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Effect of Fish Scale Powder Addition to Flexural Strength of Heat Cured Acrylic Resin

Kholidina Harahap
Department of Dental Material and Technology
Faculty of Dentistry, Universitas Sumatera Utara
Medan, Indonesia
kholidinaimandaharahap@gmail.com

Ika Andryas
Department of Prosthodontic
Faculty of Dentistry, Universitas Sumatera Utara
Medan, Indonesia
andryas_doc@yahoo.co.id

***Abstract*–Heat cured acrylic resin has been used as dental prosthetic devices because of its excellent appearance, simple processing technique and easy repair. The absence of filler on acrylic resin causes limitation of flexural strength at the time of use. Fish scales can be used as filler to reinforce the acrylic resin because they contain collagen and hydroxyapatite minerals. This study was designed to evaluate the flexural strength of acrylic resin reinforced with fish scale powder. Thirty samples was made from heat cured acrylic resin sized 65x10x2 mm. Samples were divided into control group and treatment group which is added by fish scale powder in 5% and 10% by weight. Flexural strength of heat cured acrylic resin was tested by using three point bending method. The result shows that the addition of 5% and 10% fish scale powder decreased flexural strength of heat cured acrylic resin. There is significant differences on flexural strength among all groups (p=0.00).The conclusion is fish scale powder in 5% and 10% did not improved the flexural strength of heat cured acrylic resin.**

***Keywords*–heat cured acrylic resin, fish scale powder, flexural strength**

I. INTRODUCTION

Dentures are used to restore the function of mastication in edentulous patients. Acrylic resin as denture base material is the most widely used material for making dentures because it is cheap, light, easy to repair and easy to process [1,2]. However, this material has low mechanical properties that causing fracture easily by sudden impact or because of the long use in the oral cavity [3]. The strength of acrylic resin was influenced by the forces in the mouth, including the transverse, impact or fatigue resistance and flexural strength [4]. Flexural strength is the ability of a material to resist from load or mastication force. The flexural strength is highly considered as an indicator of the material strength [5]. Poor flexural strength of acrylic resin will unable to resist from the excessive mastication force [6].

According to Wang et al [7], higher flexural strength is required for a material to resist the mastication force. Earlier studies reported that the fracture rate of acrylic resin was 64% [8] and 68% [9]. Dentures fracture may occur inside or outside the mouth due to expelling the denture from the mouth while coughing, or simply dropping it [10]. Poor quality and poor fit of the denture base material, excessive mastication force, improper occlusal plane, high frenal attachment, and lack of balanced occlusion is claimed as the fracture reasons [11].

The absent of filler, which acts as load receiver in acrylic resin is assumed as the cause of mechanical properties weaknesses factor. Hence, there are three ways to improve the mechanical properties of acrylic resins: replacing acrylic resins with alternative materials, such as metals and nylons, chemically modify it, and strengthening with reinforcement materials such as fibers and fillers [12].

Previous studies have been done to increase the strength of acrylic resins. The addition of fibers into acrylic resin is the way to increase the strength of acrylic resin. Glass fibers, nylon, wires can be used as reinforcement materials. Furthermore, the addition of fillers into acrylic resin, such as chitosan and alumina, has also been widely studied to increase the mechanical strength of acrylic resin [13,14].

Currently, a few studies inform the utilization of natural fillers which have several advantages as reinforcement materials compared to mineral fillers. The filler may be classified according to its chemical and physical properties and divided into organic and inorganic fillers [15]. Several previous studies have suggested that fish scales can be used as resin fillers. Fish scales have a yield ranging from 3.8 to 4.9% that can be obtained based on specific molecular weights so it can be used as filler [16]. Gopi (2016) [17] found that the addition 10% of fish scales into vinyl ester resins can increase flexural, compressive and impact strength. Satapathy (2012) [18] stated that fish scales can bind to epoxy resins to form hydrogen bonds and increase flexural strength, tensile strength and hardness.

The above literature shows that fish scale can improve resin based materials mechanical properties. However, based on author's knowledge, research on the utilization of fish scales waste as a filler material for acrylic resins used in dentistry was extremely limited to be found in literatures. Therefore, authors are interested to evaluate the effect of adding fish scales powder to mechanical properties of heat cured acrylic resins. The aim of this study was to evaluate the effect of fish scale addition on flexural strength of acrylic resin. The null hypothesis is there would be no effect of fish scale addition on flexural strength of heat cured acrylic resin.

II. MATERIALS AND METHODS

A. *Fish scale preparation*

Two kilogram fish scales were washed by tap water and soaked in the soap solution overnight and dried for three days directly under the sun light. Fish scales was milled using a food chopper (Cosmos, Indonesia) to produce fish scale powder which was kept and sealed in a dry container.

B. *Specimens preparation*

Thirty acrylic resin specimens (Meliodent, CE 0123, Heraues-Kultzer, Germany) mixed according to 2:1 ratio were divided into 3 groups, which are control group (A); 5 % fish scale addition into acrylic resin (B); 10 % fish scale addition into acrylic resin (C). All specimens produced using 65x10x2 mm sized master cast according to ISO 1567:1988 continued to be invested in the conventional metal flasks.

After the invested materials were set, the flasks separated, and the master cast removed from the flasks. The resin was then packed and polymerized by using waterbath (Memmert, Germany). The heating temperature starts at room temperature which were raised up to reach 74°C and maintained for 1.5 hours. The temperature was increased up to 100°C and maintained for another 1 hour. After processing stage, each specimen was polished using 1200 and 2000 grit dry sandpaper. A low speed micro motor (South Korea Traus Strong 207a, Traus Strong, South Korea) with 25000 rpm for 15 minutes was used to polished the specimens. A digital caliper (Mitutoyo, Japan) was used to record precise specimen measurements. All specimens were stored in distilled water at 37ºC for 24 hours before testing.

C. *Flexural strength test*

The flexural strength of the specimens in three groups were measured using a three-point bending test in a universal testing machine (Servopulser, Shimadzu, Japan) at a 5 mm/min crosshead speed. The flexural strength (TS) was calculated using the formula $FS = aWL/2bd^2$, where W is the maximum load before fracture (kgf), L is the distance between supports (50 mm), b is the specimen width (mm) and d is the specimen thickness (mm).

D. *Statistical analysis*

Statistical analyses were completed using a one-way analysis of variance (ANOVA) and Least Significant Data’s test for post hoc comparisons. All analyses were performed at 95% level of confidence.

III. RESULTS

Flexural strength mean and standard deviation for all specimens in three test groups are listed in Table 1. Flexural strength in the control group showed higher mean value rather than fish scales powder addition groups. There was a significant difference flexural strength between the three groups based on ANOVA analysis. LSD test showed there was a significant difference between group C compared to group A and B ($p<0.05$). On the contrary, no significant difference can be found between group A and B ($p>0.05$).

TABLE I. MEAN AND STANDARD DEVIATION OF FLEXURAL STRENGTH

Groups	Mean±SD (MPa)
A	206.44±33.35[a]
B	146.05±23.74[b]
C	147.94±30.52[b]

*Different letters indicate statistically significant difference at 95%.

IV. DISCUSSION

Heat cured acrylic resin is a commonly used denture base material. However, this material still has problems in its mechanical properties. Transverse, impact and flexural strength are factors related to denture base failure. Flexural strength is a factor which combined compressive strength and tensile strength. This strength informs the static load during mastication on a material performance. The effort to break a denture base increase as the flexural strength increased [19].

Previous studies have attempted to improve the mechanical properties of acrylic resins by the addition of reinforcing fibers or fillers into acrylic resins. Khalaf [20] found that acrylic resins added to siwak powder with different percentages can increase flexural strength, but decrease the tensile strength, impact strength, and surface roughness. Ghahremani [21] found that there was an increase in tensile and impact strength on acrylic resins reinforced with nanoparticle titanium oxide.

In this study, the control group showed 206.44±33.35 Mpa. However, the flexural strength in control group found to be higher than other groups. The Flexural strength in 5% and 10% acrylic resin with fish scale powder addition reduced to 1.4 times compared to control group. Decrease in flexural strength might be caused by the irregularity distribution of fish scales powder in the acrylic resin. Agglomeration of fish scales powder causes stress concentration in acrylic resin. The second possibility is because the fish scales powder particles are not coated with silane, so the bond between the filler and the acrylic resin is not formed [22].

It should be emphasized that the type of the fillers, their physical orientation, and their adherence capacity to the resin phase can affect the physical characteristics of resin-based materials. According to the type of the filler, it can be suggested that the hydrophilic unmodified particles cannot be dispersed appropriately and will agglomerate in the resin phase. This phenomenon causes the stress to be concentrated on particular points in the resin phase and the crack to spread easily through the unfilled parts of matrix resin. This can be the main reason for crack propagation that leads to matrix fracture and reduction in flexural strength. These explanations clarify why unmodified nanoparticles did not cause significant changes in the flexural strength [23].

The high surface area, fine size, and homogenous distribution of particle fillers improved the thermal properties of PMMA and increased its thermal stability compared to pure PMMA. The properties of resin reinforced by fillers were depending on the size, shape, type, and concentration of the added particles [24].

It can be concluded that flexural strength is an important mechanical property which can lead to denture base clinical failure. Fillers are expected to increase this mechanical property. However, uncontrolled filler particle size can play a major role in breaking down the polymer chain.

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