ORIGINAL ARTICLE

The Bond Strength of the Denture Teeth to the Polyamide Denture Base And the Conventional Heat Cure Acrylic Denture Base

[1]**Sharaz Shaik,** MDS; [1]**Muhammad Farhan Khan,** FCPS; [2]**Abdulwahab Hadi Alqahtani,** BDS; [3]**Mohammed Saeed Asiri,** BDS; **Hammam Ali Y Altamni,** BDS; **Anas Abdullah M Lahiq,** BDS

ABSTRACT

Objectives: To examine the debonding of the acrylic teeth to polyamide denture base under bending stresses, in comparison to that of the conventional heat cure acrylic denture base. **Materials and Methods:** Eighty maxillary central incisors were divided into two equal groups. Each tooth of Polyamide group was prepared with a "T-shaped connected tunnels"in the cingulam using a twist drill. Four wax blocks, having ten teeth each ware made and processed with polyamide base. For the acrylic group, four wax blocks having ten teeth each were prepared and processed with heat cure acrylic denture base. The blocks were mounted on the Instron universal testing machine, and increasing bending loads were applied at 135 degrees on the lingual side of each tooth using a 3 mm diameter rod until the tooth was de-bonded or the base was fractured. The results were statistically analyzed using Mann-Whitney U Test. **Results:** The mean bond strength of acrylic tooth to polyamide base was24.89Mpa. (load= 176N).There was no incidence of tooth debonding in the acrylic group. However, the heat cure acrylic base fractured at an average bending load of 316N (stress=44.7Mpa). **Conclusion:** Within the limitations, this study can provide the following conclusions: The polyamide denture base exhibited excellent fracture resistance, but the bond between the base and the tooth is significantly less than the fracture resistance of acrylic base. There is a significant risk of debonding of the tooth from the polyamide denture base. The bond strength of the acrylic tooth to the acrylic denture base is stronger than the toughness of the acrylic base.

Keywords: Polyamide denture base, Bond strength, Acrylic denture teeth, denture teeth debonding.

[1]Department of Prosthetic dentistry, College of Dentistry, King Khalid University, Saudi Arabia
[2] Armed forces Hospital Southern Region Khamis Mushait, Saudi Arabia
[3] Ministry of Health, Jazan, Saudi Arabia
[4]Dentaly Dental Clinic, Abha, Saudi Arabia

Correspondence should be addressed to:
Dr. Sharaz Shaik
Assistant Professor, Department of Prosthetic Dentistry,
King Khalid University College of dentistry,
P.O. 3263, Abha 61471, Kingdom of Saudi Arabia
Tel : +966 558327781
Email:sharaz@kku.edu.sa; sharazshaik@gmail.com,

INTRODUCTION

Poly-methyl-methacrylate (PMMA) has been the most popular material used for denture fabrication. It has the advantages of having a simple processing technique, easy repair, low water solubility, adequate strength, and low toxicity. On the other hand; it has disadvantages like polymerization shrinkage, weak flexural strength, lower impact strength, and low fatigue resistance.[1-4] In order to overcome the disadvantages of Poly-methyl methacrylate, various new materials and techniques have been tried including the addition of metal wires or plates, fibers, metal inserts,and modification of chemical structure.[1] Watt DM proposed Polyamides a denture base material as early as 1955,[9,] but only recently, it has attracted attention as a denture base material.Polyamide has advantages of reasonable strength coupled with higher elasticity, low solubility, high heat resistance, no toxicity from residual monomer and no polymerization shrinkage in comparison to heat polymerizing resins. On the other side, it is reported to have several disadvantages like water sorption, surface roughness, bacterial contamination, warpage, color deterioration, and difficulty in polishing.[10-15]

Fractures and debonding of acrylic teeth from denture base remains a significant problem in prosthodontic practice. It has been estimated that around 30% of denture repairs involve tooth debonding, usually in the anterior region of the denture.[16-17] The recent increase in the use of implants and natural teeth overdentures has improved the masticatory efficiency of a complete denture patient leading to increasing the stresses transmitted to the denture bases.

Vertex Thermosens is a new thermoplastic injection molding denture base material,which is claimed by the manufacturer to be virtually unbreakable.[18] It is a polyamide-based material which does not have a chemical bonding to the acrylic denture teeth. Mechanical bonding is obtained by a T- shaped connected tunnels drilled in the acrylic teeth.

The purpose of this study was to examine the debonding of the acrylic teeth to polyamide denture base under bending stresses, in comparison to that of the conventional heat cure acrylic denture base.

MATERIAL AND METHODS

This research was executed in 2015/2016 at King Khalid University College of Dentistry. The eighty cross-linked acrylic resin teeth used, were maxillary central incisors from mold no 42 (Yamahachi Dental Mfg.co).

Polyamide group: Forty teeth were prepared with "T-shaped connected channels" in the cingulum using a 1.3mm diameter twist drill provided by the manufacturer. Four sets of triangular shaped wax blocks were made,and ten teeth were mounted on each base. The four wax blocks were individually flasked in the particular flask provided by the manufacturer and dewaxed. Polyamide denture base processing was done on vertex Thermosense injection molding machine.

Acrylic group: Four sets of 10 teeth each were placed on triangular wax blocks. The wax blocks were flasked, and dewaxed. The processing was done using conventional heat cure acrylic.

The processed, blocks of polyamide base and acrylic base were trimmed and polished (Figure1).

Figure 1: Ten teeth processed in a block of denture base material

Inclusion and exclusion criteria for testing the individual teeth in the blocks:
The bond strength between the denture base and the teeth is significantly influenced by the presence of the denture base material in the interdental area as well as proximal contacts of the teeth. In order to consider these influencing factors in testing the individual teeth in the block, only the teeth with proximal contacts on both the sides were examined,and the last two teeth

which do not have proximal contacts on both sides were excluded.

The blocks were mounted on the Instron universal testing machine, and the load is applied at 135 degrees from the lingual side of the incisor using a 3 mm diameter rod. (Figure 2). The load is gradually increased until the tooth was separated or the base was fractured. The results were tabulated and analyzed, using Mann-Whitney U Test.

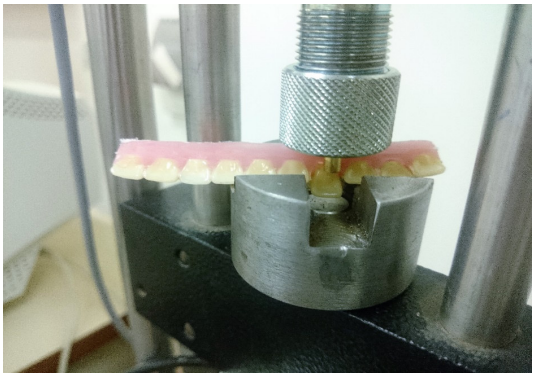

Figure 2: Loading the samples on the Instron universal testing machine

RESULTS

Polyamide group: A total of thirty-two teeth were tested following the exclusion criteria.All the teeth examined were either luxated or de-bonded without fracturing the denture base (Figure 3).

Acrylic group: There was no incidence of tooth debonding in this group. However, the denture base fractured. Twenty teeth were counted in the test based on the exclusion criteria (Figure 4).

The mean bending force required to de-bond/fracture the samples was 175.94±40.15 N and316±89 N for polyamide and acrylic group respectively (Figure 5).The calculated mean bond strengths are 24.89Mpa and 44.7Mpa. respectively. The difference in the mean debonding/fracture loads was statistically significant. (p=0.000) (Table 1).

Figure 3: Polyamide block showing the individual teeth either luxated or de-bonded

Figure 4: Heat cure acrylic block exhibiting fracture

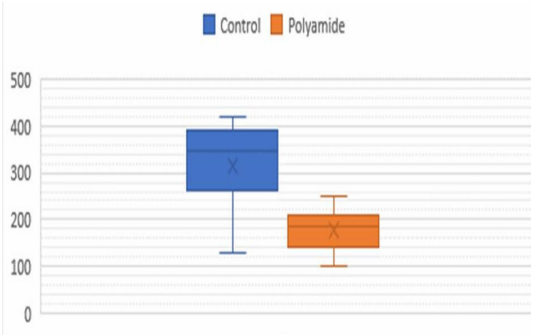

Figure 5: Comparison of mean debonding/fracture loads between polyamide and acrylic group

Table 1: Comparison of debonding/fracture loads between polyamide and acrylic group by Mann-Whitney U test

Group	N	Mean	SD	Mean Rank	Sum of Ranks	Mann-Whitney U	Z	P-value
Acrylic	*20*	*316.00*	*89.054*	*38.78*	*775.50*	*74.500*	*-4.626*	*0.000**
Polyamide	*32*	*175.94*	*40.150*	*18.83*	*602.50*			

**Statistically significant at 5% level of significance*

The results of our research demonstrated that the acrylic teeth could easily be separated from the polyamide denture base, some samples being separated at forces as low as 100 N,(stress=14.28Mpa against the ADA specification of 34Mpa). The minimum values of 100N are close to the average force of 70N transmitted during mastication in complete denture patients.[31] The average force required for debonding of teeth being 176N (stress=24.89Mpa against the ADA specification of 34Mpa) is significantly less than the average force generated by patients using implant supported overdentures.[32] The results of this research indicate that though the manufacturer of vertex thermoses (polyamide denture base) claims it to be virtually unbreakable due to its high flexural strength, its disadvantaged by the weak bond strength of the denture teeth to the denture base.

There were no incidences of debonding of acrylic teeth to the heat cure acrylic base. However, the heat cure acrylic base fractured at an average bending load of 316N (stress =44.7Mpa) which is significantly better than the polyamide dentures and exceeds the ADA specification no.15.

DISCUSSION

Physical properties of polyamide vs. PMMA

Takabayashi[19] in 2010 compared flexural strength and modulus of elasticity and tensile strength of various polyamide denture base material and noted that these materials have lower than what was required according to the ISO standard. However, they demonstrated the values to be higher than that of conventional polymethyl methacrylate.

Hamanaka[20] et al. in 2011 compared the mechanical properties of different thermoplastic denture base materials with a conventional heat-polymerized polymethyl methacrylate (PMMA) and concluded that the mechanical properties of thermoplastic denture base differ according to the composition,some being better than polymethyl methacrylate (PMMA) and some lower. Hence, the clinicians should be well aware of these properties in order to choose the most suitable one.

In 2012, Ucar et al.[21] revealed that the polyamide's flexural strength was not significantly different, and the flexural modulus was lower than compression-molded PMMA. It was emphasized that a lower flexural modulus (higher flexibility) had often been a disadvantage from clinical standpoint mainly when it is used for removable partial dentures.

Bond strength of acrylic teeth to polyamide base

Polyamide is a chemical-resistant material due to its high crystalline characteristics.[22] This property makes the Polyamide difficult to bond to resin; the bond strength of acrylic denture teeth to the polyamide denture base according to this study (24.89 Mpa)was significantly less than the values recommended by various national standards.[23-26] However, shear bond strength could be improved by using Tribo-chemical silica coating.[27] Yuki Katsumata evaluated different techniques to improve the bond strength between the polyamide and the acrylic teeth like polishing, sandblasting, adhesive primer application (resin primer), sandblasting + adhesive primer application, and tribochemical coating (Rocatec system). His study concluded that silica coating (tribochemical coating) is the most effective.[28] There should be more research in relation to chemically bonding the polyamide to the acrylic or develop denture teeth having better bonding to polyamide.

Bond strength of acrylic teeth to heat cure acrylic base

The current study could not record the exact bond strength of the acrylic teeth to the heat cure acrylic denture base due to the inherent fracture in the base. This finding (fracture in the base) is in accordance with the other researchers in literature including the study by Russell K. Catterlin.[29] The mean debonding forces may vary according to the size of the tooth, the manufacturer and compositional variations in the acrylic tooth and the denture base material. The results of this study are not significantly different from other similar studies and are close to a study conducted by one of the authors of this study Sharaz Shaik.[30] The results of this study can conclude that the bond strength of the acrylic teeth to the heat cure acrylic denture base is higher than 44.7Mpa. This value is higher than the recommendation of ANSI/ADA specification no 15.(34Mpa).[23]

The methodology of testing the bond strength

Research in the area of testing the bond strength of the denture base to the teeth is hampered by having a large number of techniques to evaluate the bond strength. The various national standards that address denture tooth bonding employ different specimen preparation

and loading methods.[23-26] Most of the researchers in the literature and the national standards have tested bond strength of a lone standing tooth of various specified dimensions, and amount of denture base to tooth contact. These methods are justifiable from a mechanical standpoint of view and to set standards for the manufacturers. However, these values do not translate well to the clinical implication as the proximal contacts and denture base material in the interdental area influences the bonding significantly. The current study has attempted to evaluate the bond strength of the acrylic teeth to the denture base simulating the clinical application.

LIMITATIONS OF THE STUDY

Though there is a statistical significance in the results, the sample size could have been increased. The initial sample size of the acrylic group could have been expanded to compensate the reduction of samples due to fracture in the base.

The methodology used in this study is different from the recommendations of various national standards like ADA, BS, AS, and JIST.[23-26] Hence the bond strength values generated in this research cannot be accurately compared to those of the recommendations by national standards.

CONCLUSION

Within the limitations, this study can provide the following conclusions: The polyamide denture base exhibited excellent fracture resistance, but the bond between the base and the tooth is significantly less than the fracture resistance of acrylic base. There is a significant risk of debonding of the tooth from the polyamide denture base. The bond strength of the acrylic tooth to the acrylic base is stronger than the toughness of the acrylic base.

DISCLOSURE

The author reports no conflicts of interest in this work.

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