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RESEARCH ARTICLE - MEDICAL TECHNIQUES

The Effect of Nano Hydroxyapatite on the Bond Strength of Acrylic Teeth Repaired to an Acrylic Resin Denture Base Using Two Types of Auto Polymerized Acrylic Resins

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Abstract

The insufficiently binder between acrylic teeth and dentures is considered to be the primary cause of teeth fractures from the dentures and is one of the disadvantages of acrylic denture base material. This research has been conducted to assess various concentrations of Nano hydroxyapatite addition on the shear bond between repaired acrylic teeth and polymer. One-hundred specimens of resin were split into two main subdivisions. 50 specimens were repaired with cold cured Duracryl Plus and the other 50 were repaired with a special type of acrylic O-cry1. Each one was sectioned into tested groups depending on (1%., 2%., 3%, and 5% by wt. of nano hydroxyapatite) incorporation and control group (0% of nano hydroxyapatite) with (n=10). The Universal testing machine was utilized for shear bond strength measurement. The obtained values were diffracted by t-test, ANOVA, and LSD-test. There was an increase in bond strength that repairing with O-cry1 than Duracryl Plus with a heightening in the bond strength, which was seen with incorporating nano hydroxyapatite into the acrylic resin with a significant difference between them. The 2% wt. Nano hydroxyapatite group demonstrated the maximum mean values, while those for the 5% wt. Nano hydroxyapatite group were recording minimum value with a significant difference between them. Repairing with O-cry1 recording better bond strength than Duracryl Plus acrylic. Furthermore, the addition of hydroxyapatite in Nano-form has successfully improved the "shear bond strength" of teeth to the PMMA at 2% wt. nano hydroxyapatite.

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Keywords: Hydroxyapatite Nanoparticles; Acrylic Teeth; Heat Cure Acrylic; Shear Bond Strength; O-cry1.

1. Introduction

The choice of Polymethyl methacrylate (PMMA) as a dental prosthesis attributed to many reasons such as its cosmetics choice, low water sorption and solubility, fewness toxicity, as well as its simple processing technique [1]. The first introduction of denture supplementation acrylic teeth was in 1940, which then became the most popular artificial material is due to its economic benefits [2]. Failure of bond or fracturing of the denture teeth was popular acrylic prosthesis failure types often take place in the denture's anterior region [3]. Many materials were used for the reinforcement of denture base since they have high fracture incidence and require constant redressing. Thus, nano-sized fillers can be added to achieve the polymers' best properties. For the purpose of achieving the highest abrasion resistance, improved aesthetics as well as other physical and excellent dental materials' properties, nano-fillers are used [4]. Using the Nano powder in dental materials is considered as a potent bio-coincident in order to strength the polymer matrix [5]. Due to the excellent biocompatibility with skin and tissues, the hydroxyapatite is considered an inbred safety material that is broadly used in ceramics [6]. In comparison with the micro-scale HA/polymer composites, particles of hydroxyapatite Nano were added to the polymer showing better characteristics of nanoscale HA/polymer [7]. Wang et al., (2011) added the bio inert polymer (polyamide) to both micro and Nano crystalline hydroxyapatite, and studied the mechanical properties of the resulting nano composites, and they found improvements in both the micro and nano hydroxyapatite [8]. Better mechanical properties have also resulted from the hydroxyapatite fillers (HA), which are added to poly methyl methacrylate, because they increase the "flexural strength and the flexural modulus" of the PMMA [9]. Incorporation of HA nanoparticles makes the compression strength and fatigue of PMMA better when compared with the pure PMMA [10],and also causes increasing of the thermal conductivity [11].

A successful development of a novel acrylic type was achieved by Pan and others who added the whiskers of hydroxyapatite (HA) in various concentrations, and they concluded that the flexural strength was reinforced at low concentration of incorporation of (HA) [12]. The olden trials revealed that the denture's characteristics of polymers were enhanced with the HA nanofillers, but no study was concerned with the bonding between teeth and resin with these nanofillers addition and the proper concentration for best bonding between them.

According to the technical data sheet of the self-polymerized O-cry1which is activated chemically due to presence of a tertiary amine as one of the liquid ingredients. In addition to self-polymerized monomer (Type II), methyl methacrylate, and ethylene glycol di-methacrylate. While the polymer ingredients are: self-polymerized acrylic (Type II) polymethyl methacrylate, pigments, and polyester. The first important feature of O-

Nomenclature & Symbols			
nHA	Nano Hydroxyapatite	ml	Milliliters
ANOVA	Analysis of Variations	g	Gram
LSD	Least Significant Difference	N	Newton
PMMA	Poly Methyl Methacrylate	mm	Millimeter
MPa	Mega Pascal	P-value	Probability Value
HA	Hydroxyapatite	NS	Non-significant at P > 0.05
n	Number	HS	High significant at P < 0.01

cry1 is the duration needed for the repairing of different acrylic structures is enough because it permits an optimum handling period. As well as, it has high resistance to fractures as flexural strength of about 65.4 MPa and flexural modulus about 3700 to withstand the occlusion forces. Another feature is a lower quantity of monomer stay after complete setting of denture that leads to minimal irritant of oral tissue, so this resin has good clinical performance. This study was designed to assess the shear bond strength between the repaired acrylic teeth and heat cured acrylic following the addition of different concentrations of modified nano hydroxyapatite (nHA) using two types of auto-polymerize acrylic (O-cry1) and (Duracryl Plus).

2. Materials and Methods

The materials used in this study are listed in Table 1.

Table 1. Materials used in this study

Materials	Brand name	Manufacturer
Hydroxyapatite Nano particles Ca10(PO4)6(OH)2, 98.5%, <40 nm	Hydroxyapatite Nanoparticles	Sky spring Nanomaterials Inc, USA
Acrylic resin teeth for denture processing	Synthetic resin teeth Model no. SDT-SA41	SDT-SA41, Zhengzhou,smile Dental Equipment CO. ltd, China
Heat-cured denture base resin (powder + liquid)	Superacyl plus, Powder and liquid	Spofa Dental akerr Company, Czech Republic
Cold-cured denture base resin (powder+ liquid)	Duracryl Plus, Powder and liquid	Spofa Dental akerr Company, Czech Republic
Special type of acrylic auto-polymerized acrylic (powder+ liquid)	O-cry1, Powder and liquid	O-cry1, new stetic Colombia
Silane coupling agent, 3-methacryl-oxypropyl trimethoxy sila	Alfa Aesar	Sigma-Aldrich Germany
Sheets wax	Poly wax base plate wax	Bilkim chemical company, Turkey
Dental stone, type 4 dental die stone	Elite stone	Zhermack, Italy
Methanol	Solvent	Scharlua, Spain

2.1. Specimens grouping

One hundred specimens are divided into the following groups:

- Group 1: 50 specimens of acrylic teeth were repaired with auto-polymerized acrylic (Duracryl Plus) to heat cured acrylic.
- Group 2: 50 specimens of the denture teeth were repaired with a special type of acrylic (O-cry1) to heat cured acrylic.

Further subdivision into 5 groups of each main group (n=10) according to the percentage of nHA that was added into acrylic resin as seen in (Fig. 1).

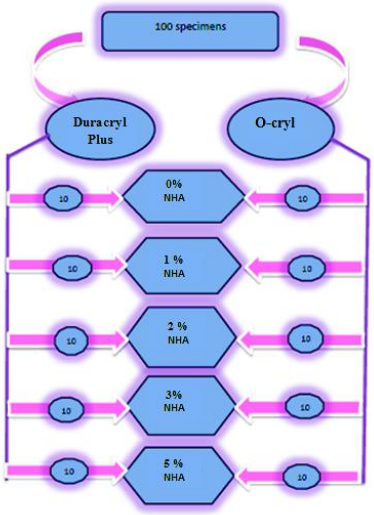

Fig. 1. Flowchart of the specimens distribution

2.2. Specimens preparation

For measuring the shear bond strength of all groups, 100 right maxillary central incisor acrylic resin teeth were embedded in a (35 mm length and 12 mm diameter) cylinder of heat-cured acrylic resin(Fig. 2) [2, 13].These dimensions were confirmed by the Japanese Standards for acrylic teeth which were fitted to the jig of the Instron machine [14].

First of all, the preparation of the mould for heat-cured acrylic resin was done by the traditional flasking technique, where the dental stone that was mixed in accordance with the manufacturer's instructions was laid in the inferior part of the metal flask. The powder/water ratio was 100g / 25ml. The cylindrical wax patterns for acrylic specimens with 35 mm length and 12 mm diameter dimensions were placed to one-half of their depth for easy removal, and the stone was left to set Fig. 3, then the two parts of the flask were connected and filled with dental stone and left to be hard an hour prior to unclosing. After the utilization of wax elimination by the water bath, the painting with isolating material was done prior to the application of dough resin.

Fig. 2. Acrylic sample with acrylic tooth

Fig. 3. Wax patterns of acrylic specimens in the dental flask

For the control group, the acrylic materials (Superacyl plus, Czech Republic) were mixed with a P/L ratio of 10 g: 4.4ml by weight and manipulated pursuant to the manufacturer's instructions. A measured volume of liquid was put in a mixing vessel, and then a powder was added slowly and offed to reach into the dough phase. The polyethylene sheet was then used to do the tri-closure after rolling the acrylic resin dough in the mold. The flask parts were locked under pressure until proper attachment was established and exposed to (100 Kpa pressure) takes 5minutes. The specimens were cured in the water bath and processing using a short-curing cycle by placement the specimens in the water bath at 74ºC for one hour and a half then elevated the temperature to 100ºC for thirty minutes) [15]. Finally, the flask was left for thirty minutes for bench cooling, then laid below the water for fifteen minutes before de-flasking. The acrylic patterns were then taken out from the stone mold [16]. A careful de-flasking was done with the removal of the excess of acrylic for all samples with an acrylic bur, then stone bur was applied followed by (120) grain size sandpaper. The samples were polished with continuous cooling in water to minimize overheating which may result in sample distortion [15] (Fig. 4A).

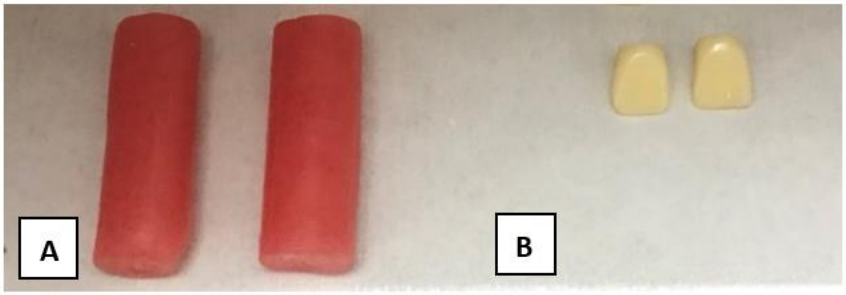

Fig. 4. (A) The acrylic samples after finishing and polishing, and (B) The prepared maxillary central incisors

2.3. Salinization of hydroxyapatite nano particles

Salinization of nHA was done in 90 ml methanol / 10 ml distilled water, 3-methacryl oxy propyl trimethoxy silane (γ-MPS) was used by the following procedure: 30 gms of nHA powder and 270 ml / 30 ml of methanol/distilled water were mixed in a beaker by probe sonicator (soniprep-150, England) for 2 hours until the solution became homogeneous[8 ,9].The vigorous magnetic stirrer (Hanna instrument HI300, China) was applied for the addition of 3 ml of (γMPS) to the previous solution for 12 hours at room temperature [17].The mixture was air-dried for 24 hours for water and methanol to be evaporated. Then the dry powder was placed in the oven at 60°C over-night to get rid of any moisture, and to maintain salinized HA nanopowder in its final form [17].

2.4. Incorporation of nHA nanoparticle

To prepare experimental group samples, modified *nHA particles* according to certain percentage used in this study by weight were added to the monomer in appropriate percentages by weight. For determination of the exact weight of PMMA and nHA powders, the digital scale with (0.0001g) accuracy was utilized. To the volume of selected monomer, the proper weight of nHA filler was added, and then the probe sonicater apparatus (120W, 60 KHz) was applied to disperse the filler thoroughly in the monomer for three minutes. To reduce any particle aggregation, the resulting nHA-monomer suspension was immediately mixed with PMMA powder. The accurate P/L ratio was obtained by subtracting the

weight of the nHA powder from the weight of the PMMA powder [18] as shown in Table 2. Then the conventional packing, processing, finishing and polishing of the acrylic samples as mention it for the control one.

Table 2. Proportion of PMMA,MMA and nHA used in the study [18]

HA nanofiller% by wt.	Amount of nHA (gram)	Amount of polymer (gram)	Amount of monomer (ml)
0%	0	10	4.4
1%	0.1	9.9	4.4
2%	0.2	9.8	4.4
3%	0.3	9.7	4.4
5%	0.5	9.5	4.4

2.5. Preparation of acrylic teeth for repairing

For the current study, upper right central incisor acrylic teeth (SDT-SA41, China) were selected (Fig. 4.B), and repaired to a cylinder of acrylic. In order to standardize the surface area to be the same for each tooth with regular circular shapes in 5mm diameter, all the denture teeth were prepared by ground bur[19] and flattened from the anterior aspect about a half millimeter inside the acrylic cylinder so as the attachment of the teeth at 45° with the acrylic cylinder. For mimicking the clinical conditions, this angulation was made similar to the real denture. To flatten the surface of the tested tooth, 600-grit silicon carbide paper was applied [20]. Deionized water (10 minutes for each wash) was used to clean the specimens ultrasonically for three times. The mold index method was used to standardize the space of 0.5mm thickness for cold-cured acrylic resins [21].This technique was maintained by the teeth fixed into cylindrical acrylic specimen by wax as the previous mentioned manner and after stone mould was completely set then the specimens were removed and ready for application of O-cry1 and Duracryl resins [21].

2.6. Repair procedure

The acrylic teeth and acrylic resin were repaired by the O-cry1 in accordance with the manufacturer's indicated recommendations. First, the repaired area was painted with a single monomer drop by a fine brush (No.zero), then repaired with O-cry1 after waiting for 180 seconds [22]. After that, the mixture was prepared by applying the liquid and sprinkling the powder over it, and then it was applied on the repaired area slightly overfilling the repaired space at 0.5mm thickness which was standardized by using the mould index method as recommended by manufacturer instruction (Fig 5. A, B, and C). The right maxillary central incisor and the acrylic sample were realigned in their stone mould. The repaired material was cured by putting the flask in the Ivomet (Palamat universal/ England) for 30 minutes at 40°C temperature and under 2 bar pressure[23 ,24].

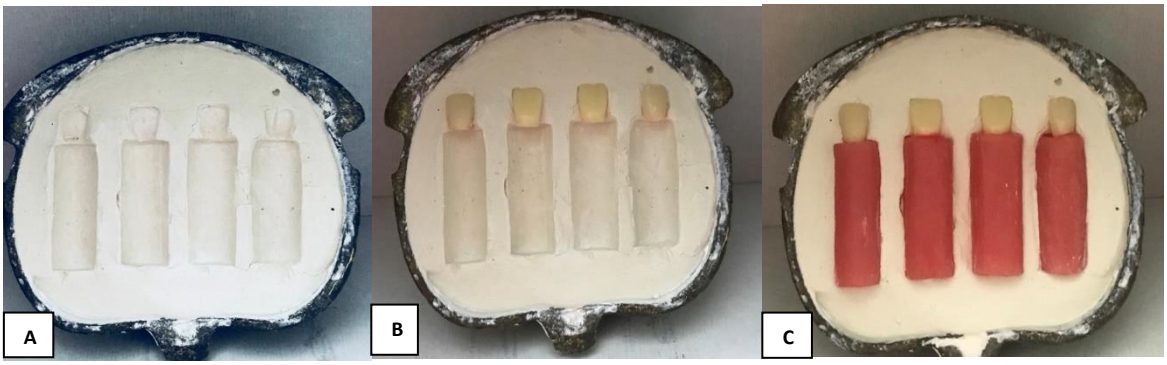

Fig. 5. Mould index preparation; (A) Mould of the specimens, (B) Teeth inside the mould, and (C) The teeth and acrylic specimens realigned in their stone mould after repairing

The manufacturer's instructions were applied for mixing the cold cured acrylic (Duracryl). After that, Ivomet was used in packing and curing processes under 2-bar pressure for 30 minutes. Before the start of the testing process, all the specimens were positioned in distilled water at 37°C for 7 days [21]. Then, a special device (Haackt, Germany) with a temperature ranging between (5°C-55°C) in one minute cycle was used for subjecting the specimens to thermocycling for three days, which represents 1000 cycles by placing the specimens in chamber of the device at 5°C and then converted into the chamber of 55°C in one minute for each one and repeated until all cycles were completed [25, 26].

2.7. Shear bond strength test

The Universal testing machine (Instron Corporation, 1195, canton mass, England) equipped with a 50 kN load cell and a knife-edge shear testing apparatus was used to calculate the shear bonding. Each sample was positioned as seen in Fig. 6. The cross head loading force was placed on the incisor third of the tooth until fracture to resemble the occlusal load (ASTM, 1986). A knife with 0.8mm thickness at edge was zapped vertically at a cross-head speed of 0.5 mm/minute for rupturing the tooth-acrylic interface surfaces, and Newton units were used to record the fracture loads [27].

The values were obtained by application the formula:

Shear bond strength = F/A MPa (ASTM, 1986)

F = Force at failure (Newton). A=Minimum cross sectional area (mm).

The surface area was calculated according to the following formula:

$S = \pi/4 \times D^2$

where D is the bonded tooth diameter, which is (5mm), and π =22/7 or 3.14, hence A=19.64mm2 in testing the shear bond strength [26, 28].

In all the tested specimens, visual examination of the specimens was performed for determination of the fracture type at the site of the fracture [29, 30].The failure kinds were defined as: adhesive, cohesive, and mixed. The interface failures were classified into 3categories: Adhesive failure: when the fracture takes place at interface, Cohesive failure: when the fracture takes place within the tooth or the resin exclusively, Mixed failure: when the fracture takes place such that some tooth structures were left intact on the ridge lap resin surface. After complete examination of the failure type in fracture area for all specimens, they were indicated to the cohesive failure type for all specimens (Fig. 6) [31].

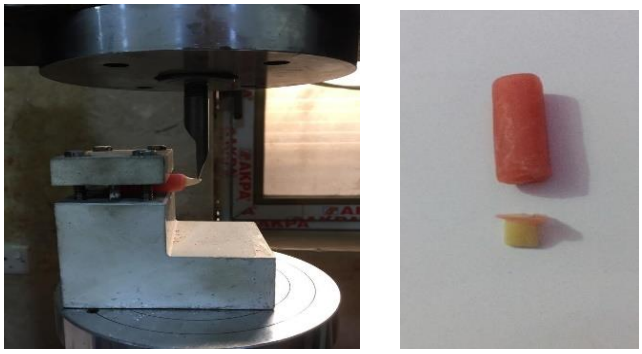

Fig. 6. The specimen during shear bond strength testing

2.8. Statistical analysis

Data were analyzed by using Statistical Package for Social Science (SPSS) version #21 (SPSS, Chicago, Illinois, USA). The t-test, one-way ANOVA-test and LSD-test were used to detect the significant differences between groups at significance level (P<0.05).

3. Results

The descriptive statistics for the results of shear bond between repaired acrylic teeth and heat cured resin for all groups showed that the optimum mean values were in the groups which were repaired with O-cryl in comparison with those which were repaired with Duracryl Plus. According to the addition of nHA, the highest mean value for shear bond recorded by 2% NHA group and lowest mean value recorded by control group as shown in Table 3 and Fig. 8. Performing the t-test to decide the significance of difference between the mean values of repairing the artificial teeth with O-cry1 and repairing them with Duracryl resin showed a highly significant difference ($p < 0.01$) (Table 4).

Further analysis of the shear bond strength means values between the repaired acrylic teeth and addition of different concentrations of nHA into the heat-cured acrylic, the ANOVA-test has shown a highly significant difference between all the tested groups that repair with cold curd according as seen in Table 5. For comparison between the tested groups, there was a highly significant difference between the tested groups excluding the control one and 1% *nHA* filler incorporation revealed the non-significant difference ($p > 0.05$) that was obtained by the LSD-test as shown in Tables 6, 7, and 8.

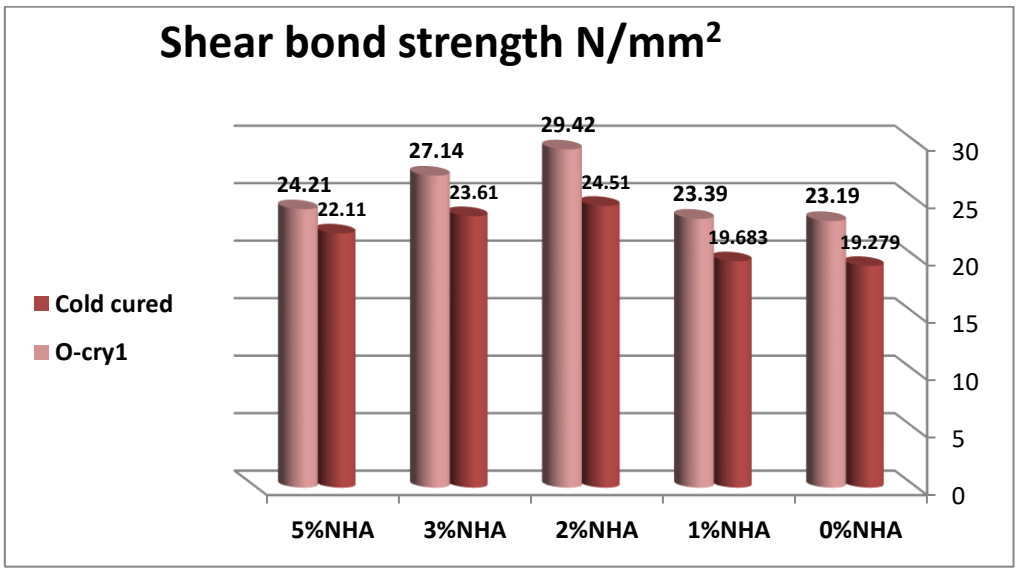

Fig. 7. Bar chart displaying the shear bond strength mean values of all the studied groups

Table 3. The descriptive statistics of shear bond strength (N/mm^2) for all the studied groups

nHA %	Repairing material	N	Mean	SD	Std. Error	Minimum Values	Maximum Values
0%	Duracryl Plus	10	19.28	0.469	0.148	18.7	20.2
	O-cry1	10	23.19	0.311	0.098	22.81	23.57
1%	Duracryl Plus	10	19.68	0.659	0.208	19.0	21.2
	O-cry1	10	23.39	0.366	0.115	22.81	23.90

2%	Duracryl Plus	10	24.51	0.669	0.211	23.8	25.9
	O-cry1	10	29.42	0.371	0.117	28.81	29.92
3%	Duracryl Plus	10	23.61	0.568	0.179	22.5	24.4
	O-cry1	10	27.14	0.263	0.083	26.70	27.50
5%	Duracryl Plus	10	22.11	1.049	0.331	21.2	23.9
	O-cry1	10	24.21	0.080	0.255	23.80	24.50

Table 4. Independent t-test for comparison between cold cured and O-cry1 repairing of all the study groups

nHA% wt.	Repairing material	t-test	P-value	Sig.
0%	Duracryl Plus material O-cry1 material	22.016	0.000	HS
1%	Duracryl Plus material O-cry1 material	15.558	0.000	HS
2%	Duracryl Plus material O-cry1 material	20.309	0.000	HS
3%	Duracryl Plus material O-cry1 material	17.817	0.000	HS
5%	Duracryl Plus material O-cry1 material	6.149	0.000	HS

Table 5. One-way ANOVA- test between groups of repair with cold curd according the use of different concentration nHA

		Sum of Squares	DF	Mean Square	F-test	P-value	Sig.
Duracryl Plus	Between Groups	215.461	4	53.865	106.579	0.000	HS
	Within Groups	22.743	45	0.505			
	Total	238.204	49				

Table 6. Least significant difference test for comparison of the shear bond strength according to different percentages of nHA among cold cured repair groups

Repairing material	nHA %		Mean Difference	Std. Error	P-value	Sig.
Duracryl Plus	0%	1%	0.404	0.317	0.210	NS
		2%	5.231	0.317	0.000	HS
		3%	4.331	0.317	0.000	HS
		5%	2.831	0.317	0.000	HS
	1%	2%	4.827	0.317	0.000	HS
		3%	3.927	0.317	0.000	HS
		5%	2.427	0.317	0.000	HS
	2%	3%	0.90	0.317	0.007	HS
		5%	2.40	0.317	0.000	HS
	3%	5%	1.50	0.317	0.000	HS

Table 7. One-way ANOVA- test among groups of O-cry1 repair according to the use of different concentrations of nHA

		Sum of Squares	DF	Mean Square	F-test	P-value	Sig.
O-cry1	Between Groups	294.760	4	73.690	733.079	0.000	HS
	Within Groups	4.523	45	0.101			
	Total	299.284	49				

Table 8. Least significant difference test among groups of O-cry1 repair according to the use of different concentrations of nHA

Repairing material	nHA%		Mean Difference	Std. Error	P-value	Sig.
O-cry1	0%	1%	0.200	0.142	0.165	NS
		2%	6.227	0.142	0.000	HS
		3%	3.945	0.142	0.000	HS
		5%	1.015	0.142	0.000	HS
	1%	2%	6.027	0.142	0.000	HS
		3%	3.745	0.142	0.000	HS
		5%	0.815	0.142	0.000	HS
	2%	3%	2.282	0.142	0.000	HS
		5%	5.212	0.142	0.000	HS
	3%	5%	2.930	0.142	0.000	HS

4. Discussion

The shear strength is defined as a maximum stress which can be withstood by a material before the failure in a shear mode of loading [15]. The calibration of a denture teeth's shear bond strength that is inserted in an acrylic resin base is a very important matter because most detachment phenomena of artificial base under functional load result from stresses at tooth-based interface [32]. Study of Polymethyl methacrylate (PMMA)

and Polyethyl methacrylate (PEMA) has been a major concern of many researches on artificial denture teeth. Alteration levels in such materials was relatively elevated because of the hot processing or cross-linking method applied by the manufacturers [33].

This study investigated the impact of modified nHA on shear bond strength property of heat cure resin. Because of the biocompatibility and bioactivity of nHA [$Ca_{10}(PO_4)_6(OH)_2$], it was used in the current study [34].

Because of the better properties of modified nHA than the non-modified materials, its use is of a great importance as it participates in favorite gluing, sparser, and coincides with acrylic and causes mechanical characteristics enhancement of the prepared denture prostheses [12]. Other researcher added modified nHA powder treated by silanation process to PMMA and obtained similar results i.e. treated nHA could help in decreasing the water uptake of PMMA depending upon the nHA powder concentration [9]. The same results were found by Wang et al., (2011) [8].

The effect of adding nHA particles on the bond is increased compared with the effect without adding nanoparticles when adding 2% nHA to PMMA. This was in accordance with other studies, which found that the addition of 2% of these fillers resulted in an improvement in the impact strength and transverse strength than any other percentages [17].This is probably attributed to the significant enhancement of strength in the current search, which may be clarified by the resultant covalent bonding between the silane coupling agent and the polymer matrix due to silane treatment of nHA. The interfacial strengths are determined between silane coupling agents and polymer matrix immediately after the establishment of the bonding between silane and HA [35]. Furthermore, the silanol groups are condensed with the hydroxyl groups of hydroxyapatite nano particles to produce the stable Si-O-HA, which allows assembling and coupling of the inorganic hydroxyapatite and organic PMMA [17].Throughout polymerization reaction, the other functional group (methacryloxy group (vinyl group) C=C) which is present on the other side has the ability to react with the vinyl group of PMMA [36].

The getting outcomes coincided with Zebarjad et al., (2011) who obtained significant improvements in the strength after the addition of 2.5 wt% nHA to PMMA. However, no direct proportionality was found between bonding strength results and NHA contents, and they inferred that changes happened in the polymer structure through mixer milling caused the changes of strength not the change in nHA content [5].Our findings also agreed with another study which found an improvement in the bond between nano-reinforced resin and teeth as a result of the action of saline coupling agent that was formed the bond between the two materials [13].This may be attributed to the fact that there was strong interstitial bonding between the modified nHA-filler's surface and matrix resin that protects and guards the nano-fillers against outer and inner stresses, which results in the creation of polymer chains with a high molecular weight which is strongly packed and less susceptible to thermal and mechanical stresses [18, 26].

Moreover, the increase in nHA concentration to polymer results in the strength reduction, which in accordance to Lezaja et al., (2013) who obtained similar results after replacing 10% resin bonded composites conventional filler with different shapes of hydroxyapatite showing that strength was significantly decreased by nanohydroxyapatite [37]. According to the repairing materials, our results revealed there was an increase in the shear bond strength in comparison the acrylic teeth repaired with the O-cry1 with those which were repaired with Duracryl Plus acrylic, and this may be attributed to the material using method and depending on the application of the manufacturer's guidelines regarding the use of monomer first on the repaired area followed by O-cry1 application, resulting in the dissolve of the external surface of PMMA which made the connect between the repaired material and the acrylic better by making of the interpenetration polymer network matrix during polymerization and causing an improvement in this characteristic [3], which result in copolymerize with that material by formation of free double bonds that lead to improve the bonding between repaired material and acrylic resin denture base material [25].

The other reason was that the repaired acrylic resin samples were cured under 40°C heat and pressure in the Ivomet device which might have improved the fracture strength of the auto polymerized resin. The heat could also cause activation of the chemical reaction between the monomer and the polymer components [23], this was due to the high polymerization temperature of resins which reinforced the diffusion between the acrylic resin polymer and the monomer with further conversion of monomers to polymers [38] which resulted in maintenance of complete polymerization with better mechanical properties of the auto-polymerized acrylic resin.

The debonding should not take place along the resin and the tooth connect, i.e. the cohesive failure type must be occurring. This result was agreed with another study which revealed that all the fractures of the sheared sample were shown to be cohesive in nature [2], but it was not in conformity with Yadav et al.,(2015) who found that the most common fractures occur within the tooth more than the interface between tooth and acrylic [39]. Abass et al., 2011 concluded that the failure point at the junction between the acrylic and tooth occurred when the surface was pretreated by a monomer [30].The obtained result of the cohesive failure indicated an evidence to increase in bond strength between tooth and denture base [31].

5. Conclusions

This study concludes that there was an enhancement in the shear bond strength between the acrylic teeth and heat cured acrylic with special type of acrylic O-cry1as well as the incorporation of 2% of modified nHA-filler into resin material improved the shear bond strength, but the increase in the percentage of more than 2% caused an adverse effect.

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