

Biocompatibility of New Copolymers of Acrylic Resin Denture Base Materials

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ABSTRACT

Aims: Study the biocompatibility of new copolymers by investigating the histo-pathological effect on the tissue of the rabbits.

Materials & Methods: 36 disc like specimens of new copolymers were made by adding Meth Acrylic Acid (MAA), Butyl Meth Acrylate (BMA), and Ethyl Acrylate (EA) with 5%, 10%, and 15% concentrations to Vertex heat cured acrylic resin. These discs were implanted into 9 rabbits (4 discs for each rabbit). After 14 days, tissues around discs were taken and histo-pathological changes were studied under microscope.

Results: There were no difference between the control groups and the other variables. All of them showed mild degree of detrimental pathological effects.

Conclusions: The three tested materials with their three concentrations are biocompatible.

Keywords: biocompatibility, copolymers, acrylic resin.

INTRODUCTION

Biocompatibility is defined according to the Williams Dictionary of biomaterials as "The ability of a material to perform with an appropriate host response in a specific application".^[1] The ecology of the oral cavity constitutes a demanding environment for resin-based materials. The materials are constantly exposed to water and saliva components like enzymes that have impact on the degradation of the materials.^[2,3]

Copolymer is a polymer derived from two (or more) monomeric species, as opposed to a homopolymer where only one monomer is used.^[4] Copolymerization refers to methods used to chemically synthesize a copolymer. Copolymers may also be described in terms of the existence of or arrangement of branches in the polymer structure.^[5]

Recently, there have been many materials used for denture base such as polymethyl methacrylate (PMMA) resin, modified PMMA resin and nylon. The material most often used to fabricate denture base and denture teeth was PMMA resin. PMMA is the most commonly used material due to its good mechanical and physical properties, compatibility with oral tissue, aesthetics, ease of repair and low cost. However, some problems such as denture fracture and wear of the denture teeth still exist. In order to overcome these problems, several attempts were made to modify and improve the PMMA.^[6,7,8]

Meth Acrylic Acid (MAA), is an organic compound. This colourless, viscous liquid is a carboxylic acid with a characteristic odor. It is soluble in warm water and miscible with most organic solvents. Meth Acrylic Acid is produced industrially on a large scale as a precursor to its esters, especially methyl methacrylate (MMA) and poly (methyl methacrylate) (PMMA). The methacrylates have numerous uses, most notably in the manufacture of polymers. Meth Acrylic Acid occurs naturally in small amounts in the oil of Roman chamomile.^[9]

Butyl Meth Acrylate (BMA) are produced for the use as a building block to make a wide range of polymer based products that we see and use every day from paints and coatings, toners and inks, oil additives to dental and medical products. Butyl Meth Acrylate are of low concern to human health and the environment and have been handled safely by industry and professionals for over 60 years. Butyl Meth Acrylate based polymers is inert in the environment and can be recycled back to the monomer. Butyl Meth Acrylate is produced for the use as monomer for production of polymers.^[10]

Ethyl Acrylate (EA) is an organic compound. It is the ethylester of acrylic acid. It is a colourless liquid with a characteristic odor.^[11] Ethyl Acrylate is used in the production of polymers including resins, plastics, rubber, and denture material.^[12]

The aims of the study are to study the biocompatibility of new copolymers (the modification of heat cured acrylic resin denture base material through the addition of: Meth Acrylic Acid, Butyl Meth Acrylate, and Ethyl Acrylate using three different concentrations; 5%, 10%, and 15%) by investigating the histo-pathological effect of these new copolymers on the tissue of the rabbits. The research was approved by the scientific and ethical committee of the College of Dentistry, University of Mosul.

MATERIALS & METHODS

The total numbers of specimens prepared in this study were (36) specimens. The specimens were prepared as disc like with dimensions of 5 mm in diameter and 2.5mm thickness. The specimens were prepared from (Vertex™, Netherlands) heat cured denture base acrylic resin material with additives. The three types of acrylate derivatives additives are: Meth Acrylic Acid (MAA), Butyl Meth Acrylate (BMA), and Ethyl Acrylate (EA). All additives are manufactured by (Fluka, Switzerland) chemical industries. The additive materials have been added to the monomer of acrylic at a percentage of 5%, 10%, and 15%. The control specimens were prepared from (Vertex™, Netherlands) heat cured denture base acrylic resin material without additives. For each variable group, first, the additive was added to monomer, and mixed together until a homogeneous mixture liquid was obtained. Then, the powder was added to the liquid according to the manufacturer instructions ratio (22g powder/10ml monomer).

The powder and liquid was mixed, covered, and waited 30 minutes to reach dough stage. The dough, then, applied into the molds and pressed to 200 μ pa pressure for 10 minutes, then cured in short cycle according to manufacturer instructions (start with tap water and gradually increase the temperature until reach boiling degree and maintain at 100°C for 30 minutes, bench cooling then open the flask). The specimens, then, removed, carved with engine stone bur, polished with pumice, incubated in distilled water at 37 \pm 1°C 48 hours for conditioning (ADA specification No.12, 1975).^[13,14,15]

Experimental Animals:

Nine male rabbits, 4-6 months old with an average weight 1250-1350g weight were used, these rabbits were divided into 3 groups, each group represent one of the additive materials. This mean that each of the three materials have three rabbits. On each rabbit, four specimens were implanted; which represent the three concentrations of additive in addition to the control. The animals were housed in an animal house specially prepared for this purpose, the animals were fed a normal diet and tap water.^[16,17]

Description of the Experimental Procedure:

An intramuscular injection of a mixture containing 1.3 ml ketamine hydrochloride (40mg/kg) general anesthetic agent,^[18] and 0.3 ml xylazine (2mg/kg) sedative, analgesic solution.^[19] Complete anesthesia had been obtained within 5 minutes, this dose kept the animal anaesthetized for about 40 minutes. The anaesthetized animal was laid on its abdomen on the operation board. The fur was shaved in 2 areas of the rabbit's back on the left side of the vertebral column and 2 areas on the right side of the vertebral column. These four areas represent the control and the three concentrations of the additive. A distance of about 10cm was left between one area and another. The shaved areas of the skin were disinfected using 5% hibitane. Using no. 15 detachable blade on a scalpel handle, a small longitudinal incision (about 6 mm) was made in the skin of each area, a pocket was created in the subcutaneous layer (by using a blunt dissection) to accommodate the implant, the specimens were applied immediately in to the created pockets, the skin were sutured with one stitch of 3.0 black silk suture.

Immediately after the operation, a mixture of antibiotics containing 2.5ml procaine penicillin (500.000 IU) and 2.5 ml streptomycin (0.5g) had been administrated intramuscularly in the thigh muscle of the rabbit.^[19] The same dose were repeated every 12 hours for three days. During this period the animal was isolated from other animals as they will try to harm the animal or remove the suture. After sacrificing the animal after 14 days, the biopsy specimen had been excised. The sacrificed animal was laid on its abdomen, then the implantation sites were examined grossly, the implantation and control sites were excised from the skin and kept in 10% formalin for 48 hours, processed in alcohol and xylol embedded in paraffin wax, sectioned at 5 micron thickness, stained with haematoxylin and eosin and examined under light microscope.^[20,21]

Histopathological examinations were performed by specialist pathologist. Histopathological examinations were done according to Al-Neimee^[16] who suggested a system that classify the histopathological changes that could occur during

implantation of foreign materials, this system includes five grades depending upon the severity of the detrimental pathological changes associated with the implantation of various materials. This system also was used by Al-Ni'aimi.^[21] The grades were as follows:

Grade 1- Only expectable inflammatory and reparative tissue responses have been seen such as infiltration of the area by an inflammatory cells, presence of oedema fluid, fibrin strands, and at late stages formation of fibrous tissue well attached to the original one, no detrimental effects have been seen.

Grade 2- Mild degree of detrimental effects were observed. This grade is characterized by the presence of minimal tissue necrosis around the implanted materials and accumulation of few number of inflammatory cells such as polymorphonuclear and mononuclear cells. Sometimes newly formed poorly vascularized granulation tissue have been seen.

Grade 3- moderate degree of tissue necrosis, presence of suppuration, fibrin strands and accumulation of large number of inflammatory cells have been seen. In addition, proliferation of fibrous tissue sometimes have been observed.

Grade 4- severe reaction where necrosis, inflammatory reaction around the implanted materials, and inflammatory exudate have been noticed.

Grade 5- very severe reaction when an extensive amount of tissue necrosis, very large number of inflammatory cells, and extensive abscessation around the implanted material were noticed.

RESULTS

The results of the Meth Acrylic Acid (MAA) showed grade 2 for the control, 5% concentration, and 10% concentration. While the 15% concentration appeared between grade 2 and grade 3. (Figure 1).

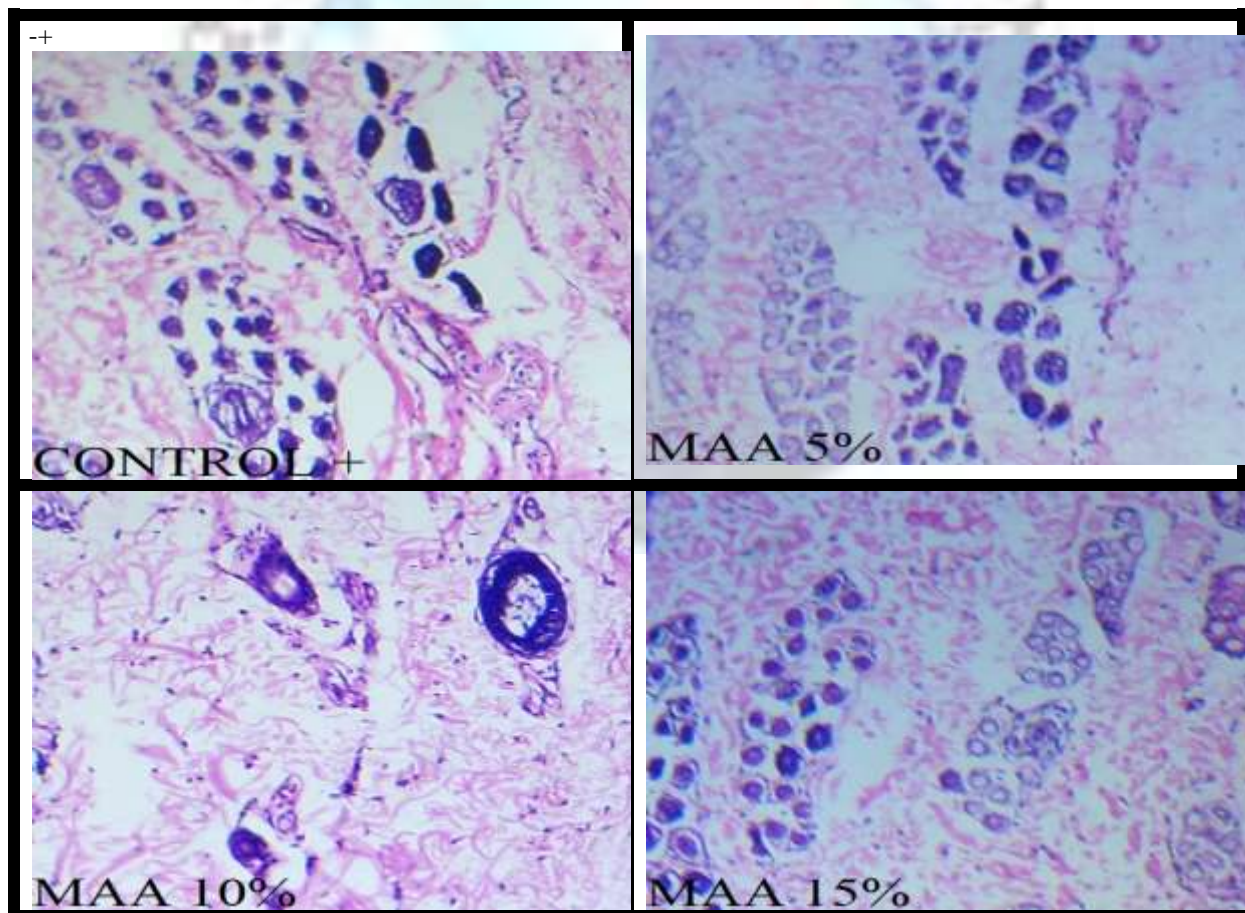


Figure (1) Biopsies taken from the Meth Acrylic Acid (MAA) implant site; Control site, 5% site, 10% site, and 15% site. The results of the Butyl Meth Acrylate (BMA) showed grade 2 for the control, 5% concentration, 10% concentration, and 15% concentration. (Figure 2).

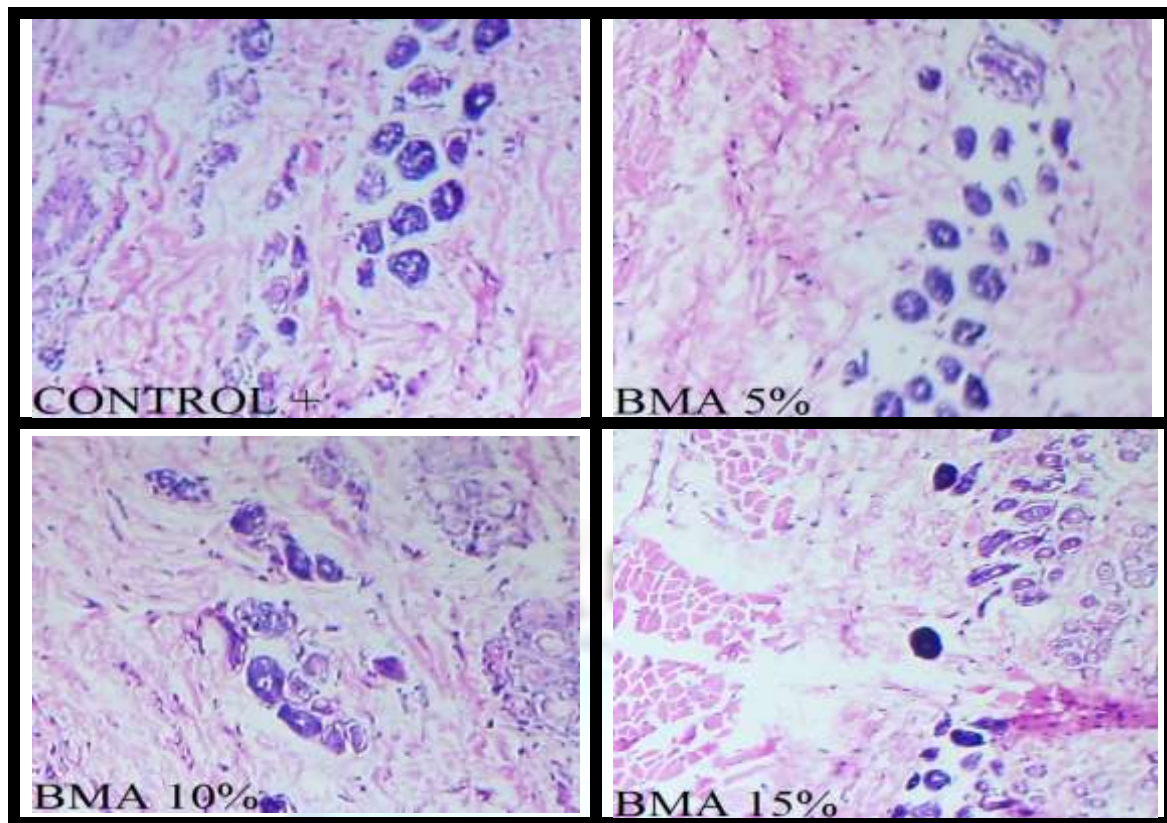


Figure (2) Biopsies taken from the Butyl Meth Acrylate (BMA) implant site; Control site, 5% site, 10% site, and 15% site.

The results of the Ethyl Acrylate (EA) showed grade 2 for the control, 5% concentration, 10% concentration, and 15% concentration. (Figure 3).

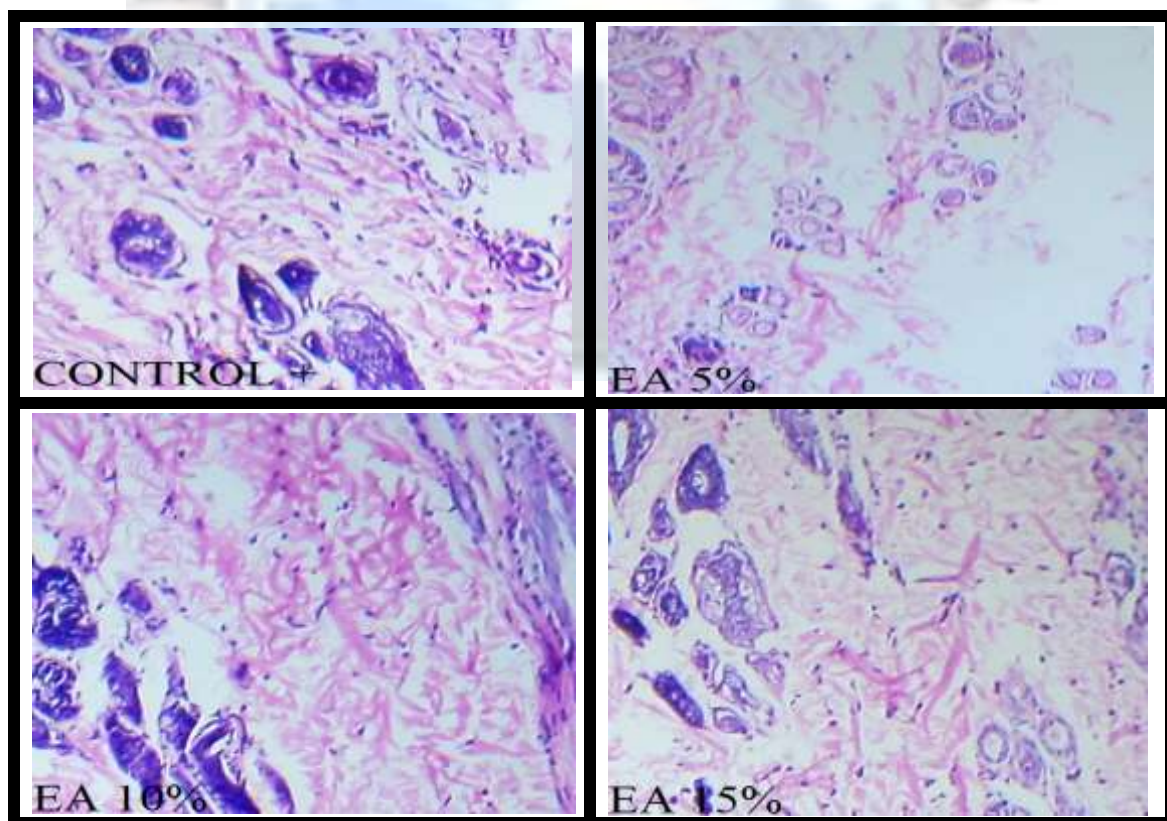


Figure (3): Biopsies taken from the Ethyl Acrylate (EA) implant site; Control site, 5% site, 10% site, and 15% site.

DISCUSSION

A material is biocompatible when it does not interfere, neither toxic, injurious nor immunological, with living tissue. An important aspect of biocompatibility of a resin-based dental material is the material's degree of monomer- polymer conversion. A material with a low degree of conversion, will have more unreacted double bonds, and will therefore have a greater ability to cause a reaction in living tissue.^[22]

Biocompatibility is also dependent on the material being appropriately polymerized; this is encouraged scientifically and by clinical knowledge. Easy handling of the material will increase the biocompatibility as a thorough polymerization will be easier to achieve for the operators.^[3,23]

Despite being exposed to potential allergens and toxic substances, the oral mucosa seldom shows inflammatory and allergic reactions. In addition, wounds and lesions heal faster in the oral cavity compared to skin. This is proved to be due to diminished inflammatory response in the oral mucosa. It is therefore strong reasons to believe that the immune system of the oral cavity helps to diminish the degree of reactions to materials.^[3,24,25]

The results of the present study demonstrated neither the evidence of sever inflammation nor the presence of necrotic tissue in implanted material when compared to the control .Therefore, the tested materials may be accepted as a biocompatible materials.

In the present experimental groups, the body reaction to the implanted materials showed good response since there was no clinical signs of inflammation. The presence of fibroblast cells in the histological slides may directly indicate that experimental materials allow cell proliferation without a cytotoxic effect, and they are biocompatible with cells.

CONCLUSIONS

There were no difference between the control groups and the other variables. All of them showed mild degree of detrimental pathological effects. So, the three tested materials with their three concentrations are biocompatible.

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