Comparison of debonding of different composite resin bonds and acrylic tooth with Acrylic denture base after thermocycling regimes.

Aso M. Zangana [(1)], Ghalib R. Hawrami[(1)], Samir A. Hamad[(1)]

ABSTRACT

Background and objectives: The purpose of this study was to repair detached acrylic tooth using composite resin and comparing it debonding with cold cure acrylic after thermocycilg process.

Methods: Materials used in the study include: four composite groups (Ceram, Composan, ESTELITE and Dynamic Plus) with a single group of acrylic artificial teeth bonded to acrylic (n=10). Specimens have tested the thermocycling then specimens were subjected to stress using a universal testing machine.

Results: The outcome data statistically were analyzed, results showed that (ESTELITE) Tokoyama, brand has the highest value of tensile bond strength (7.05 MPa), and the lowest one Cerama brand with the (5.12 MPa) mean composite groups, but the cold cure acrylic one with the (2.07 MPa).

Conclusion: Replacement of missing artificial teeth on the denture base with a different brand of composite can be done as an alternative to acrylic teeth and the thermocycling regime influence the debonding process.

Key-words: composite resin, artificial teeth, denture base, thermocycling, and debonding.

[(1)] Dental assistant dep., Erbil polytechnic university
Corresponding author: Ghalib Rahman Hawrami
email: ghalibrahman.ghalibhawrami@gmail.com

INTRODUCTION

The dental defects were restored with several types of appliances such as denture[1], bridge[2] and implant.[3] Sometimes artificial teeth on the dentures are subjected to debonding due to various types of stress.[4] The replacing of debonded teeth consumes time[5] and requires cooperation among dental specialities.[6] Dentists can manage this type of issue in the private clinic by rebuilding new teeth with composite light cure material.[7]

Since 2010 many article was published attempted to fill the gap that related to different type of material rather than acrylic artificial tooth at the same time articles related to the bond strength of repaired acrylic denture teeth using visible light cure (VLC) composite resin, those studies assemblies concluded that VLC composite can be used as an alternative for acrylic tooth that missed or debonded from acrylic denture base. [8] (Ghaffari T *et al*, 2019) concluded that The greatest shear bond strength was attributed to Ivoclar acrylic teeth followed by Apple composite and B-Star nanocomposite artificial teeth. Addition of monomers to the tooth surface significantly strengthened the shear bonding of acrylic base resin to the teeth.[9] Where (Ghahramani L *et al*, 2010) in a different article published that type of denture base sssssss

material and artificial tooth may influence the failure load where auto-polymerized resin ($P<0.05$). However, the bond strengths of all composite teeth to both denture base resins were not significantly different ($P>0.05$).[10]

Thermal changes naturally occur in the oral cavity and the laboratory represented this occasion similarity are thermal cycling regimens where it is the extra orally processes of subjecting dental prosthesis to extreme temperatures.[11]

Other researchers managing the effect of thermocycling on bonding strength between acrylic artificial teeth and denture base, in a study done by Fatah N. 2009 conclude that type of denture base and thermocycling influence the shear bond strength.[12] Where Hawrami G. 2011 concluded that thermal regime decreases the strength of bonding that occurred between acrylic teeth and denture base.[13] Freitas S et al, 2018 conclude that thermocycling did not affect the bond strength teeth-denture base.[14] Other researcher published that it was showed that there is a significant difference between the shear bond strength of acrylic and composite denture artificial teeth to heat-cured acrylic resin.[15]

Several techniques using to evaluate the bonding that occurs between prepared tooth and denture base, the brass collar is one of them where researchers try to evaluate the bonding amount between tooth and acrylic.[16]

The aim of the current study is to compare the debonding (tensile bonding strength) among repaired teeth with a different type of composite and acrylic artificial tooth and what is the influence of thermocycling on different types of composite, finally which of these materials and techniques are the best.

METHODS

According to (Cunningham and Benington, 1996) a brass collar[15] from metal was performed using a turning operator machine, then preparing a mold for tested brass done using Silicone rubber

base (ZetaPlus soft, Zhermack, Italy) to perform a uniform mold, the prepared mold cutting vertically at the middle with a blade no. 15 allowed to form four indices to excellent repositioning after each sample making, using two large rings for fixation of the mold during each sample preparation Figure 1 and 2.

The beam of the sample to be in the same position and alignment during wax pattern preparation, the brass ring put in the lower large area of mold after that repositioning of the two halves of silicone mold together with aiding of indices and fixing it with two large brass rings tight both halves, finally molten wax [Polywax toughened dental modeling wax (Russia)] was added to the upper hole of mold and allowed for bench cool then remove the large rings and separate the two halves of the mold at the end specimens will be obtained. Using the above technique prepare 40 wax patterns each of them attached to the small brass ring.

Flasking , wax elimination, deflasking , packing and curing were performed by conventional procedure to prepare acrylic beam with the mentioned dimension in the Figure 1-B .

Addition of composite on the top of the specimens:

Each sample was prepared so that the acrylic beam side beyond the metal ring as shown in Fig(1,2) was flattened using a diamond disc which was fixed horizontally with an engine that was fixed on the surveyor in the zero tilt and equaled to the level of the ring; the ring was separated from the acrylic shaft and reinserted to ensure free movement of the acrylic shaft in order not to interfere with the result of debonding measure test, Fig (3 - B). After testing the rotational and vertical movement of the acrylic shaft the ring was reinserted into the shaft and acid etch (37% phosphoric acid etching gel, D line company, Lithuania) was applied to the end surface of the acrylic shaft for 15 seconds then washed out the used triple syringe and dried for 5 seconds, after that bonding {(beautiBond, self-etch light cure one component Dental Adhesive) SHOFU INC. USA}, applied with a brush to the prepared surface, after 15 seconds, dried for 5 second according to manufacturer's instruction then light cured by using light cure apparatus (LED curing light unite DB68500c19 super doul Foshan COXO medical instrument C.Ltd. Chin) for 20 seconds. By using a cel-

luloid band, a mold was prepared around the metal ring and then fixed with a clear stick tape after that composite was applied to the mold using ash no. 6 then condensed and flattened to an equal thickness of 2 mm by using cement condenser, finally, this layer was cured with a light cure for 20 seconds, further additional layers of composite applied according to the same manner until getting the mass that can be inserted to adapter which constructed for universal testing machine to subjected for debonding stress, the same procedure was done for all samples Fig (3 - C).

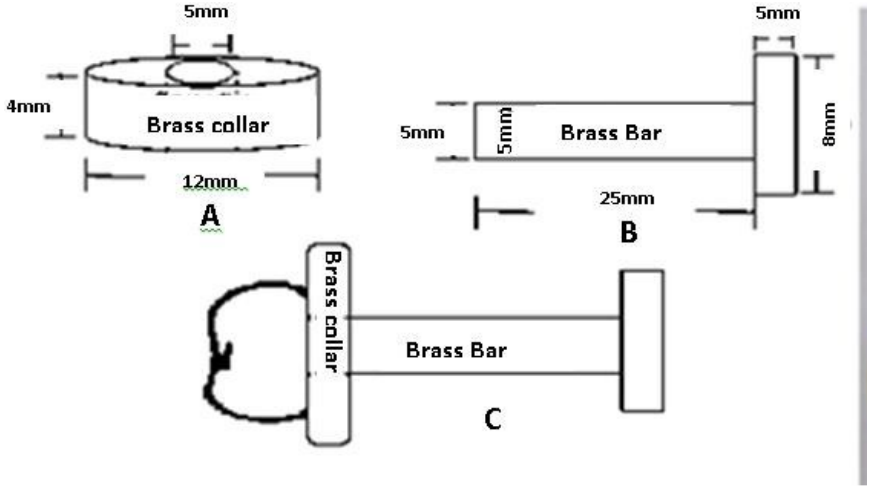


Figure 1: A: Brass collar, B: Brass bar, C: Tooth attach to brass bar through brass hole (Cunningham and Benington, 1996)

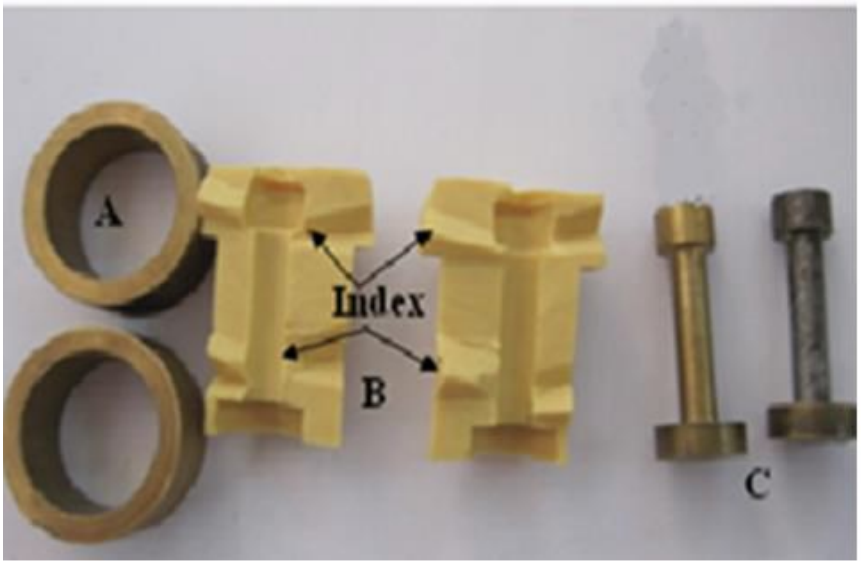


Figure 2: Mold to obtain standard attachment, alignment, diameter and length of wax pattern A: Ring to fix the silicone rubber, B: Silicone rubber with indexes, C: Brass bar with brass ring

The sample was subdivided into 4 groups A, B, C and D each group (n=10)
For group A we use {(Ceram .x sphere TECo one) Dentsuply Sirona}.
For group B we use {(Composan LCM) Promedica, Germany}
For group C we use {(ESTELITE Alpha α) Tokuyama dental, Japan}
For group D we use {(Dynamic Plus) President Dental, Germany}
Finally, the samples were stored in (distilled water) in a room temperature for 24 hour then prepared these 40 samples for thermocycling regimes.
Repairing missing tooth using cold cure acrylic:
Additional 10 beams with the above property are made, on the other hand 10 acrylic artificial teeth grind on the survey using the same procedure of grinding discussed in the previous part of this study, then cold cure acrylic is used to bonding the tooth with the prepared face of beams, above the collar ring, finally, this groups is stored in the distilled water ready for thermocycling regimes as 5th group of the sample.

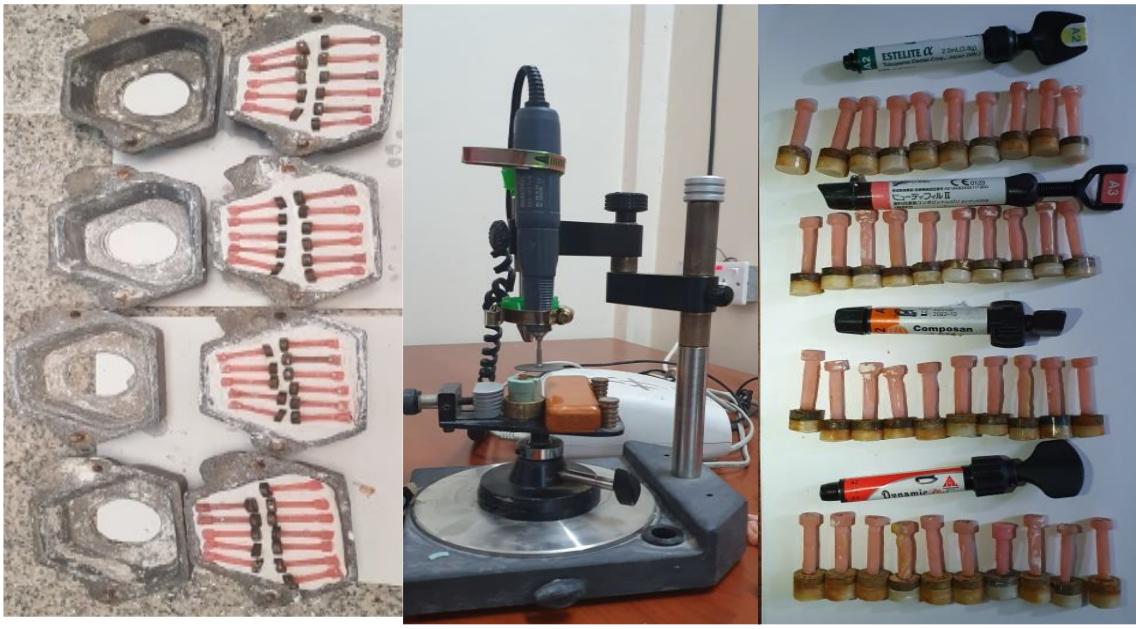
Thermocycling the specimens:

According to ISO standard, ISO TR 11405:1994 (E) testing dental materials[25], involves placemat of specimens in thermocycling for 500 cycles between 5° C and 55° C with 20 second dwell time in each water bath and 5-10 second interlude between water baths when one cycle constitutes a combined hot and cold water bath immersion. [3] There a prepared sample undergoes this type of regime using a local full automatic thermocycling machine [13], Figure 4 . According to (Pinto et al, 2004) man drinks cold and hot in each meal were 1095 cycles representing one year of dental material used [20], in the current study the sample undergo 500 cycles representing near 6 months. All samples were treated in a thermocycling device at 500 cycles at border temperatures ranging from 5° C ± 2° C and 55° C ± 2° C with an interval of 30 seconds following each immersions.[13]

Debonding of the samples:
The samples were held in the metal fixtures part that was constructed by turning the operator machine to grasp the sample ends in one side and the end of the machine on the other side[13], Figure 5.A. the universal tensile testing machine model HD-B604B-S – China Figure 5.B is programmed by the shape of the sample where it is round, the length is with 25mm finally the diameter with 5mm at the end the velocity of the machine during the uprising just it is 2.000mm/min were it is the optimum velocity for debonding the plastic material Fig (5.C), this device is updated computerized one all content is controlled with update software, for each sample the preloaded force, elongation, stroke and maximum force standardized to zero Figure 4.D.
The machine directed to loaded through its own computerized software, in a moment the outcome of data appeared on the computer monitor were a graph is drowned continuously with the uprising the machine within the couple minutes the curve reach a peak, the sample were debonded, the maximum force calibrated and the loaded force down to zero. This procedure is first done to the pilot sample to know the safety of the process, then shifted to the real specimens by the same method applied then the outcome are saved and documented according to sample and groups.
At the beginning, the data outcome from the Universal testing machine was represented by a graph and the maximum load was given by Newton at the same time on the other excel sheet this outcome using several complex mathematical steps was converted to (MPa) (O'Brien, 2002) [17] , (Craig and Powers, 2004). [18]
The following equation discusses the debonding force by Mega Pascal:
T.S= F/S
Surface area of circle = pi* r2 were D (diameter) = 5mm,
S= (22/7) * (5/2) 2

S= 19.643 mm2
T.S= tensile strength ((Kg. m. s2)/mm2) or (N/mm2)
F= force at failure (N)
S= area of cross-section (O'Brien, 2008).[19]
Changing the Kg to N must be multiplied by the result by 9.81(m.s2) Newton,s low of gravitation.

At the end application the following equation :
T.S = F/S
To obtain Mega Pascal, the Pascal (N/mm2) dividing on 1000000 according to (The International System of Units).
Microsoft Office 2010 was used for statistical analysis



A **B** **C**

Figure 3: A: Wax sample invested in the flask, B: Surface roughening of acrylic beam on the surveyor, C: Specimens with composite brand.

Figure 4: Specimens during thermocycling regime

Figure 5: A: Spacimens ready for test, B: Universal testing machine, C: Specimens between jows of machne , D: Software of tested machine

RESULTS

After estimation of the Tensile bonding strength (T.B.S.) of the thermocycling specimens using a universal testing machine, the data are collected, tabulated, and organized then statistically managed using software platform statistical analysis (spss 2020) , in the current study four composite and one acrylic groups are estimated and in each groups there are 10 samples.

The collected data was statistically managed, after that the final data consider the base for other statistical analyses using Test of Normality, the outcome of the process which is normality test for all five groups that observed in Table 1

Then descriptive analyses between different groups after managed by thermocycling regime are seen in the Table 2, the mean debonding of the samples in group C Tokoyama are the highest one 7.0573 MPa S.D.= ±1.99 MPa, after that the both group D Dynamic and B composan in the middle but the range of D Dynamic is less than of the B composan finally group A cerama sss

.

give minimum 5.12225 MPa S.D.= ±2.70 , while the group E Cold cure Acrylic is the worse one by the range of 2.074444 MPa S.D= ±0.77.

In Table 3 the test of ANOVA single factor is used to estimate the significancy of groups to estimate that if P-value in the accepted range or in the rejected zone and the table was illustrate that the significancy are in the accepted range($p<0.01$).

In Table 4 using Multiple comparison test to illustrate the comparison of all thermocycled groups among each other, each group separately compered to other four groups.

In Figure 6 there is estimation for mean of different groups where subjected to stress using Tensile bonding stress by universal testing machine, it shows that the mean of ESTELITE composit is in the peak (7.057 MPs) , at the same time repairing tooth with cold cure is in the lowest level (2.074 MPs) on the other hand (Dynamic , Composan and Ceram) respectively remain in the middle.

Table 1: Test of Normality for five groups (Ceram, Composan, ESTELITE, Dynamic and Cold cure)

	Group	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	Df	Sig.	Statistic	df	Sig.
T.B.S	Ceram	.170	8	.200*	.893	8	.248
	Composan	.180	10	.200*	.932	10	.467
	ESTELITE	.209	10	.200*	.909	10	.276
	Dynamic	.225	9	.200*	.861	9	.097
	Cold cure	.214	9	.200*	.873	9	.134

Table 2: Descriptive analysis for all groups (Ceram, Composan, ESTELITE, Dynamic and Cold cure)

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Ceram	8	5.122	2.697	.954	2.867	7.377	1.80	8.32
composing	10	6.012	2.262	.715	4.394	7.630	3.01	9.97
ESTELITE	10	7.057	3.768	1.192	4.362	9.753	1.49	11.74
Dynamic	9	6.457	1.992	.664	4.926	7.988	2.39	8.35
Cold cure	9	2.074	.771	.257	1.482	2.667	1.07	3.04
Total	46	5.401	2.991	.441	4.513	6.290	1.07	11.74

Table 3: where using Analysis of variance (ANOVA) single factor among all five groups

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	141.423	4	35.356	5.549	.001**
Within Groups	261.230	41	6.371		
Total	402.652	45			

Table 4: Multiple comparison among groups (A:Ceram, B: Composan, C: ESTELITE, D:Dynamic, E: Cold cure) with denture base

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Ceram	Composan	-.88995	1.19732	.462	-3.3080	1.5281
	ESTELITE	-1.93505	1.19732	.114	-4.3531	.4830
	Dynamic	-1.33486	1.22653	.283	-3.8119	1.1422
	Cold cure	3.04781*	1.22653	.017	.5708	5.5248
Composan	Ceram	.88995	1.19732	.462	-1.5281	3.3080
	ESTELITE	-1.04510	1.12884	.360	-3.3248	1.2346
	Dynamic	-.44491	1.15978	.703	-2.7871	1.8973
	Cold cure	3.93776*	1.15978	.002	1.5955	6.2800
ESTELITE	Ceram	1.93505	1.19732	.114	-.4830	4.3531
	Composan	1.04510	1.12884	.360	-1.2346	3.3248
	Dynamic	.60019	1.15978	.608	-1.7420	2.9424
	Cold cure	4.98286*	1.15978	.000	2.6406	7.3251
Dynamic	Ceram	1.33486	1.22653	.283	-1.1422	3.8119
	Composan	.44491	1.15978	.703	-1.8973	2.7871
	ESTELITE	-.60019	1.15978	.608	-2.9424	1.7420
	Cold cure	4.38267*	1.18991	.001	1.9796	6.7857
Cold cure	Ceram	-3.04781*	1.22653	.017	-5.5248	-.5708
	Composan	-3.93776*	1.15978	.002	-6.2800	-1.5955
	ESTELITE	-4.98286*	1.15978	.000	-7.3251	-2.6406
	Dynamic	-4.38267*	1.18991	.001	-6.7857	-1.9796

*. The mean difference is significant at the 0.05 level.

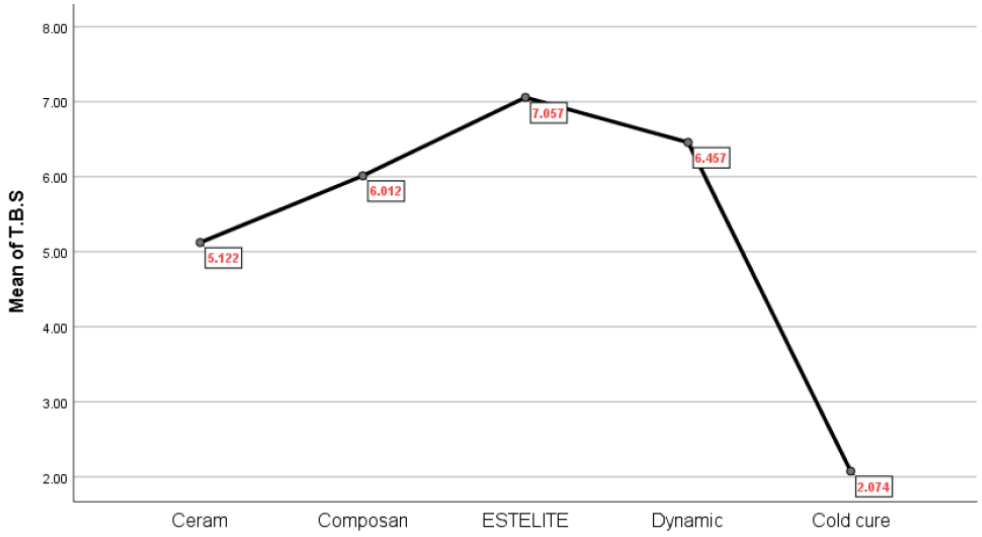


Figure 5: Shows relation between mean of T.B.S among groups(Ceram, B: Composan, C: ESTELITE, D:Dynamic, E: Cold cure)

 doi.org/10.15218/edj.2024.13

DISCUSSION

Every outcome gives different variations were it is viewed from other sides, so as the current results Tensile bonding strength between unlike materials obtained mechanically or chemically, the popular material for replacing missed artificial tooth with the denture base is adding new tooth to old denture were both acrylic base, the connection between them mainly acquire with chemical bonds that happen among similar types of methyl meth acrylate in different time and situations, but were composite used as an alternative material, for this process the situation are differs, which there are different materials and technique lead to this type of joining.

Before separating the outcomes and discussing them independently, its better if we focus on the means of results, it is noticeable that the force required for debonding of the samples is in the ((ESTELITE) Tokoyama, brand has the highest value of tensile bond strength (7.05 MPa),at the same time Dynamic group are the second by range of (6.456 MPa), then Composan is the third one (6.012MPa), finally Cerama brand with the (5.12 MPa) mean in composite groups, but the cold cure acrylic group with the (2.07 MPa). where this consequence compared to other observations in the same fileded the following conclusions seen, in the study done by (Pinto RR et al, 2004) were they studdying the bond strength of tooth with soft liner denture base they discovered that the stress that required to debonding the artificial teeth from its base after thermocycling is (1.06±0.45) MPa. [20] In both study, there are debonded procedure and thermocycling management but there are differences between the type of joining material they used acrylic base materials whereas in the current study the composite is the alternative to acrylic tooth therefore, differences seen in the results.

Another article published by (Muhsin S. 2017) after studying the bond strength of artificial teeth using visible light cure composite resin concluded that using of VLC bonding agent with the management of methylmeth acrylate on the acrylic teeth lead to maximizing the bonding strength with composite resin. [8] The same result in the current study is observed where the debonding load is maximize by using different type of composite resin if compare to acrylic base with denture base material.

The article that published by (Ghaffari T et al , 2019 A) are conclude that the load required to shear debonded teeth with acrylic are 250MPa to 438MPa in different materials this is observed during comparison of bond strength of different material of artificial teeth with heat cure denture base [9], the management of different material and situations of denture base in addition to usage of shear bond instead to debonding are the main causative factors for obtaining different feature to the current study.

Dealing with different composite group and acrylic resin was study in the comparison of bond strength of composite and acrylic teeth to heat-cured and auto-polymerized acrylic denture base by Ghahramani (2011), they concluded that the load range that used for debonding of the artificial tooth with the denture base was 10.5 ± 4 MPa[10], there is differences between results that seen in this study and outcome that observed in others, teeth brand and curing technique main cause for unlike result.

The effect of thermocycling on a different brand of artificial teeth is another study that was done in the same field the author discovered that the force which influences artificial teeth and makes them loose in their place is (11.1 ± 0.9) MPa[13], the result of current study was grow down to level of (2.074 to 7.057) MPa, the major factor between these study and previous one is thermocycling regime 2000 cycle and surface management, but inconvenient outcome seen where may be due to that different amount of composite was used instead of the acrylic artificial teeth in the current study.

Pinto (2002) during studying the bond strength and elasticity of long-term soft denture liner after the thermocycling process they discovered that the stress required

to debonding the artificial teeth from there base after thermocycling is (0.97±0.45) MPa and they find that In the tensile test under control conditions, Molloplast-B (1.51 +/- 0.28 MPa [mean +/- SD]) and Pro Tech (1.44 +/- 0.27 MPa) liners had higher bond strength values than the others (P <.05). With regard to the permanent deformation test, the lowest values were observed for Molloplast-B (0.48% +/- 0.19%) and Flexor (0.44% +/- 0.14%) (P <.05). Under thermocycling conditions, the highest bond strength occurred with Molloplast-B (1.37 +/- 0.24 MPa) (P <.05). With regard to the deformation test, Flexor (0.46% +/- 0.13%) and Molloplast-B (0.44% +/- 0.17%) liners had lower deformation values than the others (P <.05)[21], whrer comparing this result to finding data the un-similarity noted in the mean which could be due to differences in the bonding materials , debonding test and thermocycling regime.

The researchers use different force for debonding the teeth with the denture base, (Mosharraf and Mechanic, 2007) they study shear bonding between tooth and denture base and they concluded that the stress range for debonding tooth was 287.38 ± 51.82 N, where in the grinding group was 301.52 ± 113.65 N, in addition in the retention grooves group was 374.38 ± 88.22 N and finally in the diatorics group was 415.19 ± 226.37 N. The highest mean bond strength was seen in diatorics group (P=0.009). The percentage of cohesive fractures in this group(90.5%) was significantly more than that in other groups (P<0.001) [22] if we convert this result to MPa we see the result of (287.38 ± 51.82 N 14.6 MPa) however the tested material and management are same but the applied force are differed so that un-matching result seen in responses to that un-similarities.

On the other hand researchers cover the space in studying the light-curing composite with the denture base and they give a different impression, (Ghaffari T et al , 2019 B) during comparison of bond strength of light-cured teeth concluded that the shear load that makes the untreated composite tooth displaced in its place is 238.33 ± 24 MPa where for Nano composite one this amount increased to 311.56 ± 32 MPa [24], there are differences among this result and current study outcome which it's may come from different applied load and thermocycling management in the current study.

CONCLUSION:

Within the limitation of this study it has been concluded that, Tokoyama required the highest force for debonding (7.05 MPa) whereas the lowest one Cerama brand (5.122 MPa) among the composite one at the same time the Cold cure Acrylic one have inferior debonding property(2.07 MPa). Replacement of missing artificial teeth on the denture base with a different brand of the composite can be done as an alternative to acrylic teeth. There for to avoid spending time impression taking, pouring, sending the cast and repairing the missing tooth, which all are boring to the both operator and consumer, this research tries to cover a part of this effort.

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest relevant to this article.

REFERENCES

1. Manappallil J . Complete denture prosrhodontics . New Delhi: Arya (Medi) Publishing House :2006, 1-3, 190, 323-324, 335-358

2. Bonwill W.: New methods of clasping artificial dentures to human teeth without injury versus immovable bridges. Dent Items Interest, 1899;656670

3. Dudley J. . The influence of compressive cyclic loading on the retention of cast crown coping cemented to implant abutments .2008, PhD Thesis, university of adelaid. Australia

4. MaCabe J and Walls A . Applied dental materials, 9th ed. Oxford: England black well scientific publication :2008, 100-105, 133-13

5. Dentures- Medline Plus, NIH, U.S National Library of Medicine [internet]. Medlineplus.gov2019. available from:https//medlineplus.gov/dentures.html

6. Taylor T, Bergen S, Conrad H, Goodacre C, Piermatti J. 2018. What is a Prosthodontist and the Dental Specialty of Prosthodontics?. Reaffirmed ACP Board of Directors: June 2, 2018
7. Contemporary Fixed Prosthodontics, 5th Edition. Authors : Stephen F. Rosenstiel & Martin F. Land. Date of Publication: 09/2015.
8. Muhsin S. Bond Strength of Repaired Acrylic Denture Teeth Using Visible Light Cure Composite Resin. The Open Dentistry Journal. 2017; 11:57-64.
9. Ghaffari T, Hamedirad F, Miruzadeh K. Comparison of bond strength of acrylic, composite, and nanocomposite artificial teeth to heat cure acrylic denture base resin. Front Dent. 2019 ; 16(3): 166–172
10. Ghahramani L, Shahabi S, Amirjan A, Fazel A, 2011. Comparison of bond strength of composite and acrylic teeth to heat-cured andautopolymerized acrylic denture base. Journal of Dental Medicine-Tehran University of Medical Sciences 2011(4):215-226.
11. Nalcai A and Ulusoy N. Effect of thermocycling on microleakage of resin composites polymerized with LED curing techniques. Quintessence Int.2007;38:433-9.
12. Fatah N. The shear bond strength of artificial teeth with denture bases. J Bagh Coll Dentistry.2009, 21(3):15-20.
13. Hawrami G. The Effect Of Thermocycling On Tensile Bonding Strength Of Three Different Brands Of Artificial Teeth With Denture Base In vitro study. M. Sc. Thesis Hawler Medical University:2011, 50-62
14. Freitas S, Brandt W, Miranda M, Vitti R. Effect of Thermocycling, Teeth, and Polymerization Methods on Bond Strength Teeth-Denture Base. International Journal of Dentistry Volume 2018, Article ID 2374327, 5 pages https://doi.org/10.1155/2018/2374327
15. Ramezani M, Moradi P. A comparative analysis of shear bond strength of composite and acrylic teeth to heat-cured acrylic resin by difference preparation method. Pharmacophore, 8(4) 2017, Pages:27-34
16. Cunningham J and Benington I. A new technique for determining the denture tooth bond. J Oral Rehabil1996 ;23(3):202-9.
17. O Brien W. Dental Materials and Their Selection,3rd. Chicago:2002 Quintessence:377
18. Craig R, Powers J and Wataha R (2004). Dental materials: Properties and manipulation. 8th ed. St. Louis: Mosby Inc. : 286-7
19. O Brien W. Dental Materials and their selection, 4th edition. Quintessence. Chicago. 2008, Pages 62-74, 75-90, 114- 133.
20. Pinto J, Mesquita M, N´obilo M and Henriques G. Evaluation of varying amounts of thermal cycling on bond strength and permanent deformation of two resilient denture liners. J Prosthet Dent;2004, 92:288 293
21. Pinto J, Mesquita M, Henriques G, N´obilo M. Effect of thermocycling on bond strength and elasticity of 4 long-term soft denture liners. J Prosthet Den2002t ;88:516-21
22. Mosharraf R, Mechanic N. Comparison of the Effects of Four Pre-Bonding Preparation Methods on the Bond Strength between a Multilithic Tooth and Denture Base Resin. Dent Res J 2007; 4(2): 102-105
23. Stoia A, Sinescu C, Negrutiu M, Enescu M, Rominu R, Pielmusi M, Tudor A, Rominu M. Tensile Bond Strength of Acrylic Resin Teeth to Denture Base Repair Resin . ISBN:2010, 978-960-474 -250-9
24. Ghaffari T, Hamedirad F, Motiei M, (2019). Effect of thermal and mechanical cycles on shear bond strength of zirconia core to porcelain veneer under different surface treatments. Journal of Dental Research, Dental Clinics, Dental Prospects.2019 13 (3): 227
25. International Organization for Standardization ISO TR 11405 . ISO; Geneva: 1994. Dental Materials-Guidance on Testing Adhesion to Tooth Structure.