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THE EFFECT OF ADDING HARD & SOFT LINERS ON ADAPTATION OF CAD-CAM 3D PRINTED & CONVECTIONAL HEAT CURED DENTURE BASE MATERIALS BEFORE & AFTER THERMAL-CYCLING

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Purpose: An in vitro study to compare the adaptation of denture bases fabricated with 2 different techniques (CAD-CAM 3D Printed & Conventional Heat-Cured), Before Relining, After Relining with Hard & Soft liners & After Thermal-Cycling.

Material and Methods: maxillary edentulous definitive casts were prepared from an edentulous silicon mold that fabricated with morphology closely resembling an American College of Prosthodontists, Type A classification of residual ridge morphology. Dental stone type IV was mixed at a ratio of 25 ml of water to 100 gm of powder. A three-dimensional image for the stone model was taken by (3Shape laboratory scanner, Denmark) scanning was accomplished with (6 µm) accuracy according to ISO (12836). The next step was the Lazer production of (60) metal casts by using the STL file with machine (RITON, Procured Company, China). After fabrication of 60 record base the digital superimposing with the best fit by EXOCAD was done and measuring the gap in 10 points in which it distributed over the whole anatomical landmark. (A, B, C, D, E, F, G, H, K&L) The 10 points were distributed randomly on the whole anatomical landmarks area on the cast. The cast was divided into five major areas evaluated in the five functional areas, namely, posterior palatal seal, anterior border seal, crest of the ridge, maxillary tuberosity, and palatal area. 20 specimens were tested before relining, 10 were CAD-CAM 3D Printed & 10 were Conventional Heat cured (control), 40 specimens of adaptation test were divided into two main groups, 3D printed group 20 specimens & conventional group 20 specimens, each group subdivided into another two subgroup, 3D samples from (1-10), they were hard relined with PMMA (PROCRYLA, Germany). 3D samples from (11-20), they were soft relined with resilient material (SUPER SOFT, USA). conventional denture base material samples from (1-10), they were hard relined with PMMA, conventional denture base material samples from (11-20), they were soft relined with resilient material then they were tested. The specimens were kept for 24 hours in an incubator at 37°C and not thermocycled, then they were thermocycled for a total of 5000 cycles between 5 °C and 55 °C with a dwell time of 60 seconds and a transfer time of 30 seconds. subjected to 5,000 cycles of thermocycling (SD Mechatronik Thermocycler; SD Mechatronik GmbH, Westerham, Germany) then they were tested again Figure (11).

Results: (ɫ): t-test (Two independent sample), (¥): Z=Mann-Whitney U were used to compare the mean values of Adaptation Before Relining: 3D Printed vs. Conventional denture base materials, Adaptation: Conventional significantly higher than 3D Printed ($p<0.01$). £: F-test One Way ANOVA, Ᵹ: Kruskal-Wallis H test, [(a),(b),(c)] multiple comparison by Duncan multiple range test for Parametric test, [(1),(2),(3),(4)] Rank for Not Parametric test, were used for Comparison Analysis of Adaptation of 3D & conventional Denture Bases between 3DH (3D Hard), 3DS (3D Soft), CH (Conventional Hard), & CS (Conventional Soft) liners at Both Group after relining, Adaptation: Significant differences($p<0.05$), highest in (3DS),

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lowest in (CH). After Thermal-Cycling the results were; Adaptation: Significant differences ($p<0.05$) highest in (3DS), lowest in (CH).
Conclusion: Adaptation of the CAD-CAM 3D Printed denture Base was lower than Conventional heat-cured before Relining. Adaptation of the CAD-CAM 3D Printed denture Base After Relining with hard & soft liners were increased significantly, but decreased slightly After Thermal-Cycling. 3D soft was the best adaptable denture base & the Conventional hard was with the lowest adaptable denture base.
Key words: CAD-CAM 3D Printed, Convectional Heat cured, Relining, Soft liner, Hard liner & Thermal-Cycling.

Introduction

The adaptation of the denture base (the space between the intaglio surface of the denture and the reference cast) is essential for adequate retention and stability. It has also been included as one of the evaluation indexes. Denture base adaptation in dentistry means the degree of fit between a prosthesis and supporting structures. [38] Polymethylmethacrylate resin (PMMA) was the most popular material used to manufacture complete and partial removable prostheses due to its excellent chemical and physical properties, processing simplicity, and affordability. However, the material has some limiting properties, most importantly a volumetric loss of about 7% and a linear shrinkage of 0.45%-0.9% are noted. The discharge of excess methyl methacrylate monomer causes it, which compromises material's dimensional stability, the adaptation of the denture base to the underlying mucosa is hampered by this deformation. [1,2,9]

There are subtractive and additive methods in CAM technology. The subtractive procedure for making complete dentures involves cutting from large resin blocks using a milling bur.[18] Because resin blocks that have already been polymerized are used, their mechanical properties are superior to those of conventional heat-cured resins.[26]

The additive method is based on light-cured resins with lower allergenic potential than PMMA-based resins. However, scientific evidence regarding 3D printed resins' physical and mechanical properties shows they are related to the incremental production mode, as the binding of constituents within each layer is stronger than the binding between layers. This technique leads to lower core cohesion, which can promote the propagation of failures and fractures in the material.[32]

However, it is not possible to reproduce a component that is smaller than the size of the milling bur, and there is considerable wastage of materials. Conversely, additive technology is a process of stacking up layers, so there is little wastage of materials, and small parts can be produced. [1,2,33] Furthermore, there are also several output methods for additive processes, among which stereolithography apparatus (SLA) and digital light processing (DLP) using light polymerization are widely used in dentistry. The SLA method uses a laser beam to polymerize point by point, and the DLP method achieves polymerization using a projector. [13,26,43]

Removable prosthesis may decrease adaptation by time. Aging and resorption of the residual ridge result in a decrease of occlusal vertical dimension, loss of retention and stability, change in occlusal plane, and sore spots. To address these problems, relining, rebasing, or refabrication should be considered. Among these three treatments, relining is the most frequently used method and may be the most appropriate for mild or moderate ridge resorption. Relining dentures can be performed by direct or indirect methods. The direct method, which is inserted directly in the mouth of a patient, is widely

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used because it is faster and simpler than the indirect method. [28]
Denture reline materials are used to prevent chronic soreness for patients with excessive residual bone resorption, thin and non-resilient mucosal tissue, bony undercuts, a tendency to brux, defects that require obturation, xerostomia, or for modification purposes after dental surgery. The bond strength between the denture relines material and the denture base is crucial because a weak bond causes bacterial accumulation, staining, compromised oral hygiene, and eventual detachment of the reline material. Factors that can contribute to bond failure of denture reline materials include the chemical composition of the materials, liner thickness, nature of the adhesive, tear strength, and thermal stresses [7,17]
Immediate and interim complete dentures are commonly relined with soft materials to provide a therapeutic effect to the underlying soft tissues. Short-term resilient liners are materials specifically formulated for this purpose. Resilient liners decrease the energy transmitted to the edentulous ridge from mastication impact, thus making them a useful resource for the treatment of recent extraction sites, abused and irradiated tissues, and the transient obturation of intraoral surgical defects. Plasticized acrylic resins, including poly methyl methacrylate (PMMA) or poly ethyl methacrylate (PEMA) mixed with alcohol and dibutyl phthalate as a plasticizer, are the most commonly used types of resilient liner.[5]
A limitation of short-term resilient liners is rapid leaching of the plasticizer, making them prone to absorb liquids. Continuous liquid absorption leads to progressive hardening, staining, and degradation, eventually leading to the separation of the resilient liners from the denture base because of stress buildup at the adhesive interface.[8]
Thermocycling is extensively used in the dental field to simulate aging. International Organization for Standardization standard 11450 recommends a thermocycling regimen of 5000 cycles between 5C and 55C to simulate aging.[29,41]
A thermocycling regimen of 3000 cycles has been reported to correspond to a dental prosthesis that has been in service for 3 years, on the assumption that patients consume an average of 3 meals a day. Considering that thermal stress was a notable factor in the aging and failure of dentures, thermocycling was expected to decrease observed bond strength values. Although this hypothesis has been corroborated by several studies.[24,41]

Materials and Methods

Denture Base Adaptation: To accomplish the denture base adaptation test, the specimens needed two main layers, the first layer was the dental metal cast which is prepared by pouring a dental stone in a mold prepared specific for the test.The prepared cast was transferred to virtual cast after scanning with digital scanner. Lazer production machine was used to analyze the virtual data to metal cast, The second layer was recording base which was designed virtually bya computer-aided designing (CAD) to fulfill the requirement of the test by reference virtual CAD denture base. After that each technique was caried out by its materials and steps. The fabricated denture bases were rescanned after finishing and excess removal in which digital superimposition was carried out **Figure (1).**

maxillary edentulous definitive casts were prepared from an edentulous silicon mold that fabricated with morphology closely resembling an American College of Prosthodontists (ACP) **Figure (2).** Type A classification of residual ridge morphology. Dental stone type IV was mixed at a ratio of 25 ml of

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water to 100 gm of powder. The ratio and mixing time were carried out according to manufacture instruction.[15]

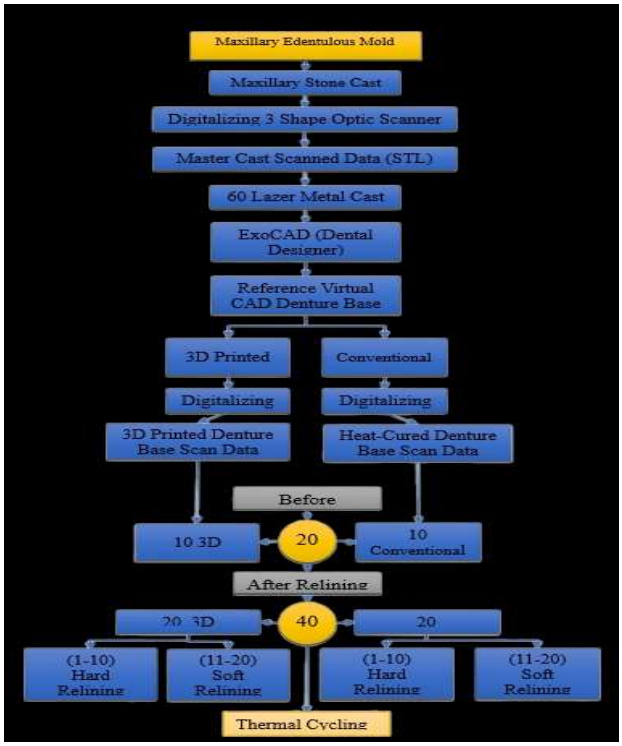

Figure 1: Denture base adaptation protocol.

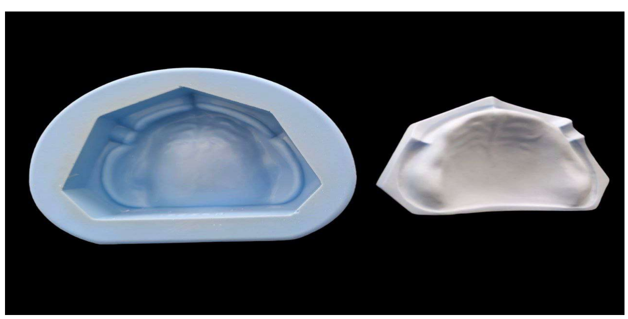

Figure 2: cast preparation from an edentulous silicon mold.

A three-dimensional image for the stone model was taken by (3Shape laboratory scanner, Denmark) scanning was accomplished with (6 µm) accuracy according to ISO (12836) by fully automated Z-axis scan in which the scanner automatically guides the object to be scanned into the measuring field. The model was rotated in a measurement field (X=80x, Y=60x, Z=85 mm), the total scanning time of one model take (29 sec) only with resolution (1.3 MP), So that all surfaces and fine details of the model were shown clearly, scanner outputting STL file Figure (3).[21]

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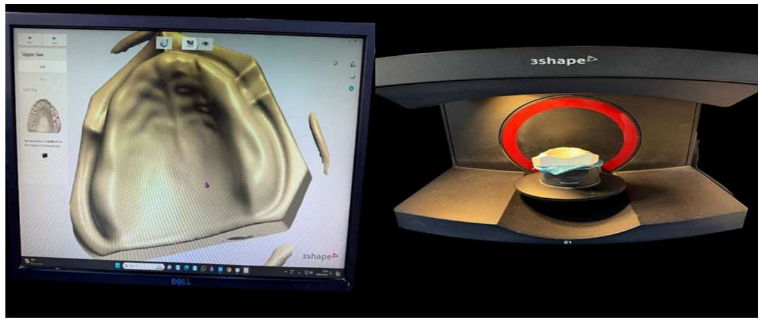
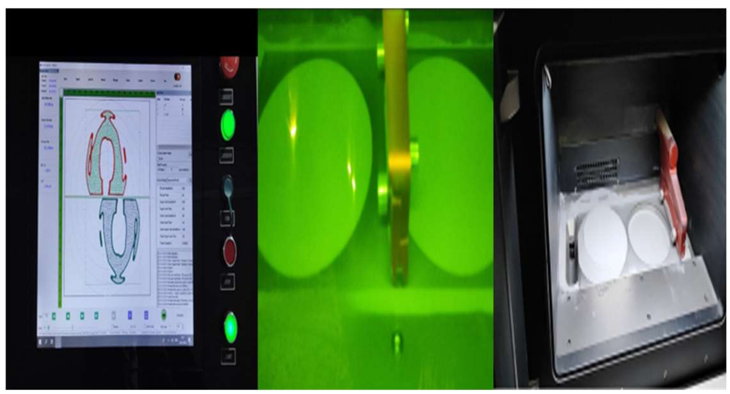


Figure (3): 3Shape; smart optics scanner &Scanner outputting (STL) file.

The next step was the Lazer production of (60) metal cast Figure (4) by using the STL file with machine (RITON, China, Procured Company). Figure (4)



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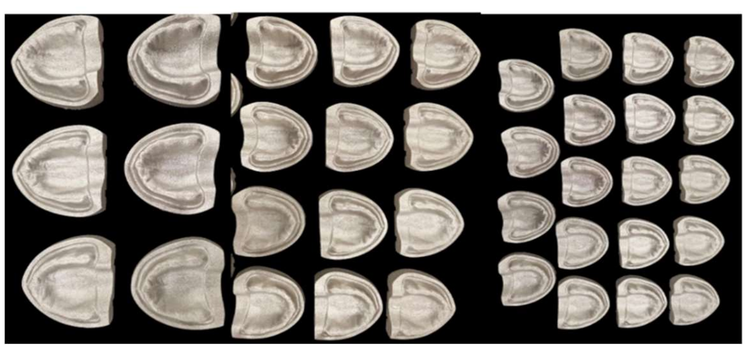

B

Figure (4): A, steps of metal cast production by RITON, Lazer Production machine. B, Metal cast.

Each metal cast was labeled and the denture bases were properly hydrated for 24 hours, at that point softly sprayed with anti-glare spray (3-D laser checking anti-glare shower; Erum-YOONWON) with a particle diameter of 2.8 µm on average, after processing the tissue surfaces of each denture were scanned using (3 Shape optic scanner, Denmark), resulting in STL Files for the tissue surfaces of each denture

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base. Scanning process was completed at room temperature.[19]
The next step was designing of the denture bases in (DESIGN) phase, (3D Builder, Microsoft, U.S.A). Then 3-D printer denture bases were created with a 3-D printable material based on the reference design denture base (Saremco Print, DENTURETEC, Germany).[22]
The 3-D printer specimens were followed the same protocol for the denture base fabrication except that the design was taken from (AutoCAD) as STL file. The substance is an acrylic that is similar to PMMA and has the same qualities as traditional acrylic (Aliphatic Di-fluctional methacrylate, 2.2' Ethylene-Dioxy-Diethyl Di methacrylate, Aliphatic urethane Acrylate, Phosphine oxide). Using (ASIGA printer, Australia) with its specific program that slice the object into multiple layers according to the selected layer thickness with orientation the object to improve the dimensional stability. The light source (a light-emitting diode) of the printer had a 385-nm wavelength, and each building layer was 100 nm thick as illustrated in Figure (5). [31]

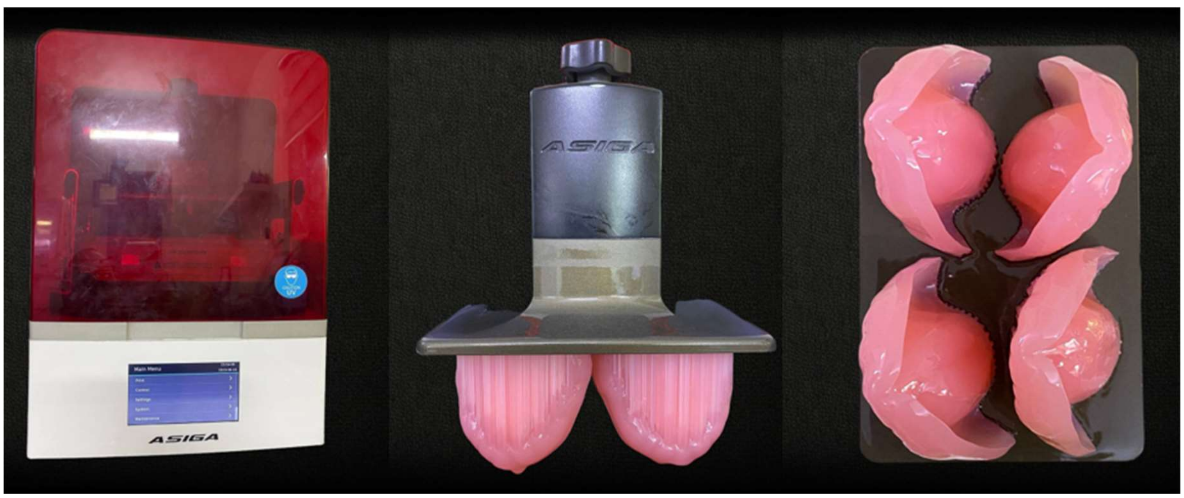

Figure (5): ASIGA Printer & production of 3D Printed denture base

The microplay support structure was located on the outer surface of the denture base, with a 135-degree build angle. According to the manufacturer instructions, the accuracy of the ASIGA printer was ±57 mm. the denture bases were cleaned with ultrasonics in isopropyl alcohol for 10 minutes and then treated with an ultraviolet light post polymerization machine for 15 minutes Figure (6).[23]

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Figure (6): A, 3-D printer denture base in isopropyl alcohol. B, 3-D printer denture base treated with ultraviolet light post polymerization machine

The 3D denture bases were used to create a silicone putty mold by Laboratory silicone rubber base material (R&S, Turboflex, France) with two holes in separated location, one hole for molten wax insertion and the other for the excess wax escapement to ensure that all spaces between the mold and the metal cast was filled by wax for standardized duplication after the removal of the 3D denture base from the metal cast. A total of (30) wax denture bases with identical shapes and thicknesses were prepared based on the corresponding master casts using the putty mold. molten baseplate wax was injected into the mold to create standardized wax denture bases Figure (7).

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Figure (7): The silicone putty mold of wax denture bases, which then used to fabricate heat-cure acrylic denture base.

The powder and liquid of the heat-polymerizing acrylic resin (PROCRYLA, Germany) were mixed according to the manufacturer's ratio; 3:1 the mixture was then packed in the molds. The two parts of the flask were tightened to each other, they were pressed under a compression force of 13.8 kPa. (TISSIDental, Italy), The flask was kept in curing machine (Li Zhonc, China) at room temperature and the temperature is raised to 74C (165F) and maintained for 9 hours in the curing machine.[4] The flask was removed from the water bath after completing the curing cycle and allowed to be cooled at bench for 3 hours. The flask was opened carefully and the cast with its corresponding denture base was deflasked Figure (8).

Figure (8): Defklasking of the denture base.

All finished dentures were hydrated for 24 hours, then lightly coated with anti-glare spray (3-D laser scanning anti-glare spray; Erum- YOONWON) with an average particle size of 2.8 mm, and the intaglio surface of each fabricated denture base was scanned using (3Shape laboratory smart optic scanner, Denmark). outputting an STL file for each denture's intaglio surface. The STL file of each denture was superimposed on the STL file of the corresponding preprocessing metal cast using the same software (DentalCAD, Exocad, 3.1 Rijika) with four layers (metal cast, denture base after processing, cast/denture base together and the overlay guide) Figure (9).

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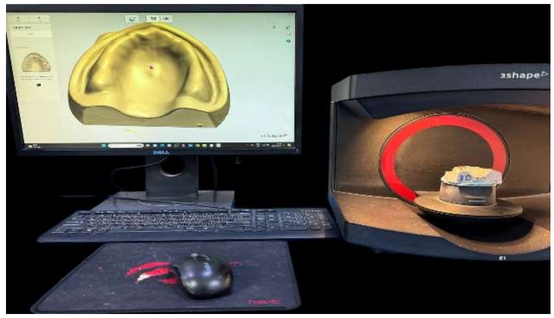

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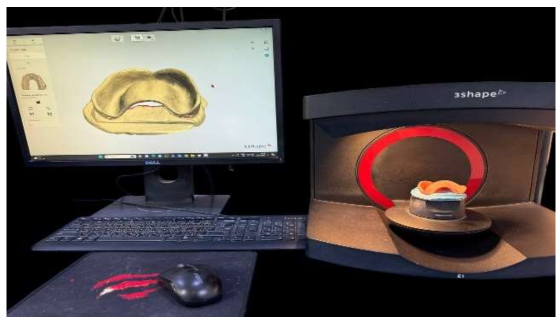

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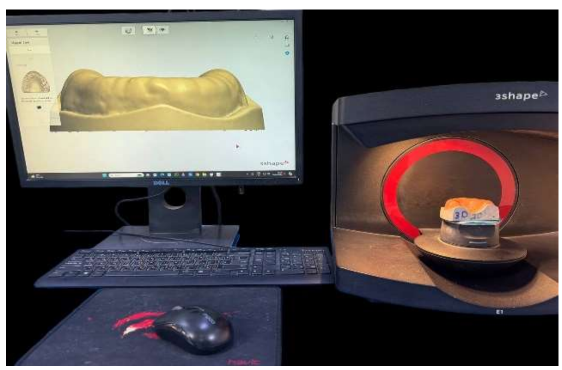

C

Figure (9): Digitalization Program, A. Metal cast after processing, B. Inner surface of the denture base, C. Cast/denture base together

The benefit from cast/denture base layer was to guide the denture to locate in its correct position. Using this software, measurements were made at 10 points (A, B, C, D, E, F, G, H, K&L) for eachof the 10 dentures using an overlay guide layer in which it represents one of best fit denture bases with 10 points drawn on it in specific location to occupy the whole anatomical landmark and used as guide for all denture bases for standardization the measurement. The 10 point was distributed randomly on the whole anatomical landmarks area on the cast. The cast was divided into five major areas evaluated in the five functional areas, namely, posterior palatal seal, anterior border seal, crest of the ridge, maxillary tuberosity, and palatal area. Figure (10).[15,30]

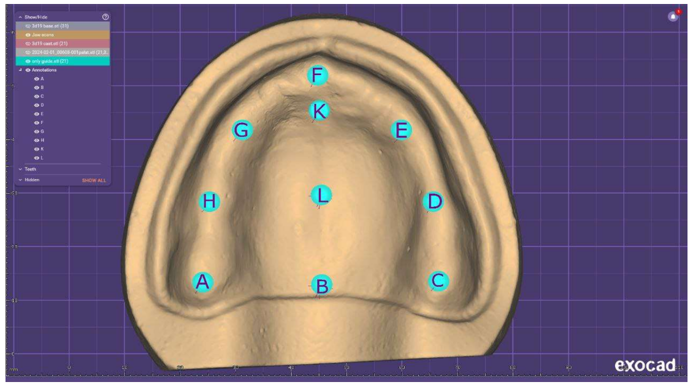

Figure (10): The testing procedure of denture base adaptation after superimposition and the 10-point determination.

(40) specimens of adaptation test were divided into (2) main groups, 3D printed group (20) specimens & conventional group (20) specimens, each group subdivided into another (2) subgroup, Group A represent 3D samples from (1-10), they were hard relined with PMMA (PROCRYLA, Germany). Group B represent 3D samples from (11-20), they were soft relined with resilient material (SUPER SOFT, USA). Group C represent conventional denture base material samples from (1-10), they were hard relined with PMMA. Group D represent conventional denture base material samples from (11-20), they were soft relined with resilient material Figure (11).

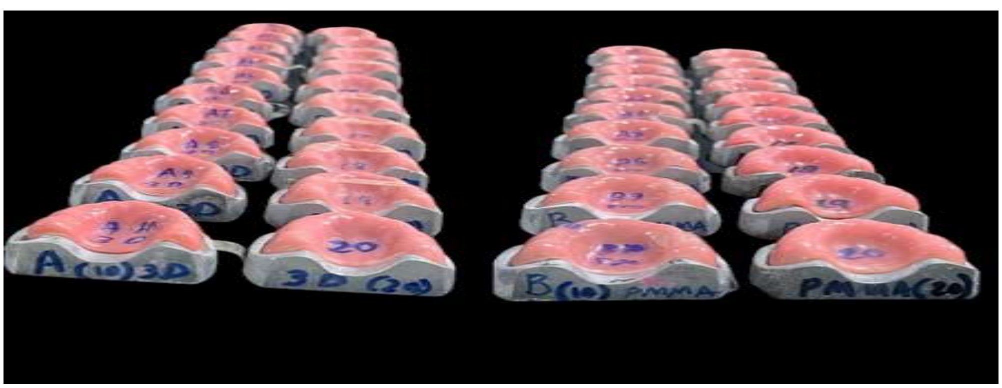

Figure (11): Specimens of 3D printed & Convectional denture base after relining

The specimens were kept for 24 hours in an incubator at 37°C and not thermocycled.[36] Specimens of adaptation test were thermocycled for a total of 5000 cycles between 5 °C and 55 °C with a dwell time of 60 seconds and a transfer time of 30 seconds .[35] subjected to 5,000 cycles of thermocycling (SD Mechatronik Thermocycler; SD Mechatronik GmbH, Westerham, Germany).The thermo-cycling machine was consisted of two baths, for the hot bath; there was a boiler, provided with a thermostat to regulate the temperature to be in 55±2 ºC, for the cold bath there was a refrigerator compressor, provided with a thermostat to regulate the temperature to be in 5 ±2 ºC. The samples were placed inside a basket connected to a handle to transfer the basket automatically between the baths; 30 seconds in each bath and 5 seconds interval between each bath. A thermocouple (HT-9815 Thermocouple Thermometer) was

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used for monitoring the temperature of the baths by inserting the one probe in the hot bath and one probe in the cold bath Figure (12).[1,6,10,16]

Figure (12): Process of Thermocycling after Relining of the Denture Bases

Statistical Analysis

(ƫ:) t-test (Paired), (£:) Wilcoxon Signed Ranks Test were used to compare the mean values of 3D Denture Bases before & after relining with Hard & soft liners & after thermal cycling. £: F-test One Way ANOVA, Ᵹ: Kruskal-Wallis H test, (a),(b),(c) multiple comparison by Duncan multiple range test for Parametric test, (1),(2),(3),(4) Rank for Not Parametric test, were used for Comparison Analysis of Mechanical Properties of 3D & conventional Denture Bases between 3DH (3D Hard), 3DS (3D Soft), CH (Conventional Hard), & CS (Conventional Soft) liners at Both Group after relining & After Thermal Cycling. When ($p>0.05$) no significant difference was reported, ($p<0.05$), statistical significance was reported for all comparisons, ($p<0.01$) highly significancy was reported.[34]

Results

When Comparative Analysis of Adaptation (Gap between denture bases & underlying metal casts) Before Relining: 3D Printed vs. Conventional denture base materials, there was 3D printed significantly higher ($p<0.01$) Table (1) & Figures (13), (16).

Table 1: Comparative Analysis of Adaptation Before Relining: 3D Printed vs. Conventional denture base materials.

				N	Mean	Std. Deviation	Test Value	d.f.	P-Value
Before Relining	Control 1-2	Impact Strength	3D	10	2.370	0.589	-0.973¥	18	0.331
			Conventional	10	2.850	1.001			
		Flexural Strength	3D	10	83.333	9.980	1.273¥	18	0.203
			Conventional	10	76.446	15.383			
		Adaptation (Mean)	3D	10	0.718	0.132	6.325ǂ	18	0.000
			Conventional	10	0.341	0.134			

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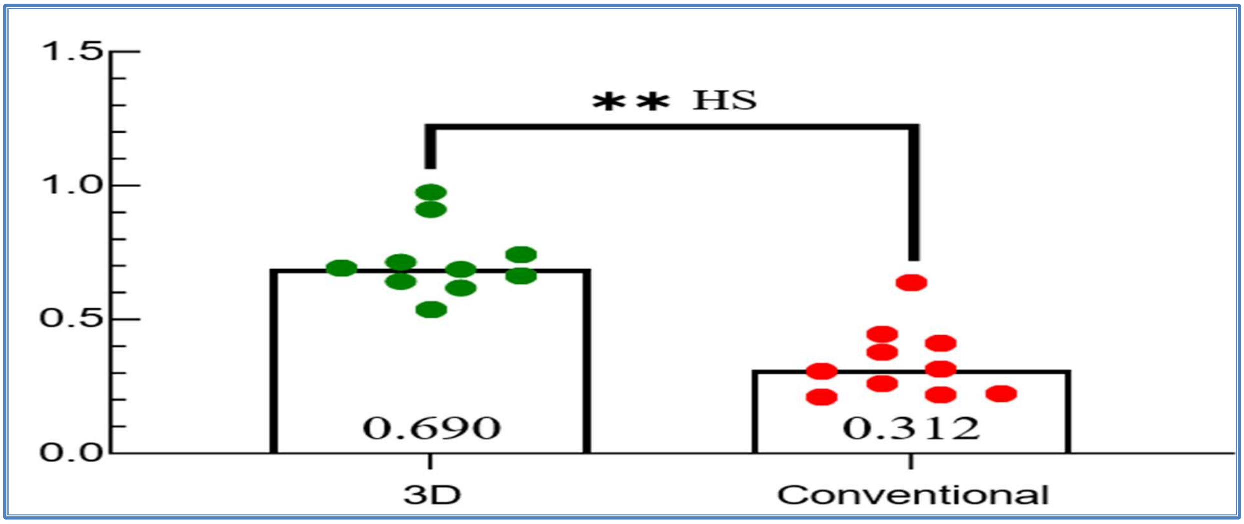

Figure (13) (: Degree of signifancy between 3D & Conventional Denture Base Adaptation Before Relining.

When the specimens of CAD-CAM (3D printed) were relined with hard liner (PMMA) & then thermal cycled, Relining significantly reduced the Gap between denture bases & underlying metal casts, but thermal cycling increased it slightly compared to relining alone, with both changes being highly significant ($p<0.01$). While when the specimens of CAD-CAM 3D printed were relined with soft liner (SUPER SOFT) & then thermal cycled, significant reduction after relining, with a slight but significant increase after thermal cycling was occurred ($p<0.05$) Figures (14), (15), (16). When the specimens of Conventional (heat cured) were relined with hard liner (PMMA) & then thermal cycled, the Gaps between denture bases & underlying metal casts, were significant increase after both relining and thermal cycling ($p<0.05$). While when the Conventional (heat cured) was relined with soft liner (SUPER SOFT) & then thermal cycled, there was no significant change after relining or thermal cycling ($p>0.05$), Figures (14), (15), (16).

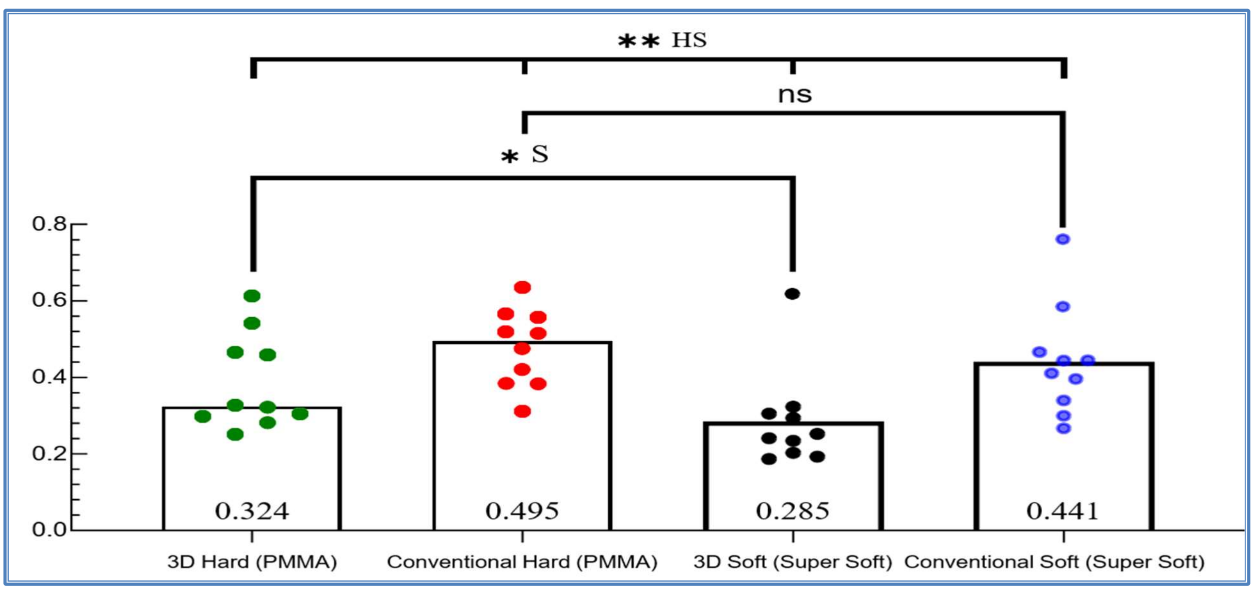

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Figure (14): Degree of signifancy between 3D & Conventional Denture Base Adaptation After Relining.

When the specimens of Conventional (heat cured) & CAD-CAM (3D printed) were compared After Relining, the Gaps between denture bases & underlying metal casts (3DH, 3DS, CH, & CS) liners from both Group, there was significant differences ($p<0.05$). Highest in conventional hard, lowest in 3D soft Table (2) & Figure (14), (16). While when the specimens of Conventional (heat cured) & CAD-CAM (3D printed) were compared After Thermal Cycling, (3DH, 3DS, CH, & CS) liners from both Group, there was significant differences ($p<0.05$). Highest in conventional hard, lowest in 3D soft Table (3), Figure (15), (16).

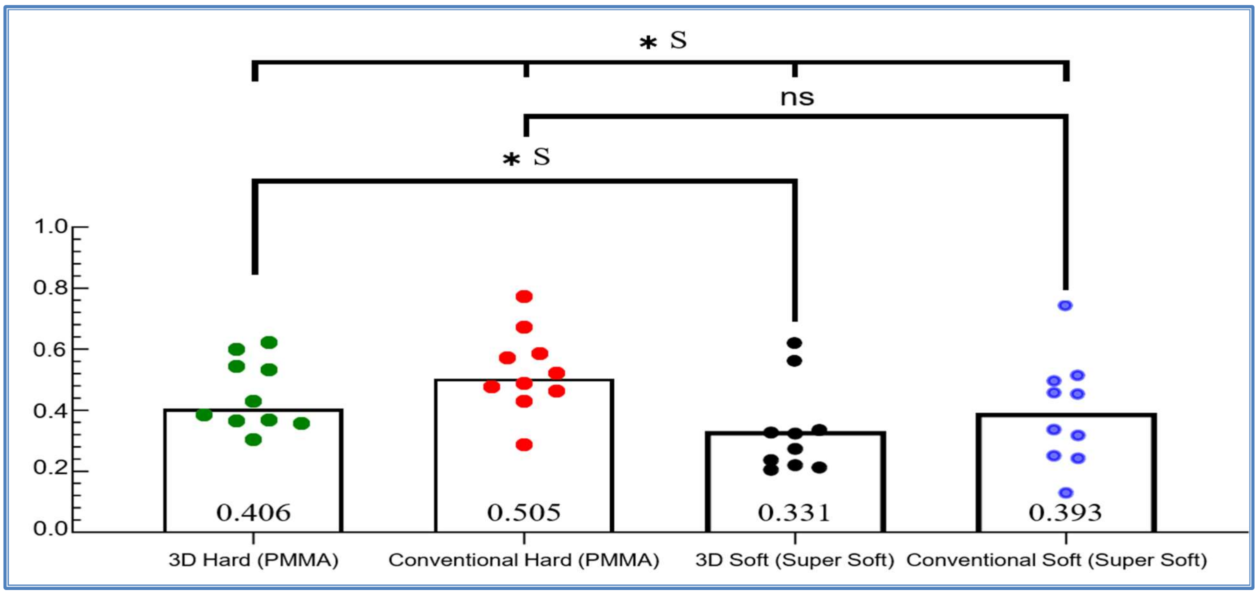

Figure (15): Degree of signifancy between 3D & Conventional Denture Base Adaptation After Thermal Cycling.

Table 2: Comparison Analysis of Adaptation of 3D & conventional Denture Bases between (3DH, 3DS, CH, & CS) liners at Both Group After Relining.

Y4 Adaptation (Mean)	3 After Relining 3D Hard (PMMA)	10	0.386(2)	0.124	13.073 K	0.004 (HS)
	4 After Relining 3D Soft (Super Soft)	10	0.285(1)	0.126		
	5 After Relining Conventional Hard (PMMA)	10	0.477(4)	0.100		
	6 After Relining Conventional Soft (Super Soft)	10	0.441(3)	0.144		
	Total	40	0.397	0.140		

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Table 3: Comparison Analysis of Adaptation of 3D & conventional Denture Bases between (3DH, 3DS, CH, & CS liners at Both Group After Relining & Thermal Cycling.

Y4 Adaptation (Mean)	7 After Relining and Thermal Cycling 3D Hard (PMMA)	10	0.450(3)	0.114	9.301 K	0.026 (S)
	8 After Relining and Thermal Cycling 3D Soft (Super Soft)	10	0.331(1)	0.146		
	9 After Relining and Thermal Cycling Conventional Hard (PMMA)	10	0.527(4)	0.135		
	10 After Relining and Thermal Cycling Conventional Soft (Super Soft)	10	0.393(2)	0.174		
	Total	40	0.425	0.156		

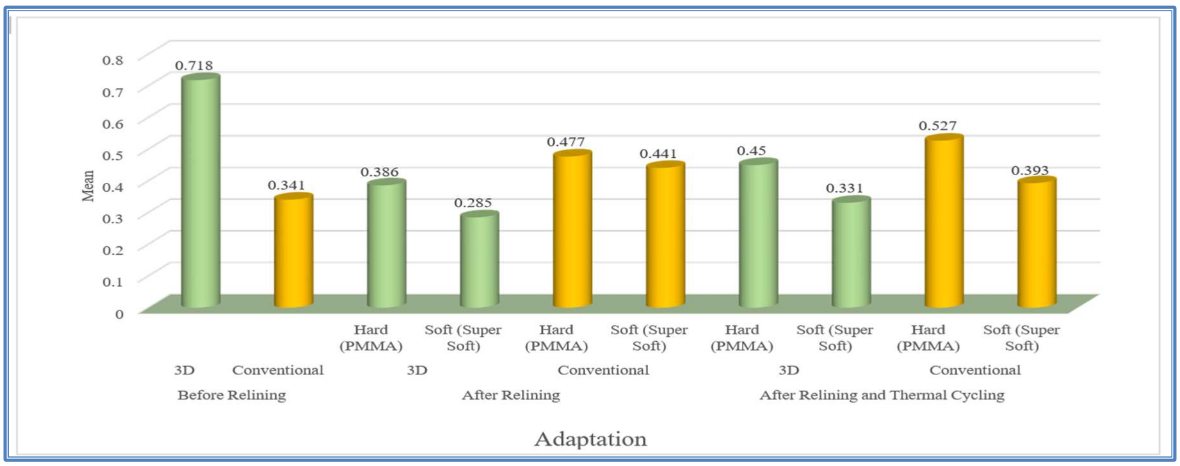

Figure (16): Bar chart illustrate the mean values of Adaptation of 3D & Conventional Denture Bases Before & after relining & after Thermal cycling.

Discussion

Adaptation of the Denture Base: Complete dentures should provide an intimate adaptation to the mucosa to enhance the performance during masticatory cycle.[12] The aim in fabricating CDs with new and advanced techniques to provide the optimal mucosal adaptation. Another important factor in CD fabrication is the reproducibility of the technique that produces the same accurate denture base each time.[18,20]

Adaptation of the denture base was evaluated by measuring the gap between the denture base and the mucosa that corresponds to edentulous cast in in vitro studies. Evaluation of adaptation by surface matching and best-fit algorithms which were attributed as digital method requires coating the denture base for scanning.[18] Coating powder may cause additional errors if not homogeneously applied albeit was not scientifically proven.[27]

Also, previous studies performed by either physical or digital techniques generally evaluated the gap using linear measurement of the vertical distance between the cast and base.[18,25,37, 42]

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The digital superimposing enables to measure the areas where the denture base implies a compression to tissue is shown by negative values. However, those areas would probably prevent the denture base from seating as accurately as this modality allowed, leading to a greater miss-fitting. As a result, rather than the actual denture base adaption, the digital superimposition method should be viewed as an assessment of overall trueness. Also, previous studies performed by either physical or digital techniques generally evaluated the gap using linear measurement of the vertical distance between the cast and base. However, because the gap between denture base and dental cast was in 3-D space, linear measurements alone would be insufficient to assess it.[15]

The processing technique associated with the least degree of distortion, thus providing the closest adaptation of the denture base to the cast, was considered as the best technique. However, when applied clinically, the soft tissue resilience and compression would definitely contribute to the prosthetic treatment outcome which could not be simulated and addressed properly. The incorporation of different anatomical situations such as the presence of alveolar resorption, the presence of undercuts, different palatal forms (high or shallow), and various mucosal surface configurations (granular or smooth) would influence the adaptation of the processed denture bases.[30]

The aim of this in vitro study was to compare the adaptation of Complete Denture Base (CDB) manufactured by two different techniques, namely, Conventional heat cured and CAD-CAM 3-D Printing, before & after relining & after Thermal-Cycling. Based on the results of this study, the null hypothesis that there is no significant difference in the adaptation of the CDBs fabricated with different techniques was rejected. The results of the present in vitro study demonstrated that the adaptation of the CAD-CAM 3D Printed CDB was statistically highly lower than that of the conventionally heat-cured CDB, both for the overall CDB surface and for preselected regions of interest & this was satisfied with other studies [15,23,30]

The difference in the adaptation between different test groups may be attributed to the difference in the processing techniques. In conventional fabrication technique, the acrylic resin polymers have been introduced as denture base materials and the majority of denture bases are fabricated using PMMA. These materials have optimal physical properties and excellent esthetics with relatively low toxicity compared to other plastic denture base materials. However, shrinkage and dimensional changes in denture bases during resin polymerization are inevitable and have been well documented. Such problems increase the gap between the denture base and underlying mucosa, compromising the adaptation of dentures.[30]

In the 3-D printing technique, complete dentures are manufactured out of unpolymerized resin; and after processing each layer, a final light polymerization step is intended to complete the procedure. The dentures being incompletely polymerized before this last step makes the polymerization shrinkage an eventual phenomenon associated with the 3-D printing manufacturing technique. Deformation might take place while disassembling the partially polymerized prosthesis from the build platform. On the contrary, 3-D printing technology presents some advantages such as less waste of raw materials and low-cost infrastructure [30] & this was the explanation for the decreased adaptation of CAD-CAM 3D (increased gaps between the denture base & underlying metal cast) when it was compared to Conventional Heat Cured denture bases.

When the CAD-CAM 3D Printed materials were relined with hard liner (PMMA), the gap between

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denture base & the underlying metal cast were significantly decreased, this may be was due to that, as PMMA was undergo heat polymerization with long cycle process 9 hrs., majority of the monomer was converted to polymers that's means very low residual monomer , therefore polymerization shrinkage was decreased, the results were more adaptation of 3D Printed to the underlying metal cast but when these materials were Thermal -Cycled there was slightly increased in gaps measurements in compression to that gaps resulted After Relining & this may be was attributed to further polymerization & this was approved by.[39] They approved that further polymerization reactions can be enhanced due to heating the acrylic resins which affect the mechanical properties, The water absorption is thus directly related with the dimensional stability of dental material.[14] Absorbed water can reduce the mechanical properties of the denture, because the water can act as a plasticizer, soften the denture and enhance the elasticity this consequences will decreasing the bond strength.[40]

When the CAD-CAM 3D Printed materials were relined with soft liner (SUPER SOFT), the gap between denture base & the underlying metal casts were significantly decreased after relining & this may be was due to that SUPER-SOFT liner was heat-cured material, it was cured for about 6 hrs., complete polymerization occurred, that's to say mechanical property (Adaptation) was enhanced after relining, which may influence the performance of the relined removable prostheses.[39] There was slight increase in gap after Therma-Cycling & this may be explained by that, the water absorption is thus directly related with the dimensional stability of dental material.[14] Absorbed water can reduce the mechanical properties of the denture, because the water can act as a plasticizer, soften the denture and enhance the elasticity this consequences will decreasing the bond strength.[40]

When the specimens of Conventional (heat cured) & CAD-CAM (3D printed) were compared After Relining, the Gaps between denture bases & underlying metal casts (3DH, 3DS, CH, & CS) liners from both Group, there were significant differences, highest in conventional hard, lowest in 3D soft & the same results were obtained After (3DH, 3DS, CH, & CS) liners were Thermal- Cycled. This may be was due to that, the use of 2 different relining materials, & this was studied by.[11] As the SUPER-SOFT liner was heat-cured for 6 hrs. & PMMA was heat cured for 9 hrs., time of curing may be was the cause for that increased adaptation of 3D Soft group & the lowest adaptation of Conventional hard, as hard liner was subjected to heating more than the soft liner & this was studied by.[39] They approved that further heating may influence the performance of the relined removable prostheses. Furthermore, different thermal expansion coefficients (CTE) of materials, as the possible differences in CTE between the denture base resin and the reline material, lead to different degrees of shrinkage and expansion.[6,40]

Conclusion

Adaptation of the CAD-CAM 3D Printed denture Base was lower than Conventional heat-cured before Relining. Adaptation of the CAD-CAM 3D Printed denture Base After Relining with hard & soft liners were increased significantly, but decreased slightly After Thermal-Cycling. 3D soft was the best adaptable denture base & the Conventional hard was with the lowest adaptable denture base.

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