Impacts of Different Surface Treatments on polyamide Denture Base Transverse Strength

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Abstract:

Introduction The polyamide nylon base family of condensation polymers was formed when a diacid interacts with a diamine monomer to produce a range of polyamides. The physical and mechanical properties of these polyamides were determined by the bonds formed between the acid and amine groups. There has recently been a lot of interest in the use of lightweight denture fabrication materials such as thermoplastic nylon. To repair these new materials, it is vital to determine the optimum bonding processes that may be applied given the technological advancements in prosthetic dentistry. The optimal performance of the material after such repairs is critical.. The goal of this study is to analyze the transverse strength of polyamide denture base material rejuvenated by flexible material and different processing processes (manual heating, reinjection and sprue- material) materials And Method A total of 80 samples were produced from a total of 60 acrylic resins for this study. Group one contain 20 specimens were used as the positive and negative control group, which were tested for transverse strength 10 without fracture and 10 with fracture both 20 specimens without addition fusing material. three groups (10 specimens for each) were formed from the sixty specimens that had been repaired by manual heating, reinjection and spruing all these groups were prepared by surface Russian treatment (evidsum fusing material) after that sample preparation ,curing and finishing and polishing process. Results The current study found highly significant differences (F=89.408, p-value 0.0001) in means of Transvers strength for different Russia's processing techniques, including spuring repair Nylon-manual heating repair, and Re-injection nylon repairas well as both controls, Control/ Nylon Non-repair (C1) and Control/ Nylon Repair negative , control positive C1 had the highest mean value of transverse strength while control had the lowest mean value (8.637 1.430 mpa).

key word: (Flexible Material, transverse Strength, repair Polyamide Denture).

تأثير المعالجات السطحية المختلفة على القوة المستعرضة لقاعدة أسنان البولي أميد

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.وزارة الصحة العراقية بغداد 1

الجامعة التقنية الوسطى – "كلية الصحة و – 2

" التقنيات الطبية – بغداد – العراق

الملخص:

مقدمة تشكلت عائلة بولي أميد النايلون الأساسية لبوليمرات التكثيف عندما يتفاعل ثنائي حامض مع مونومر ثنائي الأمين لإنتاج مجموعة من البولي أميدات. تم تحديد الخواص الفيزيائية والميكانيكية لهذه البولياميدات من خلال الروابط المتكونة بين مجموعتي الحمض والأمين. كان هناك اهتمام كبير مؤخرًا باستخدام مواد تصنيع أطقم الأسنان خفيفة الوزن مثل النايلون بالحرارة. لإصلاح هذه المواد الجديدة ، من الضروري تحديد عمليات الربط المثلى التي يمكن تطبيقها في ضوء التطورات التكنولوجية في طب الأسنان التعويضي. يعد الأداء الأمثل للمادة بعد هذه الإصلاحات أمرًا بالغ الأهمية .. والهدف من هذه الدراسة هو تحليل القوة العرضية لمادة قاعدة طقم الأسنان المصنوعة من مادة البولي أميد التي تم تجديدها بواسطة مادة مرنة وعمليات معالجة مختلفة (التسخين اليدوي ، وإعادة الحقن ، والمواد المطاطية) والمواد والطريقة تم إنتاج ما مجموعه ٨٠ عينة من إجمالي ٦٠ راتنجات أكريليك لهذه الدراسة. المجموعة الأولى تحتوي على ٢٠ عينة استخدمت كمجموعة تحكم موجبة وسلبية ، والتي تم اختبارها للقوة العرضية ١٠ بدون كسر و ١٠ مع كسر كلاهما ٢٠ عينة بدون إضافة مادة صهر. تم تشكيل ثلاث مجموعات (١٠ عينات لكل منها) من الستين عينة التي تم إصلاحها عن طريق التسخين اليدوي ، وإعادة الحقن ، وتم تحضير كل هذه المجموعات عن طريق المعالجة الروسية السطحية (مادة الصهر الدليل) بعد ذلك تحضير العينة ، وعملية المعالجة والتشطيب والتلميع. . النتائج وجدت الدراسة الحالية فروقًا ذات دلالة إحصائية($F = 89.408$) ، قيمة (p 0.0001 في وسائل قوة المحولات لتقنيات معالجة مختلفة في روسيا ، بما في ذلك إصلاح التسخين إصلاح التسخين اليدوي بالنايلون وإعادة حقن النايلون بالإضافة إلى كل من عناصر التحكم والتحكم / نايلون غير قابل للإصلاح (C1) والتحكم / إصلاح نايلون سلبي ، كان للسيطرة الإيجابية C1 أعلى متوسط قيمة للقوة العرضية بينما كان للسيطرة أدنى قيمة متوسطة (٨،٦٣٧ ١،٤٣٠ ميجا باسكال)

الكلمة الرئيسية: (مادة مرنة ، قوة عرضية ، إصلاح طقم أسنان بولي أميد).

1.Introduction

The polyamide nylon base family of condensation polymers is made when a diacid reacts with a diamine monomer to create a variety of polyamides. These polyamides' physical and mechanical characteristics are dependent on the bonds that the acid group and amine group establish.(1) Recently, there has been a lot of interest in the usage of lightweight denture production materials such thermoplastic nylon. In order to make repairs on these new materials, it is necessary to find the best bonding procedures that may be used given the technical improvements in prosthetic dentistry. The material's best performance following such repairs is a crucial factor.(2) The injection molding process, which results in reduced polymerization shrinkage, is used to manufacture thermoplastic resins to create precise and accurate denture bases(3).The benefits of thermoplastic resins over traditional powder and liquid systems include greater fatigue resistance, creep resistance, and dimensional stability (4). A family of thermoplastic polymers called polyamides are collectively referred to as nylon . The use of nylon resins as appropriate denture base materials has grown in favor and acceptance in clinical practice. Its employment is encouraged by an aesthetic result, greater flexibility, and enough transverse strength compared to the typical heat-polymerizing resins.(5) Additionally, investigations have shown that using nylon bases reduces or almost eliminates the release of free monomer, making thermoplastic nylon resins an appropriate substitute for individuals who are allergic to free monomer and traditional metals.(6) Several processing methods, including heat-polymerization, autopolymerization, light-polymerization, or microwave-polymerization of acrylic resins, have been utilized to fix the broken dental prosthesis.(7) . The surface treatment of the denture bases with various chemicals can further improve the adhesion between the nylon base and repair materials. , These substances scratch the denture base's surface and change its shape and chemical makeup.(8) Methyl methacrylate (MMA) is frequently utilized to treat the cracked denture base surfaces.(9) However, organic solvents including methylene chloride, acetone, ethyl acetate, isopropanol, toluidine, and chloroform(10) have been used to carry out the surface treatment. It has been shown that chemical surface treatment increases the binding strength between the resin used for repair and the denture foundation (11) .Thermosetting acrylic resins can be repaired by solvent-assisted bonding(3) .When subjected to chemical assaults, polyamides are typically stable and robust. However, polyamide is more likely to absorb water or other solvents and create hydrogen bonds when there are amide groups (-NHCO-) present in the solvent (12) The hydrogen bond network in polyamides is broken up by plasticization, which increases chain mobility.(13) Through hydrogen bonding, propionic acids, acetic acids, and butyric acids increase adhesion. They also produce hydrolysis, which breaks crosslinks and causes swelling comparable to that of organic solvents.(14) According to Guan and Kaizhong(15) ,surface treatment of polyamide denture base for 10 minutes with 5% acetic acid in aqueous ethanol (30/70 by volume) may be an efficient and cost-effective way for enhancing the shear bond strength to the autopolymerized reline resin. The purpose of this study was to examine the physical and mechanical qualities of the thermoplastic nylon denture base's adhesive bond utilizing various resin types, and chemical surface treatment.

2. Materials and Methods

2.1. Sample Grouping

A total of 80 samples were produced. A total of 60 acrylic resins were selected. five different sets of samples were used in this study:

Group 1: Ten specimens were utilized as positive assessed for transverse strength.

Group 2:Ten specimens without fracture and 10 specimens with fracture both 20 specimens without fusing material addition(C_2).

Group 3:Ten specimens were repaired by reinjection with fusing material addition(RiNR).

Group 4:Ten specimens were repaired by rejectednylon –manual heating repair (sprue) with fusing material addition(ReNR).

Group 5:Ten specimens were repaired by rejected nylon –manual heating repair with fusing material addition(NHR).

2.2. Sample Preparation

The specimens were made by cutting the hard metal disk piece Under running water at an angle of 450, the dimensions of the specimens were (65x12.5x2.5I 0.03)mm (length, breadth, and thickness, respectively) parameters required for the flexural strength test), in accordance with ADA Specification No.12,1975. as seen in Figure (1) Before fitting the upper half of the flask over the bottom half, which was then filled with stone, a separating medium (Zeisol) was placed over the set stone and allowed to set. When the stone had solidified, the flasks' two parts

were opened and hard, elastic models were retrieved. After drying, a separating material was applied to both parts.

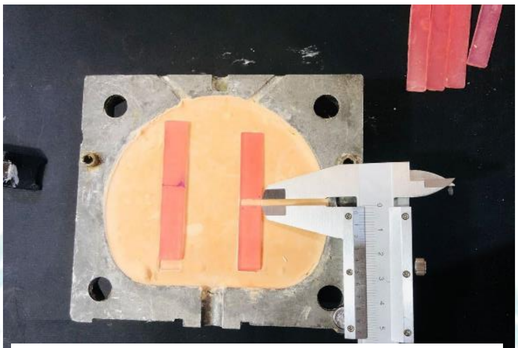

Figure (1): cutting of samples

2.3 flexible polyamide specimen preparation

Laying 4 molds on each flask, using Die Stone, (manufactured in England, type 4). After the stone has solidified, sprue wax of 4 mm and 2 mm is applied, followed by the separating material at the bottom of the flask, the upper half of the flask, and the die stone material, followed by the stone. Solidify the substance thoroughly. Open the flask with a plastic knife, dissolve the sprue wax in boiling water, completely clean the flask, seal the upper and bottom sections of the flask, set the Multipress Eco to 287 C0 for 18 minutes using the flexible capsule (deutflex medium), and apply the special oil to the capsule's surface (cartridge). When the temperature is reached, it is previously set in the device, and the device gives a warning that the required temperature has been reached, inject the capsule by pressing the button to release the capsule material in the flask on its device and waiting 3 to 5 minutes according to manufacturns, then pressing the button to empty the flask. Open it and remove the moldser's instructio.

2.4 preparing polyamide specimens

The specimens cut them from the side of the sprue using a disk bure and brightens by carbide bure and other bures used to make flexible material (valplaste), then put molds of a valplaste in another flask and pour it with plaster material to fix the sample and cut it in the middle according to measurements (1.5 mm) from each side so that the distance between the two pieces becomes 3 mm under running water and at an angle of 45^0 according to the molding device and for every samples(3), then put sprue wax on the void area as shown in Figure(3) and cover the upper part of the flask with plaster material, and after the material hardens well, the flask is opened by the plastic knife into two parts and washed with hot water, and all the wax on it is melted, and then a bonding agent repair liquid(fusing liquid evidsum) Russian origin is placed reinjection procedure two parts of the flask are closed, and the injection device is set at the same predetermined temperature(287C^0) and time and when the required temperature is reached, small cartilage is placed and lubricated in the injection device, waiting for the specified time(18 min) , the injection is done, and waiting for a period ranging between 3 and 5 minutes, after which the flask is opened, the samples are taken out, and they are brightens by bure designated for the valplast substance according to manufacture instruction .noted that there is no change in the material and their color for the all samples used

- Recycling Procedure:

take nylon sprue obtained from previous procedure and heated manually by flame (Heat gun device) then put hot sprue on the gap between fracture side .

- nylon manual heating procedure

capsule of nylon flexible material (25 mediums standard pink cartilage) open and pick crystal from it to heat by flame (Heat gun device) then heating crystal were put into the gap between fracture side then.

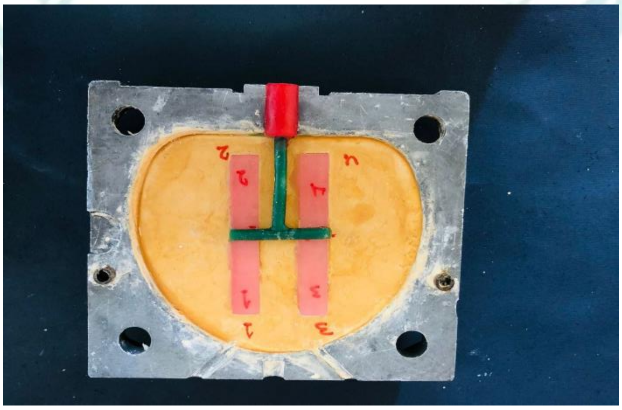

Figure 3 sprue wax on the void area

2.5 Finishing and polishing

The residual acrylic was removed from each specimen using a lab engine fitted with an acrylic bur. A stone bur is used first, followed by sandpaper with a grain size of (120) that continually refreshes the surface (immersed in cold water in rubber bowel). To polish, pumice and a bristle

brush (Vertex) were employed. The gloss finish was obtained by using POLI-R polishing gel and the rouge wheel in a lathe polishing machine. The polishing device employed low-speed spinning (1500 rpm). To ensure that all specimens were the same size, their measurements were verified using an electronic digital calliper. To avoid overheating the specimen, constant cooling was utilized. which might lead to deformation as shown in Figure (4) (16).

Figure 4: Sample After Polishing

2.6 transverse Test

the test of transverse test was carried out using instron machine illusion in figure (5)

$T.V = 3pL / 2bd^2$ …………………………………. (equation)

T.V = Transverse Strength (Ni/mm2)

p=load causing fracture (N)

L= distance

b = width

d = thickness

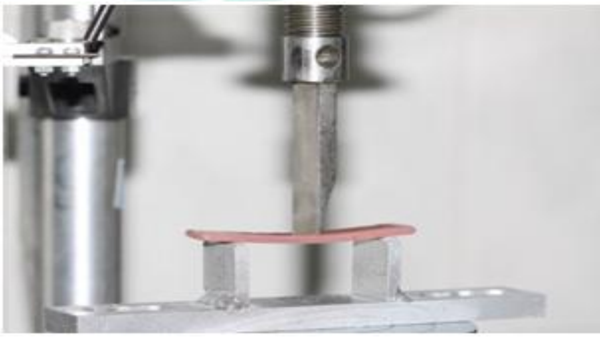

Figure 5 transverse test device(instron machine)

2.6 Statistical Analysis.

The processing procedures employed in the current investigation, as well as positive and negative controls, were input into the SPSS software (version 20). following that determined The minimum and maximum values, as well as the means, standard deviation, and standard error, were computed. Parametric tests (t-test and Welch ANOVA) were employed after examining the normal distribution using the Shapiro-Wilk test, which is a specialized test for normality, and confirming the homogeneity with Levene's test, which analyzes the homogeneity assumption needed by t-tests and ANOVA. P-value 0.05 indicated statistical significance.

3.Results

3.1 Transvers strength Test:

The results of the current study indicated highly significant differences (F=89.408, p-value <0.0001) among means of the Transvers strength for different Russia's processing techniques; Recycled Nylon-manual heating repair (RcNHR), Nylon-manual heating repair (NHR), and Re-injection nylon repair (RiNR) and both controls; Control/ Nylon Non-repair (C1) and Control/ Nylon Repair (C2). The higher mean ± SD value of transverse strength was (107.748 ± 33.692 mpa) for C1 and the lowest mean value was (8.637 ± 1.430 mpa) for C2.

In Post hoc comparisons, the Transvers strength was statistically significantly higher in C1 than C2 and all different Russia's processing techniques (RcNHR, NHR and RiNR) (p-value < 0.05), as well as it was statistically significantly lower in C2 than both NHR and RiNR (p-value < 0.05), but it was statistically not significant difference among RcNHR, NHR and RiNR (p-value > 0.05). See Table (1) and Figure (5)

Processing Techniques	No.	Mean	SD	SE	Min.	Max.	WF-Statistic	P-value	*Post-hoc* analysis Ψ
C1	10	107.748	33.692	10.654	39.790	169.360	89.408	<0.0001 (HS)	A B C
C2	10	8.637	1.430	.452	6.483	10.452			A B C
RcNHR	10	16.310	6.834	2.161	6.860	29.040			A
NHR	10	21.274	3.496	1.105	14.200	25.420			B
RiNR	10	23.206	2.529	.800	18.910	27.110			C

Table (1): Comparison of Means for Transvers Strength in different Russia's processing techniques (Recycled Nylon-manual heating repair (RcNHR), Nylon-manual heating repair (NHR), and Re-injection nylon repair (RiNR)) and both studied controls(C1 and C2) using ANOVA statistical test

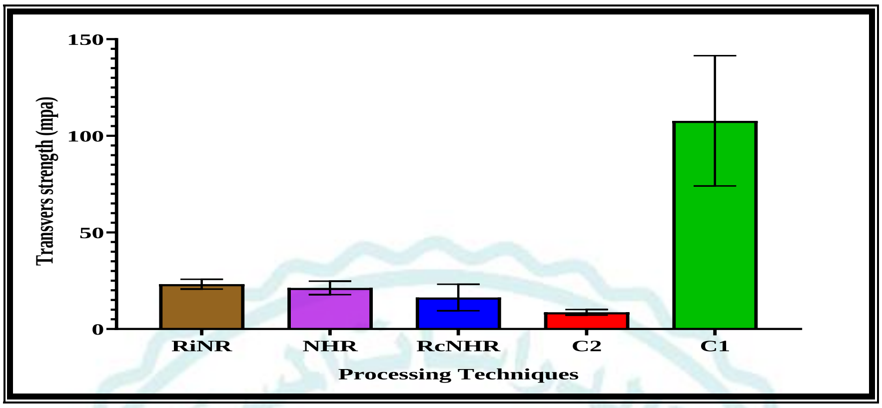

Figure (5): Bar Chart for Transvers Strength in different Russia's processing Techniques (Recycled Nylon-manual heating repair (RcNHR), Nylon-manual heating repair (NHR), and Re-injection nylon repair (RiNR)) and both studied controls (C1 and C2).

4. Discussion

Creating a new denture is an expensive and time-consuming process. As a result, repairing a denture, whether as an interim or final therapy, is a typical management strategy(18). The objective is to restore the original strength of the denture while preventing further fracture propagation. Nonetheless, fracture of restored samples occurs commonly at the interface junction of the original base and repair materials rather than at the repair center, where the stress is focused.(19). Differences in the strength and quantity of primary (covalent) bonds between the atoms and secondary (hydrogen) linkages between nearby chains, as well as the absence of a crosslinking agent in the nylon matrix, might explain the breaking.(20). Furthermore, the poor binding strength values when compared to the traditional denture base may be related to changes in the polymerization reaction during processing, which is condensation polymerization in the nylon base versus addition polymerization in the repair materials(18). Where the polymer chains do not include side groups, nylon particles are better packed (fewer intermolecular gaps) and have less water diffusion. This theory is consistent with Chang *et al* 2021 (21) they stated that nylon, as compared to amorphous acrylic resin, is a highly chemical resistant substance (low solvent solubility) with exceptional heat resistance due to its high degree of crystallinity. The results of the current investigation demonstrated that chemical surface treatments and mending approaches might improve the bonding strength of the nylon denture base polymer to heat.

. The current study found highly significant differences (F=89.408, p-value 0.0001) in Transvers strength for different Russia processing techniques, including spuring repair (RcNHR), Nylon-manual heating repair (NHR), and Re-injection nylon repair (RiNR), as well as both controls, Control/ Nylon Non-repair (C1) and Control/ Nylon Repair (C2) (C2). Transverse strength had a higher mean SD value for C1 (107.748 33.692 mpa) and a lower mean value for C2 (8.637 1.430 mpa). this results agree with Saeed, *et al*. 2020 (22) who showed that surface treatment increase transverse strength of flexible material.

The transvers strength was statistically considerably greater in C1 than C2 and all distinct Russia's processing approaches (RcNHR, NHR, and RiNR) (p-value 0.05), but it was statistically not significant difference among RcNHR, NHR, and RiNR (p-value > 0.05).this finding agree with Alfahdawi 2022. (18) who studied the effect of fusing agent on the treansverse strength and showed there were increase in transverse strength in groups with treatment.

5. Conclusion

Polyamide nylon surfaces can be modified with various flexible materials to change physical qualities . promote adherence and transverse strength

References

1. Dhanya A, Chandran S, Mathew D, Nair CPR. High Performance Phthalonitrile Resins. In: High Performance Phthalonitrile Resins. De Gruyter; 2019.
2. Mahmood A, Akram T, Chen H, Chen S. On the Evolution of Additive Manufacturing (3D/4D Printing) Technologies: Materials, Applications, and Challenges. Polymers (Basel). 2022;14(21):4698.
3. Naji GA-H. Influence of various chemical surface treatments, repair materials, and techniques on transverse strength of thermoplastic nylon denture base. Int J Dent. 2020;2020.
4. Masato D, Sorgato M, Lucchetta G. A new approach to the evaluation of ejection friction in micro injection molding. J Manuf Process. 2021;62:28–36.
5. Thomas SN, Sandhya KM. Netting materials for fishing gear with special reference to resource conservation and energy saving. In ICAR:: Central Institute of Fisheries Technology; 2019.

6. Gray D, Barraclough O, Ali Z, Nattress B. Modern partial dentures-part 2: a review of novel metal-free materials and innovations in polymers. Br Dent J. 2021;230(12):813–8.
7. DESTE G, Durkan R, Perihan O. The Effect of Autoclave Polymerization on the Tensile Strength of Various Denture Base Materials. Cumhur Dent J. 2020;23(4):364–70.
8. Dimitrova M, Corsalini M, Kazakova R, Vlahova A, Chuchulska B, Barile G, et al. Comparison between Conventional PMMA and 3D Printed Resins for Denture Bases: A Narrative Review. J Compos Sci. 2022;6(3):87.
9. Nejatian T, Nathwani N, Taylor L, Sefat F. Denture base composites: Effect of surface modified nano-and micro-particulates on mechanical properties of polymethyl methacrylate. Materials (Basel). 2020;13(2):307.
10. Fatima S, Govardhan B, Kalyani S, Sridhar S. Extraction of volatile organic compounds from water and wastewater by vacuum-driven membrane process: A comprehensive review. Chem Eng J. 2022;134664.
11. Qaw MS, Abushowmi TH, Almaskin DF, AlZaher ZA, Gad MM, Al-Harbi FA, et al. A novel approach to improve repair bond strength of repaired acrylic resin: an in vitro study on the shear bond strength. J Prosthodont. 2020;29(4):323–33.
12. Islam MT, Rahman MM, Mazumder N. Polymers for Textile Production. Front Text Mater Polym Nanomater Enzym Adv Modif Tech. 2020;13–59.
13. Shinzawa H, Mizukado J. Water absorption by polyamide (PA) 6 studied with two-trace two-dimensional (2T2D) near-infrared (NIR) correlation spectroscopy. J Mol Struct. 2020;1217:128389.
14. Ojogbo E, Ogunsona EO, Mekonnen TH. Chemical and physical modifications of starch for renewable polymeric materials. Mater today Sustain. 2020;7:100028.
15. Guan K. Designing Polymer Materials for Improved Additive Manufacturing. 2021;
16. Craig RG, Powers JM. Restorative Dental Materials. 11 [sup] th ed. St Louis Mosby. 2002;594.
17. Bondzinskaitė R, Venskutė G, Kriaučiūnas A. Fracture resistance of various laminate veneer materials: systematic literature review. Protet Stomatol. 2021;71(4):307–22.
18. Alfahdawi IH. A variety of Surface Techniques, Several Denture Base

Repair Properties Were Investigated. 2022;

19. KAMBLE VB, MANGALVEDHEKAR MS, DESAI RG, ARABBI KC, PATIL SM, DESSAI DS, et al. Assessment of Incidence, Causes and Types of Removable Denture Fractures: A Cross-sectional Clinical Survey from Northern Karnataka, India. J Clin Diagnostic Res. 2021;15(11).
20. Gedde UW, Hedenqvist MS. Introduction to Polymer Science. In: Fundamental polymer science. Springer; 2019. p. 1–35.
21. Chang XX, Mubarak NM, Mazari SA, Jatoi AS, Ahmad A, Khalid M, et al. A review on the properties and applications of chitosan, cellulose and deep eutectic solvent in green chemistry. J Ind Eng Chem. 2021;104:362–80.
22. Saeed F, Muhammad N, Khan AS, Sharif F, Rahim A, Ahmad P, et al. Prosthodontics dental materials: From conventional to unconventional. Mater Sci Eng C. 2020;106:110167.