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Research Report

In vivo characterization of polymer based dental cements

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ABSTRACT

Background: *In vivo studies investigating the characterization of dental cements have been demonstrated. As few in vitro studies on this cement system have been performed. Previous researches in dental material has been standardized dental cement which fulfilled the physical and mechanical characteristic such as shear strength but were on in vitro condition, the animal model and clinical study of dental cement from laboratory has not been done yet. This research examined physical and mechanical characteristic in vivo using rabbit by making the caries (class III) in anterior teeth especially in mesial or distal incisive, fulfilled the cavity by dental cement and analyzed the compressive strength, tensile strength, and microstructure using scanning electron microscope (SEM).* ***Purpose:*** *This study is aimed to describe the in vivo characterization of dental cements based on polymer (zinc phosphate cement, polycarboxylate, glass ionomer cement and zinc oxide eugenol).* ***Methods:*** *First, preparation was done on animal model's teeth (6 rabbits, male, 5 months old). The cavity was made which involved the dentin. Then the cavity was filled with dental cement. After the filling procedure, the animal model should be kept until 21 days and than the compressive test, tensile test and microstructure was characterized. Compressive test and tensile test was analyzed using samples from extracted tooth and was measured with autograph. The microstructure test was measured using SEM.* ***Results:*** *The best compressive strength value was belongs to zinc phosphate cement which was 101.888 Mpa and the best tensile strength value was belongs to glass ionomer cement which was 6.555 Mpa.* ***Conclusion:*** *In conclusion, comparing with 3 others type of dental cements which are zinc phosphate, polycarboxylate and glass ionomer cement, zinc oxide eugenol cement has the worst for both physical and mechanical properties.*

Key words: *Zinc phosphate cement, polycarboxylate cement, glass ionomer cement, zinc oxide eugenol in vivo, characterization*

ABSTRAK

Latar belakang: *Studi in vivo meneliti karakterisasi secara in vivo dari semen gigi. Beberapa studi in vitro di bidang ini telah dilakukan. Beberapa riset di bidang material gigi telah menghasilkan semen gigi yang memenuhi standart sifat fisik dan mekanik seperti regangan dan kekuatan secara in vitro, sedangkan uji in vivo dan uji klinis dari semen gigi dari laboratorium belum dilakukan. Penelitian ini menguji karakteristik fisik dan mekanik semen gigi menggunakan hewan coba kelinci dengan membuat karies kelas III di gigi anterior terutama di permukaan mesial atau distal insisif, mengisi kavitas dengan semen gigi dan menganalisa kekuatan tekan, kekuatan tarik dan struktur mikronya dengan menggunakan scanning electron microscope (SEM).* ***Tujuan:*** *Studi ini bertujuan memberikan gambaran karakterisasi in vivo semen gigi berbahan dasar polimer (semen seng fosfat, polikarboksilat, ionomer kaca dan seng oksida eugenol).* ***Metode:*** *Pertama, kami melakukan preparasi pada gigi hewan coba (6 kelinci, jantan, usia 5 bulan). Kemudian kita membuat kavitas yang melibatkan dentin. Lalu kami menumpat kavitas dengan semen gigi. Setelah prosedur penumpatan, hewan coba dipelihara selama 21 hari dan dikarakterisasi kekuatan tekan, kekuatan tarik dan struktur mikronya. Kekuatan tekan dan kekuatan tarik dianalisa dari sampel uji gigi hewan coba yang diekstraksi dan diukur dengan autograf. Struktur mikronya diuji dengan SEM.* ***Hasil:*** *Hasil nilai kuat tekan terbaik diperoleh oleh semen seng fosfat (zinc phosphate cement) sebesar 101,888 Mpa dan nilai kuat tarik semen gigi terbaik adalah semen gelas ionomer (glass ionomer cement) sebesar 6,555 Mpa.* ***Kesimpulan:*** *Dapat disimpulkan, dari ketiga jenis bahan semen yaitu seng fosfat, polikarboksilat, dan ionomer kaca, yang mempunyai sifat fisik dan mekanikal terburuk adalah semen ionomer kaca.*

Kata kunci: *Semen seng fosfat, polikarboksilat, ionomer kaca, seng oksida eugenol, karakteristik secara in vivo*

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INTRODUCTION

Technology of dental material has been started to develop since 50 years ago. Nowadays, dentists have many choice to making restore caries lesion, fracture and missing teeth. One of the alternative sources of dental material is based on polymer. Scientists keep on trying to develop polymer in order to get closer to characteristic and the performance of real tooth.[1] Polymer is the long chain-molecule which has many unit.[2] Polymer has been used in the domain of industry and medicine. One of the examples of medical usage of polymer is their role as dental cement. The type of dental cements are zinc phosphate , polycarboxylate, glass ionomer and zinc oxide eugenol cement.[3] Dental cement must be elastic (low strength material). This cement is made by mixing the powder with the liquid. The composition of this cement is varied in chemical composition, characteristic and function usage.[6]

The need of dental cement has been fulfilled by the overseas product but there are many candidate of dental material in Indonesia. Some previous researches in dental material resulted in standardized dental cements which fulfilled the physics and mechanical characteristic such as shear and strength but they still play in the in vitro condition, the animal model and clinical study of dental cement has not been done. The phenomena inspiring us to perform the clinical research (in vivo) which examined physics and mechanical characteristic of dental cement based on polimer using rabbit. The teeth has been perforated by the diamond bur to perform caries (class III) in anterior teeth especially in mesial or distal incisive or caninus. Then we analyze the compressive strength, tensile strength, and micro structure using SEM. The result of this research would be beneficial as base theory for the development of dental material.

MATERIALS AND METHODS

Animal models (*Bunolagus monticularis*) were prepared (6 rabbit, male, 5 month). They should be anesthesized based on the age and weight. The cavity preparation were done using round bur, fissure bur dan tappered bur. The preparation involved dentin. Then the cavity were were cleaned by cotton and water spray. The cavity and the surrounding area should be isolated using cotton roll to prevent saliva contamination. The filling material should be prepared in the glass and mixed using spatula cement. The filling material should be place inside the cavity using plastic filling instrument. After 1-2 minutes, it was pressed using amalgam stopper and carved.

The first rabbit was filled with zinc phosphate cement (group A). Second rabbit was filled by polycarboxylate cement (Group B). The third rabbit was filled with glass ionomer cement (Group C) and the fourth rabbit was filled with zinc oxide and eugenol cement (Group D). The fifth rabbit was filled zinc phosphate cement and the left cavity was filled with polycarboxylate cement. The sixth rabbit, the right cavity was filled by glass ionomer cement and left cavity should be filled by zinc oxide and eugenol cement. The whole sample are 12 samples. After the filling procedure, the animal model should be kept until 21 days and then the compressive test, tensile test and microtructure were characterized.

RESULTS

The result of compressive strength of zinc phosphate cement is 101,888 MPa and the tensile strength is 5,777 MPa. Whether for polycarboxylate cement, the compressive strength is 56,555 MPa and the tensile strength 6,111 MPa. glass ionomer cement has the compressive strength value is 70,777 MPa and tensile strength is 6,5555 MPa. Zinc oxide eugenol has compressive strength value around 46,111 MPa and tensile strength is 3,111 MPa. The detail data could be seen in the table 1.

Table 1. The compressive and tensile strength of various cement

No.	Sample	Compressive strength (MPa)	Tensile strength (MPa)
1.	A	101.888	5.777
2.	B	56.555	6.111
3.	C	70.777	6.555
4.	D	46.111	3.111

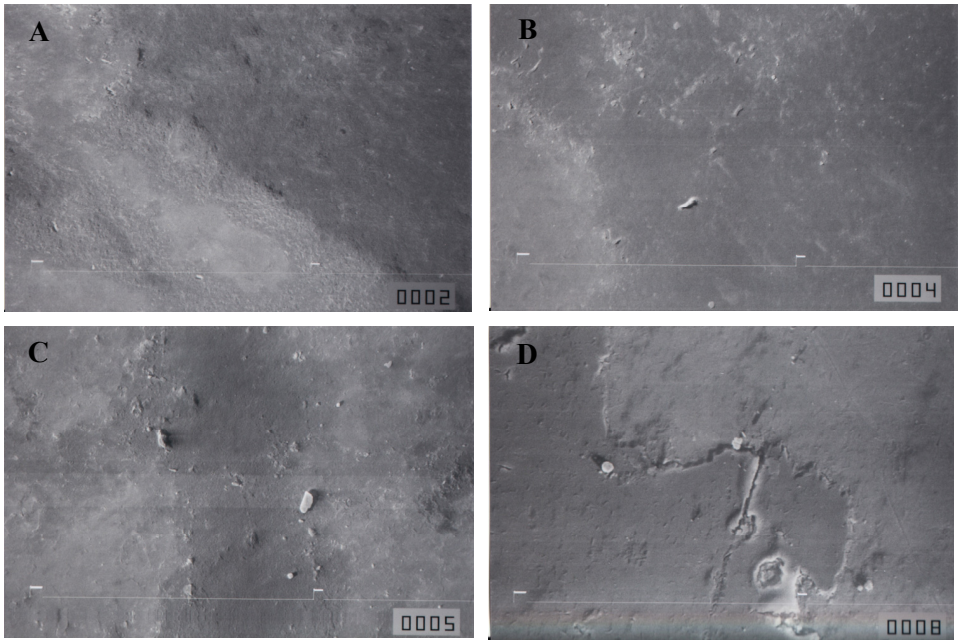

Figure 1. Microstructure of tooth and dental cement examined by SEM: for group a) zinc phosphate cement, b) policarboxylate cement, c) glass ionomer cement, and d) zinc oxide and eugenol cement.

The microstructure of tooth structure and dental cement are showed in figure 1.

DISCUSSION

The best compressive strength is 101.888 Mpa for zinc phosphate cement and the best tensile strength is 6.555 Mpa for glass ionomer cement. If done with the right manipulation, the compressive strength of zinc phosphate cement is 104 MPa and the tensile strength is 5.5 MPa.[7]

The compressive and the tensile strength is varied according to the ratio of powder and liquid. To increase the strength, much powder showed be added than it should be. The decrease of powder ratio could yield weak cement. The lost or the addition of water would decrease tensile and compressive strength of cement. Zinc phosphate cement and glass ionomer cement could be easily ossified. After ossification, the excess cement could be throw out by gouging out the cement sheer off the edge of restoration. Because of that, the edge of restoration should be prevented from early contact with the liquid.[8]

The compressive strength of polycarboxylate cement is lower than zinc phosphate cement, but the tensile strength is little higher than zinc phosphate cement. Polycarboxylate cement is not as fragile as zinc phosphate cement so it is more difficult to loosing upon the excessive cement after the ossification.

Mechanical characteristic of zinc oxide and eugenol cement is lower than other cements. This type of cement is difficult to manipulate inside the mouth. The thickness of the layer is higher and the excessive cement is difficult to discard.[9]

The difference of the compressive and tensile strength is caused by the mixing speed of powder and liquid, mixing plate and the temperature of the stirring tool. The fusion speed of powder and liquid could influence the hardness of dental cement because powder is mixed with liquid gradually in small sum would increase working time, the hardness and decrease the color and it give opportunity to add much powder in the mixture.

Mixing plate and temperature of stirring tool influence mechanical characteristic of dental cement. High temperature of stirring tool could accelerate the hardening of dental cement. The other site of the temperature of stirring tool is lower, then the hardening reaction could take longer time. The wrong mixing of powder and liquid could result in crack of the dental cement and can make the measurement of mechanical characteristic difficult.

Microstructure of zinc phosphate cement is showed that the dental cement could not fuse with the tooth correctly. When the powder is mixed with the liquid, phosphoric acid is contacted with the surface of particle and release zinc ion to the liquid. Aluminium, which form the adhesion with phosphoric acid, then reacted with zinc produce zinc aluminophosphate gel in the surface of particle. The set cement is the main core structure including unreacted zinc oxide particle, covered with dense matrix which are not from aluminophosphate zinc. Water plays important role in the acid-base reaction, so the composition of liquid should be arranged to make sure that the reaction is consistent. The alteration of composition and the speed of reaction could happen because of water evaporation of the liquid. This means, the composition alteration could influence the reaction.

Microstructure of polycarboxylate cement that the cement have strong bonding with the tooth. The hardening reaction of dental cement involved dissolving of surface particle of acid and zinc, magnesium, and tin release which fused to polymer chain through carboxyl cluster. Ions are reacted with carboxyl cluster and surrounding poly acid chain to form salt from cross binding when the cement is set. The set cement including matrix gel without proper form including many unreacted scattered particles.

Microstructure of glass ionomer cement consist of unreacted powder particles. When the mixed powder and liquid in paste form, the surface of glass particle would dissolve in the acid. Calcium ion, aluminium, natrium and fluorine are released to the based water medium. Polyacrilate acid chain would form cross binding with calcium ion and dense mass. Before 24 hours, it forms the new phase where aluminium ion bind in the cement mixture. It would make the cement rigid. Natrium ion and fluorin are not interfering in the cross binding of cement. Some natrium ion could replace hydrogen ion from carboxylic cluster, and the rest will join with fluorin ion to form fluoride natrium which is scattered inside the set cement. In the maturation process, cross binding phase is hydrated by water. Unreacted part with glass particles will be covered by silica gel which formed during the release of surface cation. The hardening set, including the group of unreacted powder particle, surrounded by silica gel in the amorphous matrix of hydrate calcium and aluminium salt.

Microstructure of zinc oxide and eugenol cement showed the very hard. In proper condition, the reaction of zinc oxide and eugenol produce hard relative mass. Mechanism of hardening zinc oxide eugenol including zinc oxide hydrolysis and reaction between hydroxide zinc and eugenol to form the cluster. Setting reaction is accelerated by the presence of dehydrate acetate zinc, which is more dissolved than hydroxide zinc. High temperature could accelerate hardening reaction.

The important characteristic of dental cement is the endurance of solubility and disintegration inside oral cavity.[10] Cement is regularly in contact with many acid produced by microorganism and mastication and swallowing. Some acids has been brought by some food and beverages. pH and temperature inside the oral cavity is always changed. So, there would be no cement which could fulfill the ideal characteristic. One type of dental cement might suitable for certain condition than the others. Every condition should be valued based on the environment, biological and mechanical factor. In conclusion, comparing with three others types of dental cements which are zinc phosphate, polycarboxylate and glass ionomer cement, zinc oxide eugenol cement has the worst for both physical and mechanical properties.

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