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A comparative study of over the counter (OTC) and standard denture repair materials on flexural strength

Research Proposal

30 June 2020

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Abstract

Purpose: To evaluate and compare the flexural strength of over the counter (OTC) Dentemp Repair-It (Doc Brands, Wayne, PA), and the universally accepted local dental laboratory denture repair resin, using Ivoclar Vivadent ProBase® Cold self-curing (Ivoclar Vivadent, Schaan, Liechtenstein).

Materials and Methods: A 65mm x 10mm x 2.5mm template was fabricated with Whip Mix Snap-Stone, Type IV (Louisville, KY), in accordance with the American Dental Association Specification No. 12 [12]. A Coltene lab putty (Alstatten, Switzerland) mold was fabricated from the Whip Mix Snap-Stone template. Baseplate Wax (Henry Schein, Melville, NY) was melted and poured into the putty mold. All forty-two wax specimens were invested in a IvoBase processing flasks (Ivoclar Vivadent, Amherst, NY). Wax in the invested flasks were boiled out into boilout tanks, the Wassermann Dental Maschmen Wapo-Ex 12 (Hamburg, Germany) at 98 °C. Using IvoBase® injection unit (Ivoclar Vivadent, Amherst, NY), the specimens were processed with heat polymerized acrylic resin (PMMA) denture base (Ivoclar, Ivoclar Vivadent, Schaan, Liechtenstein) in accordance with the manufacturer's guideline.

Forty-two samples of specimen that were processed from Ivoclar Vivadent ProBase acrylic resin were assessed for maximum flexural strength (FS) in megapascals (MPa). The samples were evenly divided between two application modalities, 21 sample in each group. One group used a commercially available Dentemp Repair-It kit following the manufactures' instruction to repair broken specimens. The other group used local laboratory standards, Ivoclar Vivadent ProBase Self Curing, following the manufactures' instruction to repair broken specimens. All specimens were sectioned into two halves using a Fibre-Cut disc (Dedeco, Eddy, NY). All specimens were prepared with a butt joint. Each specimen was placed into the mold that retained the original dimension of the specimen and a 2mm gap in between two halves, had liquid monomer applied to the two edges, and then the 2mm gap was filled with hand mixed according to their respective manufactures. The sample was subsequently sanded and polished to appropriate dimension. All specimens were submerged into the Whip Mix water bath (Louisville, KY) in distilled water at 37 °C (symbol) for 7 days to simulate use in oral environment.

The maximum fracture load (L) in N of each specimen was recorded, and the FS was calculated as follows: $FS = (3Ld) / (2wh^2)$; where d is the distance between the supporting rollers, w is the sample width, and h is the sample height, in accordance with the ISO [12]. Three-point loading FS testing was conducted using the the Instron® 5943, with 50 mm between the supports and at a crosshead speed of 1.0 mm/min until fracture.

The Shapiro-Wilk test was used to assess the normality of the data distributions for continuous data. Consequently, measures of central tendency are presented as means with associated standard deviations. An analysis of variance (ANOVA) was conducted to assess differences in maximum load and FS between the two application modalities. Statistical significance for all statistical tests was declared at $P < 0.05$. Data were analyzed using SPSS 25.0 (IBM, Armonk, NY, USA).

Results: The overall FS sample mean was 13.11 (SD = 2.1). No difference was found between the two groups in FS or maximum load, both $P > 0.05$. The mean FS of samples repaired the lab

was $M = 12.82$ MPa ($SD = 1.7$). The mean FS of samples repaired using an OTC repair kit was $M = 13.40$ MPa ($SD = 2.5$).

Conclusion: Both, commercially available Dentemp Repair-It and locally accepted dental laboratory denture repair acrylic resin using Ivoclar Vivadent ProBase® Cold self-curing were found to have no significant difference in flexural strength.

INTRODUCTION

Polymethyl methacrylate (PMMA) has been used in dentistry since the 1930s as denture base because of its biocompatibility, easy manipulation and repair, light weight, accurate fit, easiness to polish, esthetic appearance, and stability in the oral environment.[1] However, PMMA's disadvantages include allergic reaction to residual monomers, insufficient hardness, poor wear resistance and polymerization shrinkage.[1] In addition, it does not have the optimum mechanical properties fracture resistance and flexural strength.[2]

Complete dentures are susceptible to wear and fracture. [3] Approximately 68% of complete dentures are fractured within 3 years of insertion; which requires emergency repairs in order to continue to their function. [4] Common causes of denture base fracture include poor fit, lack of balanced occlusion, material breakdown and dropping of the dentures. [5] It was suggested that sharp changes in contour, pin holes or void, contamination inclusions, deep scratches, and residual processing stress in PMMA denture base may cause stress intensification. However, most failures (i.e. fractures) of denture base occurred when there was deep notching. [5]

According to the U.S. Air Force Dental Laboratory Manuals (Pamphlet 47-103V1), there are two type of denture base fractures: simple and complex. A simple fracture is when the denture is broken into pieces, but all the pieces can fit together precisely and can be repaired without the patient present. [6] A complex fracture is when the broken pieces cannot be put together properly, sometimes one or more pieces have been lost and therefore the patient's presence is required for denture reconstruction. [6]

The Air Force manual also describes step-by-step repair procedures for both simple and complex denture base fractures. [6] Denture base repair can use either the dough method or the sprinkle method for auto-polymerizing resin. [6] Other studies demonstrated different techniques and materials, such as aluminum oxide (Al_2O_3), fiberglass reinforced, for denture base repairing. [7, 8, 9, 10]. Denture base surface designs such as knife edge lap, rabbet, round, ogee [11] and surface treatment such as adding monomer (MMA) and ethyl acetate [2] can also improve strength when they are repaired in the dental laboratory setting. They also demonstrated that decreasing repair gap increased the flexural strength and impact strength of repaired PMMA. [3]

There are several over the counter (OTC) denture repair kits that are available in retail stores such as Walmart, CVS, Walgreens, and on-line stores such as Amazon and eBay for general public use. The Instant Smile® complete denture repair kit is advertised for multi-purpose uses, such as to repair any fracture, replace missing or broken teeth, and reline loose fitting appliances. It contains one bottle of methacrylate, one bottle of resin powder, and ten acrylic veneer teeth. Another example, the Dentemp Denture® Repair Kit, is advertised to repair broken dentures and loose teeth. The Dentemp Denture Repair Kit® comes with 3 packages.

The purpose of this study is to compare flexural strength of over the counter (OTC) denture repair product to that of the universally accepted dental laboratory denture repair resin (i.e. cold or heat cured PMMA). The null hypothesis is that there is no difference in flexural strength between over the counter (OTC) denture repair product and that of the standard denture repair material.

MATERIALS AND METHODS

A 65mm x 10mm x 2.5mm template was fabricated with Whip Mix Snap-Stone, Type IV (Louisville, KY), in accordance with the American Dental Association Specification No. 12 [12]. A Coltene lab putty (Alstatten, Switzerland) mold was fabricated from the Whip Mix Snap-Stone template. Baseplate Wax (Henry Schein, Melville, NY) was melted and poured into the putty mold. All forty-two wax specimens were invested in a IvoBase processing flasks (Ivoclar Vivadent, Amherst, NY). Wax in the invested flasks were boiled out into boilout tanks, the Wassermann Dental Maschmen Wapo-Ex 12 (Hamburg, Germany) at 98 °C. Using IvoBase® injection unit (Ivoclar Vivadent, Amherst, NY), the specimens were processed with heat polymerized acrylic resin (PMMA) denture base (Ivocap, Ivoclar Vivadent, Schaan, Liechtenstein) in accordance with the manufacturer's guideline.

Forty-two samples of specimen that were processed from Ivoclar Vivadent ProBase acrylic resin were assessed for maximum flexural strength (FS) in megapascals (MPa). The samples were evenly divided between two application modalities. One group used a commercially available Dentemp Repair-It kit following the manufactures' instruction to repair broken specimens. The other group used local laboratory standards, Ivoclar Vivadent ProBase Self Curing, following the manufactures' instruction to repair broken specimens. All specimens were sectioned into two halves using a Fibre-Cut disc (Dedeco, Eddy, NY). All specimens were prepared with a butt joint. Each specimen was placed into the mold that retained the original dimension of the specimen and a 2mm gap in between two halves, had liquid monomer applied to the two edges, and then the 2mm gap was filled with hand mixed according to their respective manufacturers. The sample was subsequently sanded and polished to appropriate dimension. All specimens were submerged into the Whip Mix water bath (Louisville, KY) in distilled water at 37 °C (symbol) for 7 days to simulate use in oral environment.

The maximum fracture load (L) in N of each specimen was recorded, and the FS was calculated as follows: $FS = (3Ld) / (2wh^2)$; where d is the distance between the supporting rollers, w is the sample width, and h is the sample height, in accordance with the ISO [12]. Three-point loading FS testing was conducted using the the Instron® 5943, with 50 mm between the supports and at a crosshead speed of 1.0 mm/min until fracture.

The Shapiro-Wilk test was used to assess the normality of the data distributions for continuous data. Consequently, measures of central tendency are presented as means with associated standard deviations. An analysis of variance (ANOVA) was conducted to assess differences in maximum load and FS between the two application modalities. Statistical significance for all statistical tests was declared at $P < 0.05$. Data were analyzed using SPSS 25.0 (IBM, Armonk, NY, USA)

RESULTS

Sample characteristics are summarized in Table 1. The overall FS sample mean was 13.11 (SD = 2.1). No difference was found between the groups in FS or maximum load, both $P > 0.05$. The mean FS of samples repaired the lab was $M = 12.82$ MPa ($SD = 1.7$). The mean FS of samples repaired using an OTC repair kit was $M = 13.40$ MPa ($SD = 2.5$).

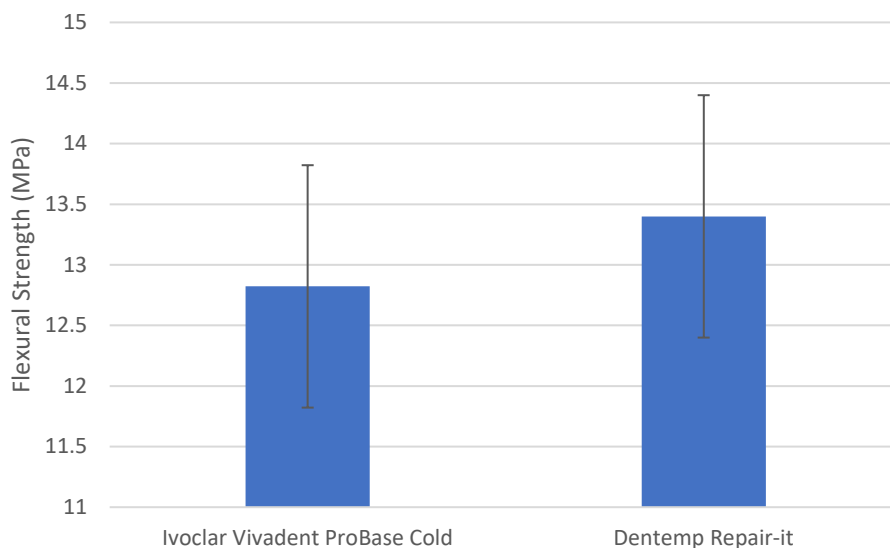
To check whether the non-significant results were due to a lack of statistical power, a post hoc power analyses was conducted using Gpower v3.1.9.2 with power ($1 - \beta$) set at 0.80 and a two-tailed $\alpha = 0.05$. This revealed that the total sample size would have to increase up to $N = 430$ for potential group differences to reach statistical significance at the .05 level. Thus, it is unlikely that the lack of difference between groups can be attributed to a limited sample size.

Table 1. Material Characteristics, M(SD)

Material	n	Ivoclar Vivadent ProBase Cold	Dentemp Repair-It	p ¹
Flexural Strength (MPa)	21	12.82 (1.7)	13.40 (2.5)	.39
Max Load (N)	21	26.81 (3.6)	27.42 (5.4)	.66

1. Significance based on ANOVA.

Figure 1. Mean Flexural Strength by Group



*Error bars represent 95% confidence intervals.

DISCUSSION

The results of this study showed that there is no difference in flexural strength of OTC denture repair material, Dentemp Repair-It, and locally accepted Ivoclar Vivadent ProBase Cold self-curing denture repair material, therefore, the null hypothesis is accepted.

Previous study shown that repair edge profile, surface treatment and gap width were important factors influencing denture repair strength [3]. A Gad and Rahoma study evaluating the effect of repair gap width on the strength of denture repair in Vitro showed that smaller gaps 1 to 0 mm and a beveled joint, found a better outcome than a wider gap [3]. Whereas a study by Shanoj and Razak, evaluation of the strength of denture base resin repaired with glass fiber-reinforced acrylic resin in vitro, found that the flexural strength was highest when the concentration of glass fiber was 1% in volume, and the gap width of 1mm provided the best strength when compared to 2mm, 3mm and 4mm gap width, using a butt joint with two rectangular grooves on one side, 5mm long and 2mm wide [9]. A study by Anasane and Ahirrao, the effect of joint surface contours and glass fiber reinforcement on the transverse strength of repaired acrylic resin in vitro concluded that both chemically polymerized repair resin and glass fiber reinforced repairs with a 2mm gap width and round joint has superior flexural strength over the butt joint, bevel joint, and rabbet joint [10].

Many previous studies showed the effect of flexural strength dependent upon the edge profile, surface treatment, differences reinforced PMMA material and gap width. However, to keep everything simple and consistency of this study, the study was conducted by a single AEGD Resident from fabricate the mold in according with ISO [12], melting wax into the mold, processing and investing and burn out wax, injection of PMMA, deflask, and ensure all specimens have the same dimensions, section into two halves and repaired all 42 specimens with a butt joint and 2mm gap width. There were 21 specimens in each group, one group repaired with OTC denture repair material, Dentemp Repair-It and the other group repaired with Ivoclar Vivadent ProBase Cold denture repair acrylic resin that is routinely used to repair broken dentures or RPD in a local dental laboratory.

The results of this study shown that the Dentemp Repair-it material has a mean of flexural strength of 13.40 (2.5), and the Ivoclar Vivadent Probase Cold flexural strength of 12.82 (1.7), the maximum load (N) 27.42 (5.4) and 26.81 (3.6), respectively. Statistically, there were no significant differences in flexural strength and maximum load of both groups.

Although both repair materials have similar mixing instructions, both materials have its own repair procedures protocol. For example, the Ivoclar Vivadent ProBase Cold material requires to have a pressure pot at room temperature at 23 degree Celsius for 30 minutes to cure. Meanwhile, the Dentemp Repair-It does not require to have a pressure pot but needs to have warm water for 10 minutes to cure. Everyone should have easy access to warm water but not everyone will have the same access to the pressure pot. In-order for the pressure pot to operate properly, it will need to have a power source, an air-source, on the other hand, the Dentemp Repair-It material only needs warm water, and warm water can be made from many sources, such as a hot water tank, cooking from propane gas or electricity oven top, and wooden fire.

Dentemp Repair-It material is commercially available at retail stores and on-line, it is cheap, only \$5.99 each box and each box has three individual packages so it can repair up to three broken prosthesis. Perhaps, the Dentemp Repair-It material is and should be the product of choice

for everyone that can follow simple repair instruction to repair their own broken denture or RPD. But the question is how well and effective the general population that is unfamiliar with dental training can repair broken denture using Dentemp Repair-It material? And another question is does it really save money and time because it's cheap and readily available for everyone to use it?

Previous studies have shown ill-fitted dentures can cause epulis fissuratum [13]. Therefore, an investigation is needed to answer the above questions to determine how well the general population (non-dental professional) can repair broken denture vs dental professional personnel using the OTC Dentemp Repair-It material. Not only can ill-fit dentures be detrimental to the health of the oral tissue, but it can be costly if the repair is not correct and requires additional repair by the dental professional.

Dentemp Repair-It material may need further review in order to consider to use in the dental field operations, in battalion aid stations, and in the medic bags.

CONCLUSION

Within the limits of this study and based on the results obtained, a conclusion can be stated that the Dentemp Repair-It material used to repair broken denture just as effective as Ivoclar Vivadent ProBase Cold material when following their respective repair protocol. Dentemp Repair-It can be great alternative material used to repair broken dentures.

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