

REVIEW

The benefits of adding eggshells to the porosity and flexural strength of temporary fixed denture in long-term-use

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ABSTRACT

Keywords: Eggshell, Flexural strength, Polymethyl methacrylate, Porosity, Temporary fixed denture.

Temporary fixed partial dentures (FPD) are worn for a limited time before definitive FPD, but in some cases like crown lengthening procedures, supra structure implant, temporomandibular disorders, and endodontic treatment, require long-term temporization. Polymethyl Methacrylate (PMMA) which is commonly used for temporary fixed dentures has weaknesses, namely porosity, low value of flexural strength and impact, low abrasion resistance, ease of fracture, shrinkage after polymerization, and leaves monomer residue, so modification is needed with the addition of reinforcing materials. Reinforcement like fiber filler is difficult to absorb resin monomers causing space between the surfaces of fiber and polymer matrix thereby reducing the mechanical strength of the resin. Eggshell is a natural source of calcium, has the potential as a biocompatible material with an economical price, and is easy to obtain as an alternative material for PMMA reinforcement. This paper discusses the long-term use of temporary FPD, PMMA as a temporarily fixed material, and the benefit of eggshell waste to porosity and flexural strength of PMMA materials. The addition of eggshell to PMMA for temporary fixed restoration could decrease porosity and increase the flexural strength of PMMA material because it contains calcium carbonate so that it could be used for the manufacture of provisional fixed restoration which requires long-term use. (IJP 2024;5(1):50-54)

INTRODUCTION

The placement of temporary dentures is an important part of the procedure fixed denture treatment. A temporary fixed partial denture (FPD) is a fixed denture designed to improve aesthetics, stability, or function over time limited before being replaced with a definitive denture. Temporary FPD is temporarily used for assessing the effectiveness of the therapeutic plan, and the form, and function of the definitive FPD.¹

Temporary FPD is usually immediately replaced with definitive FPD, but in certain conditions such as in treatment crown lengthening, the procedure of implant superstructure, endodontic treatment, and treatment of temporal mandibular disorder need a longer period of 2 to 6 months or until a definitive prosthetic can be administered to the patient.²⁻⁸

Temporary FPD is designed for the complex oral environment. In clinical conditions, temporary FPD will accept various forces

during mastication including compression, tension, and shear force. Maximum pressure the occlusal pressure can reach 900 N in adult posterior teeth and the pressure mastication is between 100-300 N. Maximum frequency of occlusal pressure can occur up to 3000 times per day, it is a consideration that temporary FPD has a large load for a long time and repeatedly in daily use, so a material with adequate flexural resistance is needed.⁹ Temporary FPD also should not dissolve in oral fluids. Many materials are commonly used for the fabrication of temporary FPD, one of which is polymethyl methacrylate (PMMA).

PMMA material has limitations and it could cause problems. These include easy to fracture, low abrasion resistance, low flexural resistance, and porosity. These limitations could interfere with biofunctionality temporary FPD, especially when it is used for a long time.¹⁰

Porosity will decrease restoration strength and make

of microorganisms to the restoration surface.¹¹ Low flexural strength will cause denture wear and fracture because of occlusal force during its function. Damage can also occur while adjustment during the process of the treatment period so in some situations temporary FPD is needed to be repaired.

To overcome the limitations of PMMA, reinforcing material is needed. Many reinforcing materials, both synthetic and natural, are used as reinforcement PMMA. Reinforce materials such as fiber or polyethylene fibers are difficult to absorb resin monomers, resulting in space between the fiber and matrix surfaces and reducing resin strength.^{12,13} Eggshell is known as waste that is easily obtained in large quantities and has the potential as a PMMA reinforcement material because it has 90% calcium content.¹²

This paper aims to discuss the long-term use of temporary FPD, PMMA as a temporary FPD material, and the benefits of adding eggshell to the porosity and flexural strength of temporary fixed denture in long-term use.

LITERATURE STUDIES

Temporary Fixed Partial Denture

Temporary FPD protects the pulp, maintains health periodontal, accelerates the tissue healing process, evaluates hygiene procedures, avoids displacement of abutment teeth, improves aesthetics and phonetics, presents an adequate occlusion scheme, evaluates intermaxillary relationships with patients, improves the patient's social life, and the diagnostic function as a prototype the outcome of the treatment that the patient will receive.²⁻⁶ To make temporary FPD function optimally, it must qualify for the biological, aesthetic, and mechanical requirements.^{2,3,7,8} Biological requirements can protect the pulp, prevent enamel fracture, maintain periodontal health, occlusal compatibility, and tooth position. Aesthetic requirements that must be owned by temporary FPD have color and can be manipulated so that its shape can resemble real natural teeth close together. The mechanical requirements are resistance to fracture, ability to withstand occlusal forces in the oral cavity when it functions and must be retentive, manipulated, and reassembled without damage, smooth surface so that it will be advantageous both aesthetically and biologically, good margins, tensile strength, and adequate dimensional stability, and easy to repair.^{2-4,6,7,14}

Type of Temporary Fixed Partial Denture

Based on the method of making temporary FPD is divided into custom and preformed.^{7,14} Custom temporary FPD is made according to the patient's teeth condition before preparation or on a modified diagnostic model, whereas preformed temporary FPD is currently available on the market. When temporary FPD installation is preformed, it needs readjustment to the patient's dental condition.^{2,14} The technique of fabrication of temporary FPD could be direct, indirect technique and a combination of techniques from direct indirect. Advantages of indirect technique are occlusal and aesthetic adjustments can be made at the articulator, there is no contact of oral tissues with monomers, avoiding the prepared tooth from heat during the resin polymerization process, good marginal fit, reduce inhalation hydrocarbons volatile by the patient. The disadvantage of this technique

increases the processing time, requires a laboratory process, and potentially increases the cost of processing. The direct technique has the advantages of being cheaper and easier to perform, but the drawback of this method is the residual monomer polymerization left behind can cause inflammation of the tissue, and heat of reaction exothermic irritation could irritate the pulp causing pain and discomfort to patients, poor marginal margin adaptation.^{2,4,6-10} Combined direct and indirect technique is a hybrid technique that combines laboratory work with intra-oral relining.⁴

Temporary Fixed Partial Denture Material

Temporary FPD could base on metal or resin material. Resin-based materials used in manufacturing temporary FPD such as polymethyl methacrylate (PMMA), polyethyl methacrylate (PEMA), polyvinyl methacrylate (PVMA), bis acrylic resin, and VLC urethane dimethacrylate.⁴

Polymethyl Methacrylate (PMMA)

The advantages of PMMA are its low density, aesthetics, economical, easy to handle during manufacture and repair, manufacture of embrasure larger ones with smaller contact points between adjacent teeth will be beneficial for periodontal tissue as well as better aesthetic appearance, easier to apply in humid areas suitable for intra-oral conditions, and has better color stability than bis acrylic.^{3-5,7,14,15} Heat-cured PMMA has a higher degree of polymerization, produces less residual monomer, higher flexural strength, and fracture resistance than self-cured PMMA. According to Supichaya, et al. (2018) the flexural strength after artificial aging proses with thermocycling 5000 cycles, heat cured PMMA has higher flexural strength value compared to acrylic self-cured and bis-acrylic materials.¹⁶ These advantages make PMMA widely used in dentistry, however, PMMA also has some limitations.

The limitations of PMMA are porosity, easy to fracture, low value of flexural strength, impact as well as low resistance to abrasion, shrinkage after polymerization, leaving monomer residue, the exothermic reaction of polymerization which can irritate the pulp and periodontal tissues, discoloration when usage, marginal inaccuracy, and external contour non-integrity of temporary FPD.^{3,7,10} This weakness will interfere it function especially when used long-term.

Temporary Long-Term Use of Temporary FPD

Indications for long-term use of temporary FPD when implant procedures require a healing process, crown lengthening procedure which takes 3-6 months, temporomandibular disorder therapy requires occlusal adjustment and endodontic treatment. This duration use is related to tissue healing procedures, monitoring patient comfort and satisfaction, and making any necessary adjustments.^{4,10,16-18} In long-term use of temporary FPD problems can be encountered, including a decrease in mechanical strength associated with a value of porosity and low flexural strength of PMMA materials.¹⁶

Porosity and flexural Strength PMMA

Porosity is a complex phenomenon caused by various factors such as laboratory techniques, methods, and polymerization materials. All related factors with laboratory techniques that affect the porosity value, as known as the ratio of powder and liquid, mixing process of powder and liquid, pressing, flask cooling, and controlled polishing time.¹⁹ Porosity creates

space within the matrix which will cause a stress point so that the restoration breaks while performing its function in the oral cavity. Porosity is also detrimental in the biological aspect, increasing the attachment of microorganisms to restoration surface.¹¹ There are two types of acrylic resin porosity, gaseous porosity or internal porosity and contraction porosity. The porosity formed in the thick part and away from the heat source is called gaseous porosity or internal porosity. Gaseous porosity formed due to evaporation of the remaining unreacted monomer to form air voids called porosity.¹⁹

Flexural strength, also known as modulus of rupture or transverse strength is the resistance of PMMA after polymerization to vertical load is applied to the test rod supported at both ends until the rod break. Flexural strength can describe as the resistance of objects in receiving masticatory load. Temporary FPD must have resistance to occurrence of fractures and permanent deformities.^{10,16}

Fractures are caused by the distribution of surface cracks, flexural strength, impact, and inadequate fatigue resistance. During function and parafunctional movements, fractures can occur due to pressure concentration, especially in the area connector, or on a blank area. Fractures of the cervical region are caused by inadequate preparation so that the restoration walls are too thin. The fracture that occurs results in a temporary disruption of the function of the restoration, causing discomfort to the patient, and harming the prepared tooth, and the periodontal tissues.⁶ To overcome the problem due to the weakness of PMMA, modifications were made to improve PMMA properties by adding PMMA reinforcing material.

PMMA Reinforcing Materials

To improve the mechanical properties of PMMA, especially in long-term use, several reinforcing materials have been used such as the addition of fiber fillers like carbon fiber, glass fiber, and polyethylene fiber. The fiber material is difficult to absorb the monomer resin, which causes spaces between the polymer matrix and can cause a decrease in the mechanical strength of the resin material.^{12,13} The mechanical properties of PMMA materials are affected by shape, size, and distribution of filler particles in the matrix.²⁰ In addition to reinforcing materials in the form of metals, synthetics, and chemicals, there are also PMMA reinforcing materials that come from nature. Natural materials used to strengthen the mechanical properties of PMMA such as nano cellulose from rice husk, chitosan, and eggshell.²¹

Eggshells as a Reinforcement Material

According to statistical data from the Ministry of Animal Husbandry and Animal Health Agriculture In 2019, the average egg production from 2015 to 2019 in Indonesia reached 3,953,411.4 tons.²² Eggshells contain calcium (CaCO_3 90.93%) and other microelements such as magnesium, boron, copper, iron manganese, sulfur, and zinc. Another advantage possessed by eggshells is that they are easy to find in large quantities and low prices.^{18,23} Eggshell be converted from eggshell waste to hydroxyapatite form.²³ Eggshell is expected to be the best natural source of calcium with 90% absorbable.²⁴

In the field of dentistry, egg shells have been used as a denture base acrylic mixture to increase the strength of the denture base, for direct pulp capping, as a tooth remineraliza-

material after the etching process, and add shear bond strength with bulk composite, as an ingredient polishing agent for denture bases, as an additive in toothpaste, and procedures bone graft.^{12,21,25-28}

Eggshell is a biocompatible material that will not only in improving the mechanical and physical properties of PMMA as temporary FDP material but also as an environmentally friendly material.

DISCUSSION

After aging heat cured acrylic has highest strength and hardness value, compared with autopolymerization acrylic material and bis acrylic (Antonio, et al. 2017). There is no significant difference between strength self-cured acrylic and bis-acrylic. The highest strength of heat-cured acrylic due to the process experienced by this material significantly affects the strength of acrylic. Heat-cured acrylic through a process of heat activation and compression molding (flasking), creating a homogeneous mixture of materials, and bubble-free with high resistance higher than other materials. Because of their hardness and functional stability heat-cured acrylic are recommended for periods longer than 1 month. Self-cured acrylic is suggested uses of FPD 1-3 units with minimum thickness of 1 mm, and using cooling techniques when polymerizing, or used on teeth non-vital to prevent the risk of overheating. Bisacrylic used for a short period of time up to 15 days.²⁹ According to Anil K Gujjari, et al. 2013, bis-acrylic has higher flexural strength than PMMA after immersion for 7 days. The difference in strength between PMMA and bis-acrylic is derived from different monomer compositions. Bis-acrylic has multifunctional monomers that increase strength through cross-linking with other monomers. The addition of inorganic fillers can increase the strength and microhardness.³⁰

Abbas Ibrahim Husain (2020) conducted research on the use of particles eggshell as a mechanical property reinforcement of PMMA, eggshell powder increased the tensile strength of PMMA material at concentrations of 1% and 2%, then tensile test decreased at 3% and stabilized at the addition of 4% powder eggshell. Flexural strength increases in increments of 1-3%, but begins at 3% the flexural value decreases, this proves that there is a bond limitation between eggshell powder and composite materials. From this research, it is stated that, the benefits of adding egg shells have a good effect on the mechanical properties of PMMA, but not exceeding 2% eggshell concentration.³¹ Maulida Lubis, et al. (2021) conducted research on the effect of nanoparticles eggshell as filler in acrylic resin biocomposite denture base. Flexural strength significantly increased with the addition of 10% then decreased at concentrations of 20% and 30%. The addition of more than 10% eggshell nanoparticles causes saturation to occur which will cause a decrease in the strength of the sample. The addition of 30% filler reduces the strength value due to particle concentration higher filler will increase the interaction between the filler particles which produces agglomerates. Agglomerates that occur due to high concentration. The filler material for the composite structure is not homogeneous, stress points occur in the matrix which will cause cracks.³²

Aseel M Abdullah, et al. (2019) researching on impact strength, modulus flexural, and wear rate from PMMA already given as reinforcing material for eggshells powder. They mix PMMA ingredients with untreated eggshells (UTESP) and treated eggshell (TESP) with ratios 1, 2, 3, 4, and 5 wt%.³³ It was found that there was an increase in modulus flexural along with increased addition of eggshell powder with TESP. Modulus flexural value TESP is higher than UTESP. Crack propagation can be converted into a good bond between the PMMA matrix and eggshell particles related to the natural properties from eggshell particles bound to PMMA. Addition of powder eggshell in PMMA reduce wear rate of PMMA.³³

Ronaldo Triputra, et al. (2019) doing research regarding the effectiveness of adding hydroxyapatite to decrease the porosity of the base heat cured acrylic resin. The test was carried out in the control group, group 1 with the addition of 2% hydroxyapatite concentration, group 2 with the addition of 5% hydroxyapatite, group 3 with the addition of 10% hydroxyapatite. In control group results obtained an average porosity of 8.53%, in the group 1 test the average porosity is 7.75%, group 2 is 4.47% and group 3 is 5.53%. From result, their research found that the residual monomer after polymerization which binds to hydroxyapatite can reduce the porosity of the acrylic resin. According to the results of the study, it was found that the addition of too many particles (in groups 2 and 3) can cause material defects, thus causing deposition of particles in the resin, and the addition of excessive particles when reaching the saturation point of the matrix will cause discontinuity of the resin matrix. The addition of hydroxyapatite has a role in reducing the porosity of the resin plate acrylic heat cured.¹⁹ M Lubis, et al. (2019) who made observations with SEM of 1500 times magnification on a PMMA denture base treated with reinforcement in the form of eggshell nanoparticles, it is stated that not occur space void on the addition of 10% eggshell nanoparticles, but at the addition of 30% eggshell nanoparticles has a fractured surface structure that coarse and many voids formed in the sample.¹²

CONCLUSION

Long-term use temporary FPD in cases of temporomandibular disorder treatment, crown lengthening procedure, supra structure implant procedure, and endodontic treatment, takes a long time to heal and requires adjustment occlusal so that a strong temporary FPD is needed for optimal function until definitive FPD can be achieved by patient. Heat-cured PMMA has the value of flexural strength and durability better fracture resistance compared to self-cured PMMA and PMMA light polymerization, PMMA also has more strength after repair so good that it becomes an option for long-term temporary FPD.

Porosity occurs in dentures due to the presence of non absorbable monomer residues adsorbed after the polymerization process. The gaps between the polymer matrix surface as well because of temporary FPD fracture. Adequate flexural strength is needed to withstand complex masticatory forces without permanent deformity and avoid temporary FPD

waste in the form of micro powder/nanoparticles can be an alternative to PMMA reinforcing biocompatible materials to improve strength flexibility and porosity at a low price and easily available and friendly environment.

SUGESSTION

The addition of reinforcing materials from eggshell waste at certain concentrations to reduce porosity and increase the value of the flexural strength of PMMA materials in order for optimal function of temporary FDP requires further research.

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