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Compressive Strength of Alginate Impression Material Incorporated with Silver and Zirconium Oxide Nanoparticles

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Abstract

Aims: To investigate the effect of adding nanoparticles on the compressive strength of alginate impression material. **Materials and Methods**: In this study, two types of nanoparticles were added to alginate impression materials: silver and zirconium oxide at four concentrations: 0.5 %, 1%, 2%, and 5% by weight. Compressive strength was tested for 45 samples made according to American Dental specification no.18 for the alginate impression material. **Results**: The addition of silver nanoparticles did not alter the compressive strength of alginate impression material, whereas the addition of zirconium oxide significantly decreased its compressive strength. **Conclusions**: The incorporation of silver nanoparticles into alginate impression materials as antimicrobial agents had no negative effect on its compressive strength, whereas adding antimicrobial zirconium oxide nanoparticles significantly reduced the compressive strength of alginate impression material

الخلاصة

الاهداف: تهدف الدراسة لمعرفة تاثير اضافة جسيمات الفضة واوكسيد الزركونيوم النانوية على قوة الانضغاط لمادة الطبعة (الالجينيت) **المواد وطرائق العمل** : فى هذه الدراسة تم اضافةَ نوعين من الجسيمات النانوية الى مادة الطبعة (الالجينيت) وهاتان المادتان هما الفضة واوكسيد الزركونيوم النانوية على شكل اربعة تراكيزمختلفة و هي: 0.5 1%, , 2% و5% من الوزن الى مادة طبعة الالجنيت. تم اختبار قوة الانضغاط ل 45 عينة تم صنعها حسب المواصفات المعيارية لجمعية طب الاسنان الامريكية ADA رقم 18 لمادة الطبعة (الالجينيت). **النتائج** : أضافة الفضة النانوية لم تغيرمن قوة الانضغاط لمادة الطبعة الالجينيت بينما اضافة جسيمات اوكسيد الزركونيوم النانوية ادت الى انخفاض معنوي في قوة الانضغاط لمادة الطبعة الالجينيت .**الاستنتاجات** :ان دمج جسيمات الفضة النانوية لمادة الطبعة (الالجينيت) كمادة مضادة للميكروبات لم يكن له تأثير سلبى على قوة الانضغاط لمادة الالجينيت بينما ادت اضافة جسيمات اوكسيد الزركونيوم النانوية كمادة مضادة للميكروبات الى تقليل قوة الانضغاط لمادة الطبعة الالجينيت.

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INTRODUCTION

Dental impression materials are one of the most widely used materials in prosthetic dentistry. During impression making, dental impressions can be contaminated with the patient's saliva, bacterial plaques and blood[1].

It is important to disinfect dental impression materials to prevent the transmission of diseases from patients to clinicians or the laboratory personnel [2,3].

The most widely used methods for disinfecting impressions are spraying and immersion. However, these methods are time-consuming and have adverse effects on the mechanical and physical properties of alginate[4].

To address these problems, disinfectant agents have been incorporated into the irreversible hydrocolloids. Irreversible hydrocolloids with disinfectants, often termed as "self-disinfectant materials", are disinfected throughout the structure rather than on the surface alone and permit immediate cast pouring without significant dimensional changes [4,5,6].

The Antimicrobial agents were incorporated into the mixing water. This provides internal disinfection, which destroys the microorganisms that enter the irreversible hydrocolloid during the impression procedure and during the pouring of the cast[6].

Silver and other nanoparticles are employed as antimicrobial agents, and silver nanoparticles have been used in various medical and dental applications. Therefore, incorporation of nanosilver particles into alginate impression materials may be useful[7-9].

This study aimed to investigate the influence of adding silver and ZrO2 nanoparticles as disinfectants on the compressive strength of alginate impression materials.

MATERIALS AND METHODS

The impression material used in this study was alginate impression material (chromatic regular set) Müller omicron ,Germany

The nanoparticles were silver 50 nm USA and zirconium oxide 20 nm Nanoshel, USA The 45 samples were divided into three groups : a control group(alginate without nanoparticles) and two groups (alginate with silver and alginate with zirconium oxide nanoparticles).The nanoparticles were accurately weighed using an electrical Sensitive Balance(Kern,Germany) then added and mixed with distilled water in sonicator for 5 minutes in four concentrations which are 0.5%,1%,2% and 5% by weight [10,11].

Preparing the specimens for compressive strength

The specimens for the compressive strength were prepared according to the procedure described by ISO 1563:1990 [14]for The Dental Alginate Impression Material.

Samples were prepared according to the manufacturer’s instructions and the mixing of the alginate was done with an electrical alginate mixer (Hangzhou Zhongrun ,China) because it provides a uniform mix with good physical properties[12] .

The compressive strength values were determined according to the ANSI/ADA specification number 18 [13] .

Five specimens for each experiment were made. The specimens were made by filling a metal ring (12.5 mm inner diameter, and 19 mm high) with unset alginate mass after 30 seconds of mixing on a flat glass plate and immediately covered by the second glass slab. the glass slab was placed on the mold with slight pressure in order to remove the excess of alginate material and to form a flat and smooth top surface of the specimen Figure 1 . After the initial setting time, the specimen was separated from the split mold[15].

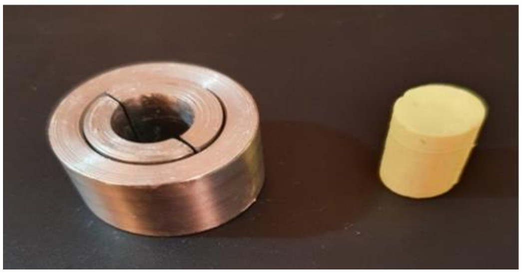

Figure (1): Sample for compressive strength Test

Testing the Compressive strength

Compressive strength of set alginate was measured after 6minutes from the initiation of the mixing. Cylindrical samples of alginate, prepared as explained above, were positioned on the lower plate of the Instron universal testing machine (Gester,China) figure 2 and were stressed at a rate of 10mm/minute until failure (n=5). The strength of compression was reported in Mega Pascals (MPa)

Compressive strength (K) was calculated in megapascals (newtons per square millimeter) by using the following formula: $K = 4F / \pi d2$

According to this formula F is the force at fracture in (N) and d is the diameter of the tested specimen in (mm) [16].

Figure (2): Instron universal Testing machine for Compressive Strength Test

RESULTS

The means and standard deviations of the compressive strength of control and alginate incorporated with silver nanoparticles were shown in Figure 3. The normality test as shown in table 1. Revealed that the P- values are above 0.05 ,therefore the Shapiro-Wilk test indicated that the data of the compressive strength of alginate with silver nanoparticles are normally distributed and we used ANOVA test because we have parametric data. One – Way ANOVA in Table 2, showed that there was no significant difference between the control and the experimental group of adding silver nanoparticles into alginate (P value > 0.05) .

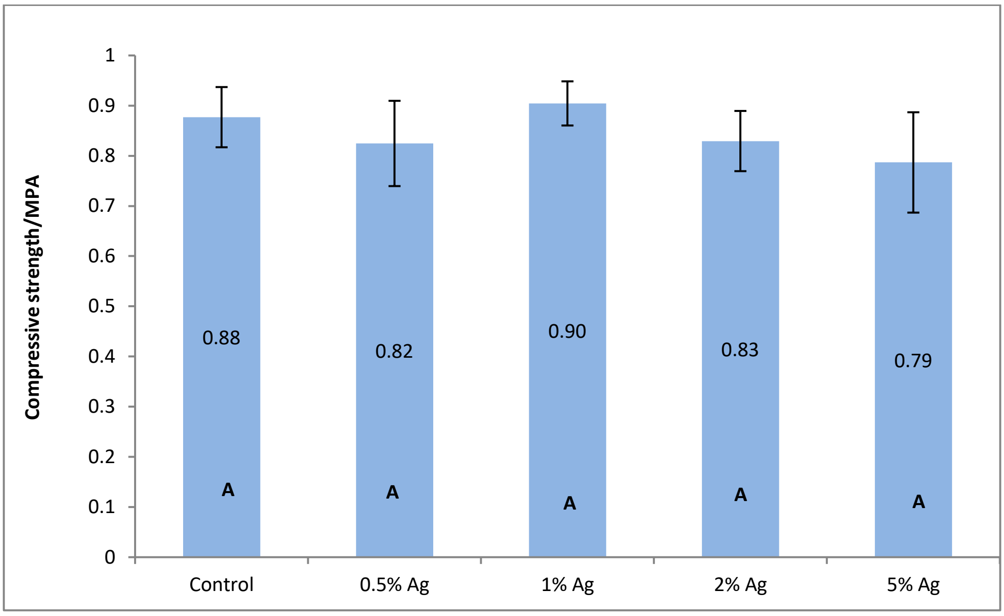

Figure (3): Mean ,SD & Duncan's multiple range test of compressive strength of alginate incorporated with silver nanoparticles in different concentrations.

Table (1): Normality test of data of compressive strength of alginate with silver nanoparticles

	Kolmogorov-Smirnov			Shapiro-Wilk		
Groups	**Statistic**	**df**	**Sig.**	**Statistic**	**df**	**Sig.**
0.5%	0.184	5	0.200	0.952	5	0.749
1%	0.225	5	0.200	0.943	5	0.690
2%	0.210	5	0.200	0.962	5	0.823
5%	0.297	5	0.172	0.794	5	0.072
control	0.280	5	0.200	0.872	5	0.275

Table (2): One way (ANOVA) showing the influence of adding silver nanoparticles on compressive strength of alginate impression material

Compressive strength	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	0.043	4	0.011	1.939	0.143
Within Groups	0.111	20	0.006		
Total	.154	24			

The mean and standard deviation of the compressive strength of the control and alginate incorporated with ZrO2 nanoparticles were shown in Figure 4

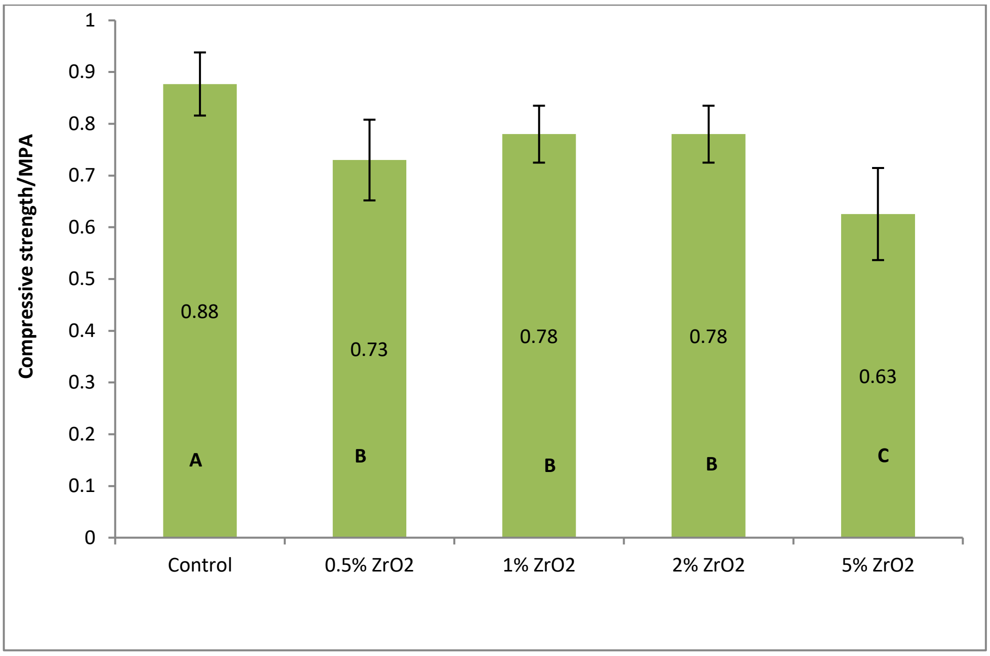

Figure (4): Mean ,SD & Duncan's multiple range test of compressive strength of alginate incorporated with zirconium oxide nanoparticles in different concentrations.

The normality test as shown in table 3 revealed that the P-value is above 0.05 ,therefore the Shapiro-Wilk test for the data of compressive strength of alginate with zirconium oxide nanoparticles are normally distributed, therefore we applied the ANOVA test because we have parametric data.

The One –Way ANOVA as shown in Table 4 demonstrated that there was a highly significant difference between the control and experimental group of adding ZrO2 nanoparticles into alginate ($P \leq 0.01$).

Table (3): Normality test of data of compressive strength of alginate with zirconium oxide nanoparticles

Groups	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
0.5%	0.198	5	0.200	0.929	5	0.589
1 %	0.280	5	0.200	0.836	5	0.154
2 %	0.154	5	0.200	0.992	5	0.985
5%	0.200	5	0.200	0.958	5	0.797
control	0.280	5	0.200	0.872	5	0.275

Table (4): One way (ANOVA) showing the influence of adding ZrO2 nanoparticles on compressive strength of alginate impression material.

Compressive strength	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	0.166	4	.041	8.706	0.000**
Within Groups	0.095	20	.005		
Total	0.260	24			

** $P \leq 0.01$ Highly Statistically Significant

DISCUSSION

Disinfection of dental impressions has been considered a very important topic for many years. The important requirements for a disinfectant are the efficiency of the disinfecting solution in destroying the pathogens and the influence of the disinfecting material on the mechanical and physical properties of the impression material (17) .

Compressive strength is considered to be an important property of alginate during the impression procedure and the production of the cast. During impression removal from the mouth, the material must have enough strength to prevent tearing and provide elastic recovery. In addition, the impression material must have resistance to the weight of the gypsum material without any distortion (18) .

According to ANSI/ADA Specification number 18, the least compression strength of alginate impression material must be approximately 0.35 MPa (13).

In this study, results of the compression strength of the experimental groups were higher than the standard value.

In this experimental study, there was no significant difference in the compressive strength between the control group and the alginate group incorporated with silver nanoparticles. Incorporation of silver nanoparticles did not significantly reduce the gel strength of alginate impression materials. However, at higher concentrations, the gel strength was reduced. A reduction in the gel strength at higher concentrations is due to the reduction in the formation of calcium alginate gel matrix as part of the sodium alginate is replaced with Ag-NP during their formulation [5]. Similar results were observed with the incorporation of disinfectants or antimicrobial additives into irreversible hydrocolloids in earlier studies [11,19] .

Alginate with ZrO2 nanoparticles had significantly lower values than the control, this can be attributed to the reduction in calcium alginate gel matrix formation with increasing concentrations of ZrO2-NP[5].

CONCLUSION

The addition of silver nanoparticles into the alginate impression material for disinfection could have an important role in dental laboratory infection control and it had no negative effect on the compressive strength of the hydrocolloid impression material. However, the addition of the antimicrobial zirconium oxide nanoparticles reduced the compressive strength of alginate impression material.

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