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*RESEARCH ARTICLE - MEDICAL TECHNIQUES*

# The Effects of $TiO_2$ Nanoparticles on Flexural Strength of Self-Polymerized Resins: In Vitro Study

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**Abstract**

Self-polymerized resins are extensively utilized in removable prosthodontics for a variety of applications in maxillofacial rehabilitation, including interim appliances, repairs, relines, customized trays, and record bases. These materials, on the other hand, are prone to fracture. The goal of this study was to see how titanium dioxide nanoparticles affected the flexural strength of self-polymerized resins. A total of 30 samples were prepared from self-polymerized acrylic resins (control, 1% $TiO_2$, and 2% $TiO_2$). Using a universal testing machine, all samples were subjected to a flexural strength test until they fractured. The data were analyzed with SPSS version 20, and the Duncan test and ANOVA tests were used to compare all groups. The results showed that $TiO_2$ increased the flexural strength of acrylic resins substantially when compared to the control. Furthermore, significant differences ($P<0.001$) were found among all groups. The addition of $TiO_2$ increases the flexural strength of acrylic resins.



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**Keywords**: Flexural Strength; $TiO_2$; Self -Polymerized; Acrylic Resins.

## 1. Introduction

Self-polymerized resins are commonly used for obturator interim appliances, repairs, relines, record bases, and other purposes in removable prosthodontics requiring maxillofacial rehabilitation [1, 2]. They're simple for the maxillofacial technician to use, quick, and can be used at clinics. These compounds, on the other hand, have several drawbacks, including poor mechanical qualities [3, 4]. When compared to heat polymerized acrylic resins, the polymerization of such substances is not complete, leading to a higher amount of unreacted residual monomer, which reduces the strength of acrylic resins [5]. Using nanoparticles such as zinc oxide and silver nitrate, several studies have been conducted to enhance the mechanical properties of self-polymerized resins. Nanoparticles improved the mechanical characteristics of resins, according to the literature [6-11]. White-colored titanium dioxide particles ($TiO_2$) have been described as biocompatible, inexpensive, free of toxicity, and corrosion-resistant [12]. The goal of this investigation was to see how titanium dioxide at 1% and 2% affected the acrylic resins' flexural strength.

## 2. Materials and Methods

### *2.1. Samples groups*

Thirty samples of self-acrylic resins were utilized in the current study. Each group had 10 samples (control, 1% TiO2, and 2% TiO2). The control group was created without TiO2 from self-polymerized acrylic resins (Spofadental, the Czech Republic). Self-polymerized acrylic resins with 1% TiO2 powder were used to create the 1% TiO2 group (Grumbacher, USA). Self-polymerized acrylic resins and 2% TiO2 were used to make the 2% TiO2 group.

### *2.2. Construction of acrylic samples*

Acrylic samples were made using plastic patterns (65 mm in length, 10 mm in width, and 2.5 mm in thickness). Applying Vaseline to the lower half of a metal flask before pouring the dental stone began the process of forming the stone mold. As shown in Fig. 1, three plastic patterns were gently placed in the middle of the stone surface.

| **Nomenclature & Symbols** | | | |
|---|---|---|---|
| g | gram | H | hour |
| ml | milliliter | SPSS | statistical package for the social science |
| mm | millimeter | S | Flexural strength |
| N | newton | I | Space between the supports |
| $mm^2$ | square millimeter | B | Sample width |
| MPa | Mega Pascal | D | Sample depth |
| P | p value | | |

Fig 1. Plastic patterns positioned onto the stone mold

After that, the stone surface was allowed to sit for 60 minutes. The separating media was used (Spofadental, the Czech Republic). After that, the upper section was filled with a creamy dental stone mixture, and the lower part was gently placed over the upper part and left to sit for 60 minutes. The two halves of the metal flask were then gently separated, and the patterns were removed as shown in Fig. 2.

Fig 2. Stone mold

Twenty-two g acrylic powder and ten ml acrylic monomer were used to make control samples. For 30 seconds, the two components were mixed in a clean ceramic jar using a small spatula. After that, the mixture was left at room temperature for six minutes. Then the acrylic dough was put inside the mold, and two halves were brought together and put under pressure( at 20 bar ) for 5 minutes. After then, the two sections were separated and left to cure for 20 minutes. Acrylic samples were meticulously removed, polished, and completed. The technique was replicated for $TiO_2$ groups with the exception that the 1 percent $TiO_2$ group was made up of 0.22g $TiO_2$ powder, 21.78 g acrylic powder, and 10 ml liquid monomer, while the 2 percent $TiO_2$ group was made up of 0.22g $TiO_2$ powder, 21.78 g acrylic powder, and 10 ml liquid monomer. Before testing, all samples were maintained in distilled water for 48 h at 23°C [14].

*2.3. Flexural strength test*

A universal testing machine was used to examine all acrylic samples (Instron, Germany). Two lines were marked at the borders of each sample that connected to the holding with the test table. Each line had a ten-millimeter gap between it and the closing border. The third line, which connects the striker to the testing machine, was drawn in the center of the sample. As illustrated in Fig. 3, each sample was subjected to a load until it fractured.

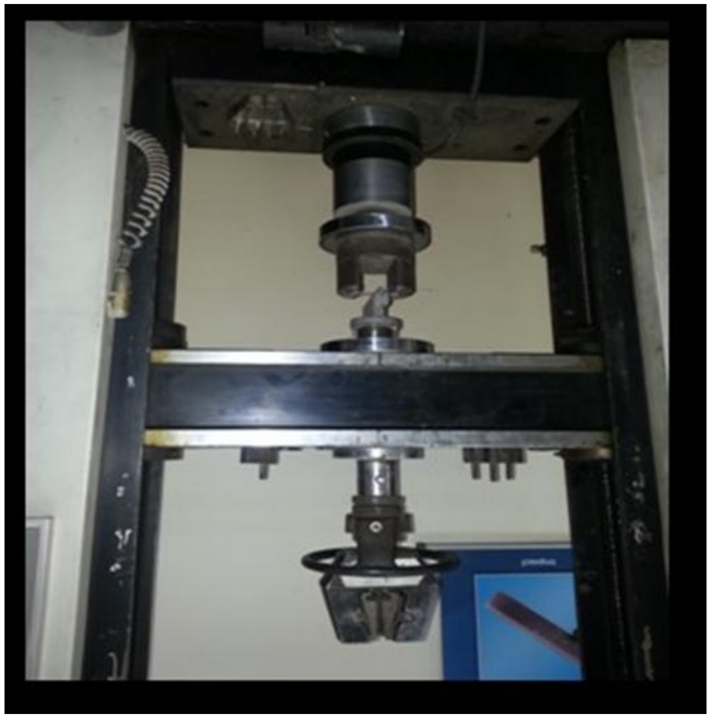

Fig 3. Universal testing machine

The crosshead was moving at a rate of five millimeters per minute. The flexural strength (MPa) values were calculated via the formula S=3P. I/2B.D2 [7].

## 3. Results

The data were analyzed using IBM's SPSS v.20 software (USA). As shown in Table 1, TiO2 nanoparticles greatly improved the acrylic resins' flexural strength.

Table 1 Mean and standard deviation of all samples groups

| Group | Mean (MPa) | Standard deviation |
|---|---|---|
| Control | 134.28 | 1.74 |
| 1% $TiO_2$ | 155.43 | 1.15 |
| 2% $TiO_2$ | 162.50 | 2.12 |

Furthermore, as shown in Table 2, the Duncan test revealed significant differences (*P*<0.001) across all studied groups.

Table 2 Duncan comparison test for flexural strength

| Group | Number | Subset for alpha = 0.05 | | |
|---|---|---|---|---|
| | | 1 | 2 | 3 |
| Control | 10 | 134.28 | | |
| 1% $TiO_2$ | 10 | | 155.43 | |
| 2% $TiO_2$ | 10 | | | 162.50 |
| Sig. | | 1.000 | 1.000 | 1.000 |

In addition, significant differences (*P*<0.001) were found among all samples groups as demonstrated in the ANOVA test , Table 3.

Table 3 ANOVA test

| | Sum of Squares | DF | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | 4649.684 | 2 | 2324.842 | 653.111 | .000 |
| Within Groups | 96.110 | 27 | 3.560 | | |
| Total | 4745.794 | 29 | | | |

## 4. Discussion

The objective of the research was to assess the effect of titanium dioxide at 1% and 2% on the acrylic resins' flexural strength. The influence of $TiO_2$ particles on the mechanical properties of acrylic resins was the subject of only a few published publications. Tables 1 and 2 show that titanium dioxide powder has a substantial effect on flexural strength when compared to the control in the current study.
The current findings were consistent with those of Al-Shammari's [7] study which reported that titanium dioxide nanoparticles improved the flexural strength of acrylics by forming a stronger connection between the polymer chains due to their tiny size.
On the other hand, these findings contradict the findings of Andreotti et al. [11] study which indicated that $TiO_2$ reduced the strength of the acrylic ocular prosthesis. The discrepancy between the current results and those of Andreotti et al.,11 could be explained in part by the materials used. The null hypothesis was ruled out since significant differences were discovered among all of the groups tested.

## 5. Conclusion

The use of $TiO_2$ powder enhanced significantly the acrylic resins' flexural strength according to the findings of this investigation. Additional research will be required, including the incorporation of $TiO_2$ to test the surface hardness and impact strength of self-polymerized resins.

## Clinical significance

Self-polymerized resins are frequently utilized in dentistry, particularly in the field of maxillofacial rehabilitation. The mechanical properties of such material must be satisfactory. The application of $TiO_2$ increased greatly the acrylic resins 'flexural strength.

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