

Development and Assessment of New Restorative Filling Material (Polyphosphonate Glass Ionomer)

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Abstract

This study aimed to manufacture a new restorative material which may known as polyphosphonate glass ionomer and investigate its properties in comparison with other restorative materials. Seven studies were done for development and evaluation of this experimental material :

1. Pilot study :

This study included three parts :

I. Analysis of the standard GI material (Ketac molar) which include analysis of the powder and analysis of the liquid.

1- Powder : The powder was analyzed by :-

- a. Particle size test using sieve and shaker and light traveling microscope. The results showed that 68.3% by weight of the powder had particle size of less than 40 μm and 31.9% by weight had between 20-30 μm particle size.
- b. Chemical analysis using ASTM and revealed the following main constituents : silica oxide , alumina oxide , calcium fluoride , sodium aluminofluoride , aluminum fluoride , and aluminum phosphate.
- c. X-ray diffraction test.

2- Liquid : The liquid was analyzed by :

- a. PH and density test using digital pH meter and specific gravity hydrometer. The results showed that the pH was 1.5 and the density was 2.5 g/cm^3 .
- b. Chemical analysis by ASTM revealed the following main constituents : 47.5% polyacrylic acid / itaconic acid and 5% maleic acid.

II. Experimental preparation which included the manufacturing of the powder and the formulation of the liquid using 3 polyacids , vinyl

phosphonic acid (VPA) , itaconic acid (IA) and maleic acid (MA). Three groups of formulations had been made to pass certain criteria. Seven formulae only had been passed these criteria and had been tested to pass the ISO specification tests no. 9917-2/1998.

III. Application of the ISO specification no.9917-2 by using fluidity test, setting time , compressive and tensile strengths , hardness , and setting and thermal expansions. One formula of liquid had been passed these tests which was 52% VPA : IA 2:1 with 5% MA , and had significant differences with the control material (ketac molar) in all the properties tested at $P < 0.05$.

Conclusion : Experimental material had been developed and passed the ISO specification with significant differences for mean values of the properties tested with the control (Ketac molar).

2. Histopathological study :

Fifteen Albino rabbits were used for the implantation of the experimental material and CGI material with the aid of polyethylene tubes in the subcutaneous tissue. The animals were divided into three groups representing three periods of evaluation (3,14, and 28 days).

At each time period , specimens were removed containing the tubes with the surrounding tissue for the evaluation of tissue response and the subsequent healing process.

The results showed different tissue inflammatory responses to the materials during the time of the study. However, the tissue reactions were changed after 14 days and fibrous tissue surrounded all the materials after 28 days.

Conclusion : All the materials induced an inflammatory response when placed in direct contact with tissue , and finally , they were well tolerated by the tissue.

3. Wear resistance study :

This study was done to evaluate and compare the wearing of experimental material (3-body wear) with other restorative materials (amalgam , CGI , and composite resin). Forty sound premolars were used with forty upper first molars and an acrylic blocks were constructed for them exposing the crowns and 3mm of the roots. The premolars were prepared by making conventional cavity preparations on buccal surfaces with certain dimensions. The molars were ground flat occlusally exposing the dentin.

The premolars were grouped into four groups to received one of the restorative materials used. After restorative material placements , pre-testing measurements were done and wearing procedure and depth of wear measurements then were done. The results showed that the amalgam had the lower mean values of wearing depth significantly compared with other materials.

The experimental material had lower depth of wear with significant differences with the composite resin and CGI materials at $P < 0.05$.

Conclusion : The experimental material was more wear resistance than the composite resin and CGI. The amalgam was more wear resistance over the other materials used.

4. Tensile bond strength study :

This study was done to evaluate and compare the tensile bond strength (TBS) of the experimental material and other materials (composite resin , LCGI , and CGI) with the tooth structure.

Forty sound premolars were used with acrylic blocks had been constructed for them exposing crowns and 3mm of the roots. The teeth were prepared for conventional cavities on buccal surfaces with certain dimensions and grouped into four groups , each of them was received one

of the materials used. After restorative filling materials placement , the samples were tested using tensile force until separation from cavities.

The results showed that the composite resin had higher TBS mean value (25.9 MPa) , then the LCGI with (15.8 MPa) , then the experimental material with (6.4 MPa) and finally the CGI with (4.2 MPa) with significant differences between them at $P < 0.05$.

Conclusion : The experimental material was bonded to the tooth structure with TBS values higher than the CGI. However , the composite resin and LCGI with their adhesive systems had higher TBS values over the other materials.

5. Fluoride ions release study :

This study was done for measuring the release of fluoride ions from set tested material (experimental GI) in comparison with CGI and LCGI.

The tested materials were made as molds with certain dimensions and each mold was placed in vial containing 100 ml. of DDW. Every 24 hrs , 5 ml. of the solution was transferred into smaller tubes to measure the fluoride release using spectrophotometer. This procedure was repeated every 24 hrs. for 14 days. The results revealed that the CGI had higher release over other materials , then the experimental material , and finally the LCGI with significant differences between them at $P < 0.05$.

Conclusion : The experimental material had higher fluoride ions release concentrations over the LCGI. However , the CGI had higher fluoride ions release concentrations over other materials.

6. Solubility study :

This study was performed to evaluate and compare the solubility of three materials (experimental GI, CGI and LCGI) . The tested materials were made as molds with certain dimensions and each mold was weighted and immersed in vial containing 15ml. of DDW. The molds

were kept in the solution for different periods of time and at every period , each mold was dried using desiccators and re-weighted. The solubility would represent the weight loss. The results showed that the experimental material had the lower solubility percentage (0.03%) , then the LCGI (0.31%) and finally the CGI (1.46%) with significant differences between them at $P < 0.05$.

Conclusion : The experimental material was less soluble than the LCGI and CGI.

7. PH study :

The three tested materials (experimental GI , LCGI and CGI) were made as molds with certain dimensions and one mold was used for each vial with 100ml. of standard buffers solution and for each time period , 5ml. of the solution was transferred in to smaller tubes. This procedure was repeated for different time periods for measurement of the pH using electronic pH meter.

The results revealed that after 2 hrs. of the materials setting , constant pH value was obtained which was (6.7). However , the LCGI had higher pH values , then experimental GI , and finally the CGI with significant differences at $P < 0.05$.

Conclusion : All the materials used had constant PH value (6.7) after two hours of the material's setting and the experimental GI had higher PH values than the CGI.