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# Comparing the Retention of Implant-Supported Frameworks Casted from Two Types of Materials: Wax and Acrylic Resin

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## Abstract

**Purpose:** Different procedures and materials have been introduced for fabrication of prostheses. The present study aimed at comparing the retention of implant-supported frameworks casted from two different types of patterns (wax and acrylic resin).

**Materials and Methods:** Twenty-four implant analogues were mounted in acrylic blocks, a solid abutment were secured on each analogue, and the samples were divided into two groups (N = 12). Die spacer was applied with specified thickness of 30 microns, up to 0.5 mm from the finish line. Frame patterns were fabricated using wax or acrylic resin material with a loop formed on the occlusal surfaces. The samples were casted, and adjusted for complete seating on the abutments. The numbers of adjustment times were recorded and analyzed through Mann-Whitney test. After cementation with zinc phosphate cement, the specimens were thermo cycled (between 5°C and 55°C, 5000 cycles), and the retention was measured using universal testing machine connected to the occlusal loop (0.5 mm/min). The results were analyzed using independent sample t-test.

**Results:** The mean retention (standard deviation) value was 407.234 (67.485) N for wax group, and 576.187 (98.673) N for acrylic formed group. There was significant statistical difference between the frameworks retention in two groups (P< 0.05). Furthermore, significant difference was noted in the quantity of adjustment times between the groups (P< 0.05).

**Conclusion:** Considering the limitations of the present study, although acrylic specimens required significantly more adjustment time compared to the wax-formed patterns, the retention quantity was significantly more in the former.

**Keywords: Accuracy; Dental implant; Dental wax; Retention**

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## Introduction

Implant dentistry has developed significantly in recent years. Cemented implant prostheses have attracted much at tensions as the result of their favorable properties over screw-retained restorations including shock absorption, beauty, occlusion, passive fit, more simple and traditional techniques, and less fracture potential of the porcelain [1]. Long-term durability, survival, and success of implant treatments depend on accuracy and fitness of the superstructure. Ill-fitting restoration could result in frequent debonding, screw loosening, screw fracture, peri-implant bone loss, and implant failure [1-4]. Marginal and internal adaptations are two factors used to determine fitness of the restoration; where the retention is an index for the later [2]. Retention test, an indicator for evaluating the internal accuracy of implant supported frameworks, could be performed by two different methods: The first method is fatigue load test, which puts the frame under low forces-cyclic loading. This test simulates dynamic masticatory forces. The second method is a static unidirectional test that measures maximum tensile force required for separating prosthesis from the related abutment. Nowadays, different techniques and materials are available to fabricate implant restorations. These range from the application of burn-out cylinders, or using different materials for hands-on pattern formation to variant computerized techniques. Wax and acrylic resin are among the most commonly used materials for conventional hands-on procedures [3]. These materials are readily accessible, inexpensive, burn without any remaining residues, could be shaped easily, and

**Table 1:** Detailed results of adjustment quantities. Frameworks casted from acrylic patterns required significantly more adjustment times (p< 0.05).

| Material | | N | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|---|
| Wax | Adjustment numbers | 12 | 0.00 | 4.00 | 1.5000 | 1.67874 |
| | Valid N (list wise) | 12 | | | | |
| Acrylic resin | Adjustment numbers | 12 | 1.00 | 23.00 | 11.8333 | 6.33652 |
| | Valid N (list wise) | 12 | | | | |

**Table 2:** Detailed results of retention test. The retention of frames casted from acrylic patterns was significantly more than those casted from wax patterns (p< 0.05).

| Material | | N | Minimum | Maximum | Mean | Std. deviation |
|---|---|---|---|---|---|---|
| Wax | Retention | 12 | 316.35 | 512.01 | 407.2342 | 67.48522 |
| | Valid N (list wise) | 12 | | | | |
| Acrylic resin | Retention | 12 | 449.25 | 753.66 | 576.1875 | 98.67302 |
| | Valid N (list wise) | 12 | | | | |

have special properties that facilitate their application [4,5]. Wax is a very technique sensitive material, influenced by storage conditions and ambient temperature. On the other hand, acrylic resin does not sustain as much dimensional changes; however, the polymerization shrinkage and related changes are the matters of concern. According to the literature, dimensional stability of acrylic resin is more that wax [6]. Implant prosthesis retention has been studied in several researches. However, when it comes to different fabrication methods, the availability of articles is scarred. The main purpose of the present in-vitro research was to determine and compare the accuracy of different materials routinely used for fabrication of implant-supported frameworks by measuring the resulted retention as an index. The null hypothesis was that the retention of frameworks casted from these two types of materials (wax or acrylic resin) had no significant difference.

## Materials and Methods

Twenty-four identical acrylic blocks were fabricated by auto polymerizing acrylic resin (Cold-cure acrylic for repair, Acropars, Iran). The center of each block was prepared dusingan acrylic bur (Tizkavan, Tehran, Iran) to create enough space for implant's analogue (Fixture Lab analogue, Ufit Dental implant system, South Korea). The analogues were mounted parallel to their long axis using acrylic resin and an impression coping connected to a surveyor (Ney Dental International, Bloomfield, CT), and the straight abutments (Solid abutment, Ufit Dental implant system, South Korea) with specified height of 5.5 mm and 6 degrees' taper were secured to the analogues to 30 N/Cm torque value. For wax specimens, die spacer (Pico-fit; Renfert GmbH, Hilzingen, Germany) was applied on each abutment wall with specified thickness of 30 microns up to 0.5 mm from the finish line. For acrylic resin specimens, bredent die spacer (XPdent, Miami, USA) was used in the same manner. The first framework pattern was formed by inlay wax (GEO classic; Renfert GmbH, Hilzingen, Germany) with anatomic contours. Twenty-three remaining samples were formed using wax or pattern resin (Acrylic resin for patterns, GC America INC, Alsip, IL, USA) according to an index made from the external surface of the first wax pattern (n = 12 for each group). A loop with internal diameter of 5mm was formed on the occlusal surface of each pattern, which was served for connecting the frame to the Universal testing machine (UTM) (Zwick/Roell Pro Line Z050, Berlin, Germany) in the later step. In order to minimize inter-operator errors, a trained and skilled technician implemented all laboratory procedures.The framework patterns were casted in1440°C using titanium-free Nickel-Chromium alloy (4 all, Ivocolarvivadent, Schann, Liechtenstein). The castings were evaluated, evident nodules were eliminated by a carbide bur (H71EF, Brasseler, Germany), and internal surfaces of the frames were air-abraded by 50-microns aluminum oxide particles (Basic master; Renfert GmbH, Hilzingen, Germany). Fit checker spray (Occlude, Aerosol indicator spray, Pascal Inc, Seattle, Washington) and no.2 round bur (Teezkavan, Tehran, Iran) were used to adjust the frameworks for complete passive sitting on the abutments. The quantity of adjustment times was recorded, and results were compared using Mann-Whitney test. Frameworks were cemented on abutment analogues using zinc phosphate cement (Hoffmann, GmBH, Berlin, Germany) by applying finger pressure for 10 minutes. Cemented samples were placed in an incubator in 37 degrees centigrade for 24 hours, and thermocycled for 5000 cycles at 5 ± 1°C and 55 ± 1°C with a dwell time of 30 seconds and transfer time of 10 seconds. This program was equivalent to 6 months' clinical application. The frames' retention was measured by the UTM (with 500-kg load and crosshead speed of 0.5 mm/min) (Figure 1). The results were analyzed using independent sample T test.

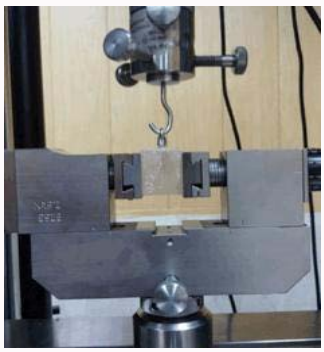


**Figure 1:** Universal testing machine was used for measuring the uniaxial tensile bond strength of the samples.

## Results

Table 1 illustrates the detailed results of adjustment times. Statistical analysis showed a significant difference between the groups (p< 0.05).The frameworks casted from acrylic patterns required significantly more adjustment times (11.83 ± 6.33) compared to wax patterns (1.50 ± 1.67). Table 2 shows the results of retention evaluations. Average retention of acrylic resin group (576.1875 ± 98.67) was significantly more than wax patterns (476.2342 ± 67.48) (p< 0.05). Plot 1 demonstrates the interval plot for the retention test (95% confidence interval for the mean). The standard deviations were

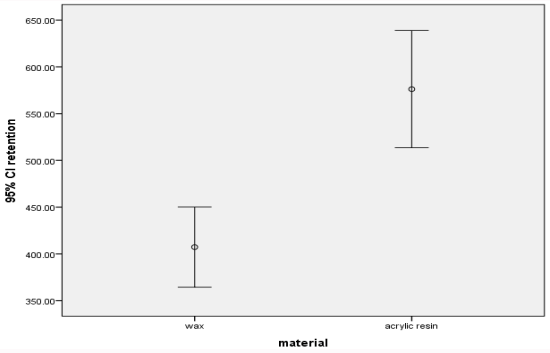
**Table 3:** The uniaxial tensile bond results (retention quantity) of different studies that used ZPC in single unit implant restorations.

| Reference | Implant system | Special characteristic | Abutment Height (mm) | Retention |
|---|---|---|---|---|
| Akça K [13] | ITI solid abutment 6 degrees' taper | 4 mm-diameter abt. | 4 | 61.0 N |
| | | | 5.5 | 130.0 N |
| | | | 7 | 154.8 N |
| | | 4.8 mm-diameter abt. | 4 | 65.9 N |
| Covey DA [14] | Nobel biocare- CeraOne | | 3.6 | 307 N |
| | | | 5 | 600 N |
| Kent DK [15] | Nobel biocare- CeraOne | With cement venting | 5 | 582.52 N |
| | | Without cement venting | 5 | 599.19 N |
| Pan YH [5] | Nobel biocare- Steri-Oss | | 3.8 | 1.225 MPa |
| Nejatidanesh F [16] | ITI solid abutment | | 5.5 | 267.62 N |
| Clyton [17] | Nobel biocare- CeraOne | | 3.7 | 452.2 N |
| Tan KM [18] | Biomet 3i | | 7 | 158.8 N |
| Bernal G [19] | | 30 degrees' taper | 8 | 200.06 N |
| | | | 4 | 105.91 N |
| | | 20 degrees' taper | 8 | 374.61 N |
| | | | 4 | 225.55 N |
| Myata-Tovalino FR [20] | Nobel biocare- | Cera One | | 459.62 N |
| | | Solid abutment | 5.5 | 459.62 N |
| Matani JD [21] | Uniti implant | 3.7 mm diameter | 8 | 464.2 N |
| | | 6 mm diameter | 8 | 667.4 N |
| Li TH [22] | Nobel biocare- Steri-Oss | | 3.8 | 0.731 MPa |
| Yeung TC [23] | Nobel biocare- Cera One | With cement venting | | 350.10 N |
| | | Without cement venting | | 344.21 N |
| Present study | Ufit solid Lab | Wax patterns | 5.5 | 476.23 N |
| | | Acrylic resin patterns | 5.5 | 576.18 N |

used for calculate the intervals.

## Discussion

Several different methods and materials are currently used for fabricating a restoration. Fabrication of a restoration has several steps. Framework manufacturing step is one of the stages that experience extensive variety. Different materials have been introduced to increase the accuracy of restorations while facilitating and accelerating the process. Are those causing any significant difference in accuracy and quality of the product? This key question calls for further investigations. The present study aimed at determining retention quantity in implant-supported frameworks casted from two prevalent materials currently used for hands-on patterns formation, conventional wax and acrylic resin. The main purpose focused on evaluation the accuracy of these two materials used prevalently in fabricating fixed restorations, either implant or dental supported restorations. Plastic copings were introduced to improve the accuracy of implant restorations. However, in addition to their application limitations, in an article it was shown that the retentive values obtained using these copings in fabrication process are generally less than the values obtained using conventional wax-up [7]. There are several variables affect the accuracy, fitness, and retention of restorations. These variables include Abutment size, height, taper, and surface properties, samples' preparations, cement type, cementing method, die spacer thickness, samples storage, and the type of material used in framework fabrication [4-11]. In addition, accuracy in fabrication process and technician skill is other factors influence the retention results. In order to attribute the results to the material used, the present study tried to equalize all the other variables affect the retention. Several studies evaluated the retention of implant supported restorations using zinc phosphate cement (ZPC) (Table 3) [5,12-22].There are great varieties in the reported results. The differences go back to the abutment properties (dimensions, taper, and type), abutment preparative procedures, application of preliminary steps (thermocycling, saliva storage, and incubation), the thickness of die spacer, the restoration characteristics (contour, thickness, and venting hole), and alloy type, fabrication




**Plot 1:** The interval plot for the retention tests (95% confidence interval for the mean).

method, and other factors that influence the retentive properties of prostheses. ZPC causes greater retentive properties. It was reported to have about 7 times more retentive strength compare to temporary cements [16]. this could be related to physical characteristics of ZPC as its compressive and tensile strength are 14 and 19 times more than temporary cements, respectively [23]. This feature suggests the application of ZPC in situations where the retentive quantity is critical. In the present study, the null hypothesis was rejected. The average retention of frameworks fabricated from wax patterns was 476.2342 N, which had significant difference compared to acrylic models (576.1875 N). The dislodging force was reported to be between 60 to 200 N in anterior teeth and 300 to 800 N for posterior area [24]. According to that, both the retentive results in the present study are in the range of clinically acceptable retentive quantities. However, the significantly higher retention obtained by acrylic patterns, suggests the application of this material for pattern fabrication where the situations calls for greater retentive strength (e.g. higher bite forces, low-profile abutments, over-tapered abutments, or maxillofacial prostheses). However, this higher retention values in acrylic resin patterns obtained in the price of significantly more adjustment times. The mean adjustment time for acrylic specimens (11.83) is far more time-consuming to be rational in the clinical practice. In order to decrease the adjustment quantity, increasing the thickness of die-spacer is suggested. According to Olivera and Torabi et al. [25,26] increasing the spacer thickness to 40 microns would not induce significant change in frames' retention. However, increasing the predicted space for cement, and evaluating its effect on the retention of restorations call for further investigations.

## Conclusion

Considering the limitations of present study, following results are obtained:

1. The retention of single-implant frameworks fabricated from acrylic pattern is considerably more than those casted from wax pattern.
2. Application of acrylic resin for fabricating implant frameworks, cause significantly more adjustment times during frames insertion.

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