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# Comparison of Strength Between Acrylic Resin Prosthetics and Thermoplastic Acrylic Against Charpy Impact on Artificial Dental Manufacturing

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**Abstract**
Heat-cured acrylic resin is the base material that is the most widely used in the manufacture of removable dentures because it has advantages in aesthetics, is non-toxic, does not irritate the oral mucosa, is inexpensive, and is easy to manipulate and repair. However, this material has drawbacks. Namely, it has microporosity so that it absorbs liquid. It is easy to fracture if it is hit on a hard surface or during prolonged use. This study aimed to determine the difference in impact strength between heat-cured acrylic and thermoplastic acrylic against Charpy impact (impact stress) so that it can be the basis for adding wire or metal plates to increase the mechanical strength of the material. This type of research is experiments in the laboratory to determine the effects of specific treatments. The research sample is heat-cured plate *acrylic* and Thermoplastic Acrylic with a size of 65 mm x 10 mm x 2.5 mm according to ADA specification no. 12, which amounted to 16 pieces for each group. Sample criteria in the form of a block according to the smooth and shiny size. Data analysis using one Way Anova and Least Significant Difference test to see differences in the impact strength of heat-cured plates *acrylic* compared to the Acrylic Thermoplastic plate with a significance level (p 0.05). One Way Anova test results obtained*P-value*< 0.05, proving a significant difference between the Heat Cured Acrylic Resin group and the Acrylic Thermoplastic group. The Least Significant Difference calculation results show that the average difference between Heat Cured Acrylic Resin and Thermoplastic Acrylic is 56.8. This is greater than the LSD calculation of 9.802465, which means there is a significant difference between the average Heat Cured Acrylic Resin and Thermoplastic Acrylic. In conclusion, Heat Cured Acrylic Resin plate has a lower impact strength than Thermoplastic Acrylic.

**Keywords**: impact pressure (charpy); heat-cured acrylic; thermoplastic acrylic

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## INTRODUCTION

Acrylic resin is a material formed by combining methyl methacrylate molecules(Annusavice KJ, 2004). Acrylic resin is a polymer that has an essential role in the manufacture of removable dentures. More than 95% of denture bases are made of acrylic resin (Wahyuningtyas, 2008). The acrylic resin type is heat cured because it has aesthetic advantages and good color stability. It does not irritate the oral mucosa, is not toxic, is cheaper, does not dissolve in oral fluids, and is easy to manipulate and repair. Changes in dimensions are small (Tarida, Handajani S, Fitriani D, 2013). However, heat-cured acrylic has drawbacks, namely the presence of monomer residues. Microporosity can absorb liquids and quickly absorbs food residue or chemicals, is easy to fracture if hit on a hard surface or due to prolonged use, and is easily discolored (Munadziroh, David, 2005).

*Heat-cured acrylic* is available in powder and liquid form. The powder contains polymer polymethylmethacrylate as the main element, (1) benzoyl peroxide as an initiator, (2) reduces translucency, (3) dyes, and (4) fiber (Van Noort R, 2007). The liquid contains methylmethacrylate monomer, a stabilizer, cross-linking agent to increase strength and hardness, and a plasticizer (Fraunhofer JA, 2010). Several things must be considered when manipulating heat-cured acrylic, namely the ratio of polymer and monomer 2:1. The powder mixing process must go through five stages (wet and stage, sticky stage, dough/gel stage, rubbery stage, and stiff stage). The application of the separator material to the mold must be thin, and even the packing process (filling acrylic into the mold) must be filled, and the curing process starting from room temperature to 100C for one hour(McCabe JF, 2008)

The mechanical properties of heat-cured acrylic are fatigue strength, which is the strength of the material subjected to repeated stresses above the proportional limit so that it breaks (Darvell BW, 2009). Transverse or flexural strength is a load given in the middle on a rod-shaped material that rests on both ends. As long as the rod is pressed, the load will increase uniformly and stop when the test rod breaks. The results obtained will be entered into the transverse formula. Heat-cured acrylic transverse strength is 85.47 Mpa (Darvell BW, 2009). Furthermore, heat-cured acrylic has an impact strength which is the durability of the material so that it is not easily broken when it gets a large and sudden power in the form of pressure.(Powers, Sakaguchi R, 2006). The impact strength required by heat-cured acrylic as a denture base is $2x10^{-3}$ J/mm$^2$. The minimum impact strength of a heat-cured acrylic denture base is 10 kg/cm (Tarida, Handajani S, Fitriani D, 2013).

Thermoplastic Acrylic is a new material for manufacturing dentures with controllable flexibility and minimal shrinkage, which is less than 1% compared to acrylic. Please do not use chemical liquids when making it. Thermoplastic Acrylic has a high density, and liquid cannot penetrate, thus minimizing the discoloration that often occurs in acrylic dentures (Dangkeng Zulkarnain, 2016). Thermoplastic Acrylic is a thermoplastic type of denture base material with a basic chemical structure of polyamide which is produced through a condensation reaction between diamine NH-(CH)-NHand CO2H-(CH)-COOH (Vodjani, Giti R, 2015). The physical and chemical properties of Acrylic Thermoplastic materials are granule shape, color by number, odorless, melting point 258C, and density ± 1.02 g/cm$^3$ @ 20C. The denture base made of thermoplastic is made by being injected into the mold (Sharma, Shashidara HS, 2014).

Thermoplastic Acrylic has better strength than acrylic material, and the thermoplastic base will absorb the impact to avoid breaking the denture base. This Acrylic Thermoplastic material also has a disadvantage, namely acrylic artificial teeth are attached mechanically, so there is a possibility of detachment from the denture base. The thermoplastic Acrylic denture will fail to use if it is not inserted adequately because the insertion technique and adjustment of the Acrylic Thermoplastic material are different (Dangkeng Zulkarnain, 2016). Currently, the use of thermoplastic-based dentures is limited in clinical use due to the lack of information provided by the manufacturer and the lack of scientific evidence regarding these thermoplastic-based dentures. The research results on differences in the compressive strength of thermoplastic nylon denture bases at several thicknesses showed differences in compressive strength at several thicknesses. The thicker the denture base, the greater the compressive strength (Agustini Ria, 2015).

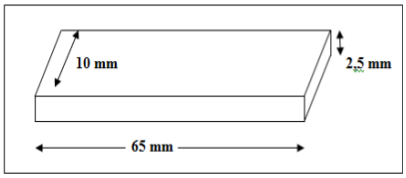
One of the mechanical requirements of a denture base is to have good compressive strength. Compressive strength is an essential material property because most masticatory strength is composed of compressive strength. Compressive strength is the maximum strength material can receive in the form of stress without fracture (Combe EC, 1992). Fractures in the denture base result from two different forces: impact and

transverse (Permatasari, 2015). In its function, the acrylic denture base has strength characteristics, one of which is impact strength. Impact strength is the material's resistance so that it does not break when it gets a large and sudden force in the form of pressure. The impact strength of a denture is needed to overcome if it is subjected to sudden pressure, for example falling on a hard surface (Tarida, Handajani S, Fitriani D, 2013).

Two tools test the impact strength, namely Izod and Charpy. In the Izod tester, the sample is tested vertically at one end, while in the Charpy test, the two ends of the sample are placed in a horizontal position resting on the end of the tester. Impact strength uses a sample of a specific size placed on a tester with a swinging bat. The bat is then swung and hits the sample until it breaks. Furthermore, the energy (E) listed on the tester is read and recorded, then the impact strength is calculated (Tarida, Handajani S, Fitriani D, 2013).

## METHOD

This type of research is experimental by conducting experimental activities in the laboratory to determine the symptoms or effects that arise due to specific treatments. The research was carried out in January 2022 in the laboratory of the Faculty of Engineering, University of North Sumatra. The research sample was made at the Dental Engineering Laboratory of the Tanjungkarang Health Polytechnic. Research sample consisted of a heat-cured acrylic resin plate and an acrylic thermoplastic size of 65 mm x 10 mm x 2.5 mm according to ADA specification no. 12 (Handajani S; et al., 2013).




The minimum sample size is estimated using the Frederer formula (Hanafiah KA, 2011).

$$(t - 1)\ (r - 1)\ 15$$

Note: t = number of treatments
r = number of repetitions

There were two treatment groups, namely heat-cured acrylic resin plates and thermoplastic acrylic, then t=2, and the number of samples (r) for each group could be determined as follows:

(t - 1) (r – 1) 15
(2 – 1) (r – 1) 15
(1) (r – 1) 15
1r – 1 15
1r 15+1
1r 16
r = 16

Based on the calculations, the minimum number of samples for each group is 16. The data collection method was placing a sample of heat-cured acrylic resin plate on a Charpy impact strength tester with an energy of 0.20 joules. This follows the results of research from Saradilla Benazia, who has conducted experiments on the sample until it breaks. This was repeated 16 times according to the number of samples, and the energy indicated on the tester was recorded. Samples of acrylic thermoplastic plates were tested in the same way. If the plate has not broken by applying energy of 0.20 joules, energy is added until the sample is fractured.

Data analysis used the One Way Anova and Least Significant Difference test to see differences in the impact strength of heat-cured acrylic resin plates compared to Thermoplastic Acrylic plates with a significance level (p 0.05).

## RESULTS AND DISCUSSION

In this study, the impact strength was obtained by providing energy that caused the fracture of the Heat Cured Acrylic and Thermoplastic Acrylic Resin samples using the Charpy Impact Test tool with a force value of 2.75 N. The strength values and average impact strength of Heat Cured Acrylic Resin and Thermoplastic Acrylic can be seen in tables 1 and 2.

Table 1. Impact Strength Value of Heat Cured Acrylic Resin and Thermoplastic Acrylic

| No | Impact Strength (KI) | | | |
|---|---|---|---|---|
| | Heat Cured Acrylic Resin | | Acrylic Thermoplastic | |
| | Energy (Joules) | KI x10-³ J/mm² | Energy (Joules) | KI x10-³ J/mm² |
| 1. | 0.68 | 27.20 | 1.38 | 55,20 |
| 2. | 0.72 | 28,80 | 1.84 | 73.60 |
| 3. | 0.70 | 28.00 | 2.74 | 109.60 |
| 4. | 0.73 | 29.20 | 1.97 | 78,80 |
| 5. | 0.86 | 34.40 | 2.06 | 82.40 |
| 6. | 0.58 | 23.20 | 1.68 | 67.20 |
| 7. | 0.43 | 17,20 | 1.57 | 62.80 |
| 8. | 0.48 | 19,20 | 1.44 | 57.60 |
| 9. | 0.53 | 21.20 | 2.39 | 95.60 |
| 10. | 0.66 | 26,40 | 2.73 | 109.20 |
| 11. | 0.60 | 24.00 | 2.10 | 84.00 |
| 12. | 0.67 | 26,80 | 2.70 | 108.00 |
| 13. | 0.65 | 26.00 | 1.57 | 62.80 |
| 14. | 0.53 | 21.20 | 2.43 | 97,20 |
| 15. | 0.24 | 9.60 | 1.92 | 76,80 |
| 16. | 0.57 | 22.80 | 1.83 | 73.20 |
| X ±SD | 24.075 ± 5.752 | | 80.875 ± 18.317 | |

Table 2. Average Value of Impact Strength of Heat-Cured Acrylic Resin and Thermoplastic Acrylic

| No | Group | n | X ± SD |
|---|---|---|---|
| 1. | Heat Cured Acrylic Resin | 16 | 24.075 ± 5.752 |
| 2. | Acrylic Thermoplastic | 16 | 80.875 ± 18.317 |

In table 2, the average and standard deviation of the impact strength of Heat Cured Acrylic Resin is 24.075 ± 5.752 x 10 J/mm², and the mean and standard deviation of the impact strength of Thermoplastic Acrylic is 80.875±18,317 x 10 J/mm².

In this study, it can be seen that the average value of the impact strength of Heat Cured Acrylic Resin has lower value than the average value of the impact strength of Thermoplastic Acrylic.

In analyzing the data from this study before the One Way Anova test (p 0.05), first, the tabulated data will be tested for normality using the Shapiro-Wilk test (p > 0.05) and homogeneity test using the Levene test (p > 0.05). 0.05) so that the results and research data are typically distributed and homogeneous. Therefore, the One Way Anova test (p 0.05) was carried out to compare the Heat Cured Acrylic Resin group with the Thermoplastic Acrylic group and the Least Significant Difference test (p 0.05). To see the significant

difference between the Heat-Cured Acrylic Resin group and the Heat-Cured Acrylic Resin group. Acrylic Thermoplastic group. The complete statistical test results can be seen in table 3 and table 4.

Table 3. One-Way ANOVA Test Results Impact Strength of Heat-Cured Acrylic Resin and Thermoplastic Acrylic

| | Sum of Square | df | mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | 25809.92 | 1 | 25809.92 | 140.0404 | 7.9E-13 (0.00000000000079) |
| WithinGroups | 5529.1 | 30 | 184.3033 | | |
| Total | 31339.02 | 31 | | | |

From the results of the ANOVA calculation, the P-value < 0.05, this proves that there is a significant difference between the Heat Cured Acrylic Resin group and the Thermoplastic Acrylic group.

Table 4. Least Significant Difference Test Results Impact Strength of Heat-Cured Acrylic Resin and Thermoplastic Acrylic

| No | Group | Mean Difference | Significance (p) | |
|---|---|---|---|---|
| 1 | Acrylic Resin *Heat Cured* | 24,075 | 56.8 | 9.802465 |
| 2 | Thermoplastic Acrylic | 80,875 | | |

From the LSD calculation, the value is 9.802465, and the average difference between Heat Cured Acrylic Resin and Thermoplastic Acrylic is 56.8. The average result is greater than the LSD calculation, so it can be concluded that there is a significant difference between the average Heat Cured Acrylic Resin and Thermoplastic Acrylic

## CONCLUSION

Based on the results of the research that has been done, it can be concluded that there is a significant difference in impact strength between the Heat Cured Acrylic Resin plate and the Thermoplastic Acrylic. The Heat Cured Acrylic Resin plate has a lower impact strength than the Thermoplastic Acrylic. Suggestion; Further research is needed to test the impact strength of Heat Cured Acrylic Resin by adding wire to determine whether it can increase the impact strength of the material. The research was conducted because the material used for manufacturing removable complete dentures is Heat Cured Acrylic Resin. Thermoplastic Acrylic material is only used for removable partial dentures because of its flexibility.

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