to enable a close contact with dentine. However, this causes new problems in the adhesion technique, such as the increase in canalicular water secretion (2) or the phase nanoseparation between HEMA and Bis-GMA (3, 4, 5).

For these adhesives photopolymerisation often takes place inside the oral cavity, a less than ideal place for light curing. As a result, free residual monomers will be present in the structure of the formed polymers, monomers which can migrate into the surrounding tissues and trigger undesired reactions (6). Several factors influence the monomers degree of conversion during photopolimerization: power density of the photopolymerization light, time of exposure, emission spectrum of the lamp, distance to the adhesive layer, contamination with water/dentinary fluid, light unit used during the photopolymerization, etc. (7,8,9).

Because of the high hydrophilicity HEMA is one of the most frequently used monomers in the composition of the self etching adhesives (10). HEMA’s cytotoxicity is well
documented (11). In vivo it produces chronic inflammatory cell reactions and dentinal resorption when it reaches the pulp. In vitro, on cell cultures, it leads to cell apoptosis (12, 13).

The purpose of this study was to observe the effects of the polymerization light source through tissular reactions at the site of the subcutaneous implanted self-etching light cured adhesive samples. That is, this work studies the biocompatibility of the self-etching Adper Prompt L-Pop (3M ESPE) adhesive, cured with different light sources.

**Material and method**

A sponge fragment impregnated with either physiological serum or Adper-Prompt L-Pop dental adhesive was subcutaneously implanted in male and female adult rats of the Wistar breed.(14) To evaluate the local effects of the implants, the biological analysis was performed in compliance with ISO 10993 norms, part 6. All procedures performed on animals have been approved by the ethics committee of the “Iuliu Hatieganu” University of Medicine and Pharmacology, Cluj Napoca.

Three groups of five subjects each were created. The subjects were healthy, well-nourished, male and female adult Wistar rats having a body weight of 180-220g, bread according to the norms for animal research. The first group, labeled 1, was the control group, while groups labeled 4 and 5 were the study groups.

For the control group, the implanted sponge fragment was impregnated with physiological serum. Of the study groups, for group 4 the implanted sponge fragment was impregnated with Adper Prompt L-Pop polymerized using an LED lamp (Elipar Freelight 2, 3M ESPE, 1000 mW/cm² for 5 seconds) while for group 5 the implanted sponge fragment was impregnated with the same Adper Prompt L-Pop adhesive alternatively polymerized using a halogen bulb lamp (Elipar 2500, 3M ESPE, 600 mW/cm² for 10 seconds).

During the experiment the researchers observed:

- How the subjects (Wistar rats) withstood the operation;
- Local and general reaction to the implants;
- The clinical state of the subjects;

At the end of the experiment the following observations and studies were performed:

- Observed local reaction of the implant;
- Observed relationship with the host tissue;
- Evaluated histological examinations.

After 21 days, at the end of the experiment, the subjects were euthanized and the local reaction at the place of implant was observed. The classic histological technique was used to process fragments of peri-implant tissue collected from the subjects. The sections were marked using the hematoxilin-eozin technique and later examined at a 200X zoom for morpho-pathological studies.

<table>
<thead>
<tr>
<th>Table 1.</th>
<th>The composition of the adhesive systems and photoinitiation systems; BIS-GMA – bisfenol A diglycidyl ether dimetacrylate; HEMA – 2-hydroxyethyl metacrylate;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adhesive</td>
<td>Composition</td>
</tr>
<tr>
<td>Adper Prompt L-Pop</td>
<td>WATER HEMA DI-HEMA PHOSPHATE BIS-GMA</td>
</tr>
</tbody>
</table>
Results

None of the subjects included in this experiment showed negative effects resulted from the inoculation. All subjects successfully passed the healing period for the implant wound. All subjects showed a per-primam healing without vicious cicatrix or implant rejection. At 21 days after the inoculation the implant area recovered completely. The only scars that could still be observed were the result of stitching. The macro and microscopic modifications for each study group are presented below.

Control Group.

The implant area shows no sensitivity and when palpated a painless and immobile subcutaneous nodular formation in the subcutaneous connective tissue can be detected. The surgical wound healed completely (Figure 1).

![Figure 1. Control group (physiological serum) at 21 days after implant: Total recovery of the surgical wound.](image)

The histopathologic examination reveals that around and within the sponge body a young connective tissue developed with high capillary neoformation and fibroblasts. Epithelial macrophage cells and giant foreign body cells were also present. The connective tissue transformed into fibrous cicatricial tissue by reabsorbing the sponge’s structure in several areas.
**Group 4: Adper Prompt L-Pop polymerized with the LED lamp**

The implant area showed complete recovery. At 21 days the wound healed without fibrotic processes. At palpation the implanted body feels like a painless and immobile subcutaneous nodular formation. The examination of the subcutaneous connective tissue reveals the presence of the sponge fragment immobilized in the hypodermic area by a thin and transparent fibrotic capsule. (fig.3)
The histological analysis shows an intact sponge body, with no tissue of neoformation penetrating its structure. The sponge fragment was immobilized by connective tissue, in which monocytes, macrophages and epithelioid cells were found present. Structurally, the tissue that covers and fixes the implant is specific to a tissue of neoformation. (fig. 4)

**Figure 4.** Group 4: LED cured Adper Prompt L-Pop adhesive. Proliferation of connective tissue of neoformation encapsulating the implant at 21 days after the inoculation.

**Group 5: Adper Prompt L-Pop polymerized with the halogen bulb lamp.**

Similar to the other two groups, the surgical wound healed completely. At 21 days the implant area was almost imperceptible and at palpation the implanted body felt painless and well fixed. The examination of the connective tissue revealed the implant immobilized in a thin and transparent connective capsule. No vascular reaction exceeding normal limits was observed. (fig. 5)

**Figure 5.** Group 5: Halogen cured Adper Prompt L-Pop adhesive. Implant immobilized in the hypodermic area at 21 days after the inoculation.
The histological analysis of the tissue around the implant shows the formation of a fibroconnective capsule covering the implant and fixing it next to the host tissue. The structure of the capsular connective tissue is specific to the tissue of neoformation with numerous capillaries and a lymph-histiocitary and monocyte macrophage infiltrate. The tissue does not penetrate the implant body. (fig.6)

![Figure 6. Group 5: Halogen cured Adper Prompt L-Pop adhesive. Proliferation of connective tissue of neoformation, forming a wall around the implant at 21 days after the inoculation. Hematoxylin Eozin x 200 staining.](image)

Our study does not reveal any macro- and microscopic difference in tissue response to implant - Adper Prompt L-Pop embedded in sponge fragments when it is polymerized with LED or halogen light.

**Discussions**

Polymerization is the chemical reaction by which unsaturated monomers transform into polymer compounds which, theoretically, stops only after the entire quantity of monomer is consumed. Nevertheless, in reality this reaction is never complete (1, 10). The product studied in this experiment is a one-step self etching light-cured adhesive which requires mixing. The main monomers in this adhesive are Bis-GMA, HEMA and di-HEMA-phosphate.

Of the three monomers, existing research mentions the allergenic character of the Bis-GMA monomer. Also related, an estrogenic effect might occur as well due to of the bisfenol A molecule. However this estrogenic effect is not very clear yet (15).

HEMA is a hydrophilic component of the adhesive system that facilitates hydrophobic monomers’ penetration into the structure of the hybrid layer at the dentine surface (1). After repeated contact with tissues HEMA was also found to trigger allergic reactions (10, 16).

For example, the intolerance some patients have to contact lenses may be related to prolonged and repeated contact with the HEMA monomer after a professional exposure to an adhesive containing HEMA (17). Compared to Bis-GMA, the cytotoxic effect of HEMA is slightly reduced (18).

The combination of hydrophobic/hydrophilic monomer from the self-etching adhesives may seem an excellent technical solution, but unfortunately, associated with water in excess it may come to a phase-nanoseparation of the two components of the adhesive.
Hydrophilic areas will occur with a very high concentration of HEMA but also hydrophobic ones containing Bis-GMA. Depending on the hydrophobic/hydrophilic character of the initiation system there will be weak polymerized areas which have negative influence on the mechanic properties and which create a source of monomers with irritative character. (5)

The acid monomer di–HEMA phosphate will hydrolyze in the presence of water under the form of Hema phosphate, and a normal reaction with Ca from hydroxyapatite will take place. (19) In the absence of a neutralizing effect of calcium, HEMA phosphate can react in other ways by forming other compounds with unstable character (Ionaș M. & all, personal communication Napoca Biodent 2009).

The local reaction of the host tissue takes place both in the presence of the absorbent layer (sponge fragments) and in the presence of the absorbed substance. The biocompatibility of the sponge is confirmed by the results of the control group.

Conclusions

The results of this study suggest that the type of light curing unit had no influence on the biocompatibility of the cured dental adhesive used during this experiment. At 21 days after the implant the samples impregnated in light-cured Adper Prompt L-Pop were found to be in a state of bioinertion with the presence of the adhesive blocking the onset of the biosorption process, present in the control group.

The increased user friendliness that this and other self-etch dental adhesives offer is often challenged as compromising biocompatibility and performance. In this research, no evidence could be found for any biocompatibility problems regarding this adhesive, making it a viable treatment option for bonding composite resin restorations.

Acknowledgements

Prof. O. Rotaru from the Faculty of Veterinary Medicine, University of Agricultural Studies and Veterinary Medicine Cluj-Napoca, Cluj-Napoca, Romania for the histopathological examination.

References


