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ORIGINAL RESEARCH

Bond strength of polymethyl methacrylate and nanohybrid composite denture teeth to fiber reinforced denture base and conventional heat cure denture base– In vitro study

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Abstract

Aim: To evaluate bond strength of Polymethyl methacrylate and Nanohybrid composite denture teeth to fiber reinforced denture base and conventional heat cure denture base.

Materials and Methods: Eighty two teeth were divided into two equal groups. In each group, 7 central incisors, laterals and canines were selected. Each tooth of Nanohybrid group was prepared with a cavity of 2 mm depth and 1.3 mm diameter was prepared. Fourteen wax blocks, having three teeth each were made and Fiber reinforced denture (Lucitone 199) base processing was done using conventional heat cure acrylic. 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 one sample t-test.

Results: 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).

Conclusions: Within the limitations, this study can provide the following conclusions: The fiber reinforced 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.

Clinical Significance: The bond strength of the Nano hybrid composite tooth to the fiber reinforced acrylic base is stronger than the toughness of the PMMA acrylic base. Keywords: Nano hybrid composite teeth, Bond strength, Acrylic teeth, Denture teeth de -bonding.

Introduction

Prosthetic teeth helps to retore form, function and esthetics of edentulous patient and improves masticatory efficiency, speech, thereby leading to selection of denture teeth with superior properties. 1 Acrylic teeth since long were used for most partial and complete cases. Due to this various changes were made to improve properties of artificial teeth. With the changing technology, sialinized silica with inorganic fillers were developed. Furthermore, nanocomposite teeth came into existence with less modifications and better advantages. Denture base resins used has been observed in dental material sciences since long. Poly methyl methacrylate introduced by Dr. Walter Wright in 1937 due to esthetics , better function and less expensive.[2,] Acrylic teeth were introduced in the 1930s with

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Polymethylmethacrylate (PMMA) the most commonly used.[4] By 1950, almost 98% of all acrylic denture teeth used were PMMA. Acrylic teeth solved some of porcelain denture teeth's problems, including brittleness, ease of contouring custom anatomical form, and bonding to denture base; however, excessive wear was still a major concern, since acrylic denture teeth can go through rapid change in occlusal morphology in a short period of time.[5-] Polycarbonates (PC) and polyamides (PA) will improve strength but are of high cost and technique sensitive. Chemical structures like polyethylene glycol with presence of cross linking agents found to enhance strength but theres no evidence present. [7,8] Various fibers present such as carbon, Kevlar, glass and aramid fibers for reinforcement of dentures. [9-12] Various modifications of PMMA also have been tested to improve the existing material; these modifications include chemical modification to produce graft copolymer high-impact resins and mechanical reinforcement through the inclusion of glass fibers, sapphire whiskers, aramid fibers, carbon stainless steel mesh, nylon, or (more recently) ultra-high-modulus polyethylene fibers. Visible light-cured denture base resin was introduced to the market in the early 1980s and was promoted that does not contain methylmethacrylate monomer and hence could be considered an alternative to heat and auto-cured PMMA polymers.[13] Nonetheless, PMMA resin has some negative problems such as polymerization shrinkage, weak flexural, lower impact strength, and less fatigue resistance. Alternative methods proposed by Mallikarjuna et al. to enhance the properties of PMMA resin such as:[14-15]

- With use of polycarbonates and polyamides as qadjuncts for PMMA.
- Modification of polymethyl methacrylate with use of copolymers, cross-linking agents and rubber substances in the form of butadiene styrene.
- Presence of fibres, metal or ceramic inserts in denture bases act as filler.

Chemical composition of dental composite are classified into organic matrix or organic phase, inorganic matrix (filler or disperse) and organosilane or coupling agent to bond filler with organic resin. Nano composites consists of nanohybrid and naofill types where naofill types include nanomers and agglomerated and non agglomerated particles for better flow and consistency.[16] In 2009, Nano-hybrid composite (NHC) were introduced to the market It comprises of UDMA matrix with three different fillers and PMMA clusters embedded in structure. The first type filler is inorganic densified silanized sio2 which strengthen the matrix and increase the material's wear resistance and hardness. The second type filler is silanized sio2 nanoparticle which strengthen the composite structure and help decrease the wear of the opposing tooth . The third type filler is inorganically filled dimethyl acrylate polymer added to reduce polymerization shrinkage stress. Nano-composite teeth were developed to overcome problems with staining, wear resistance, and polishability.[17] The purpose of this study is the comparative evaluation of two commercially available denture teeth to two commercially available heat cure acrylic resin

Material and methods

In each group, 7 central incisors, laterals and canines were selected from mold no. 42.

Group 1: Bond strength of Polymethyl methacrylate acrylic denture teeth to regularly used heat cure acrylic resin.

Group 2: Bond strength of Nanohybrid composite denture teeth to regularly used heat cure acrylic resin.

Group 3: Bond strength of Polymethyl methacrylate denture teeth to reinforced heat cure acrylic resin .

Group 4: Bond strength of Nanohybrid composite denture teeth to reinforced heat cure acrylic resin.

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Sample preparation

Samples (n=7) were prepared for each acrylic resin by wax rectangular matrices (40 mm long, 5 mm wide and 2 mm high) (FIG 1-4).

Figure1: Group A Samples –Wax Specimens

Figure2: Group B Samples – Wax Specimens

Figure3: Group C Samples- Wax Specimens

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Figure4: Group D Samples – Wax Specimens

The test specimens utilized in the current study were manufactured from heat polymerizing acrylic resin. Twenty eight specimens of dimensions 65 × 10 × 3 mm were prepared. FIBER REINFORCED GROUP: Forty two teeth of Nanohybrid composite denture teeth (ENIGMA, Vijay Dental, Chennai) were prepared with a cavity of 2 mm depth and 1.3 mm diameter was prepared by an 8 round carbide bur in the cingulum provided by the manufacturer. Seven sets of three teeth each were placed on triangular wax blocks. The wax blocks were flasked, and dewaxed. Fiber reinforced denture (Lucitone 199) (FIG 5) base processing was done using conventional heat cure acrylic.

Figure5: Lucitone &Dpi Heat Cure Acrylic Resin

Acrylic group

Seven sets of three teeth prepared with a cavity of 2 mm depth and 1.3 mm diameter was prepared by an 8 round carbide bur in the cingulum provided by the manufacturer each were placed on triangular wax blocks. The wax blocks were flasked, and dewaxed. The processing was done using conventional heat cure acrylic. Once bench curing was done, the flasks were clamped and polymerized using short curing cycle of 74ºC for 90 minutes. The processed,

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blocks of polyamide base and acrylic base were trimmed and polished. using sand paper and pumice

Preparation of mould space

A customised rod and metal mold was prepared for measuring the bond strength of samples in universal testing machine. A rod consists of 15mm length and 5 mm diameter with a pointed tip of 3 mm on one side. A round metal mold of 6.5cm length and 8cm diameter was prepared as to seat the samples in it while testing. 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.15,16 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 6).

Figure6: De-Bonding Of Teeth

The load is gradually increased until the tooth was separated or the base was fractured. The forces were delivered perpendicular to the longitudinal axis of the artificial teeth; 3 mm being in contact with the teeth.

Results

Polyamide group: A total of thirty-two teeth were tested. All the teeth examined were either luxated or de-bonded without fracturing the denture base Acrylic group: There was no incidence of tooth debonding in this group. However, the denture base fractured. Twenty teeth were counted in the test. The difference in the mean debonding/fracture loads was statistically significant. (p=0.000) (Table 1). A one sample t-test was used to evaluate the bond strength of different types of denture teeth with different acrylic resins. The minimum values of 100N are close to the average force of 70N transmitted during mastication in complete denture patients.20 There were no incidences of debonding of acrylic teeth to the

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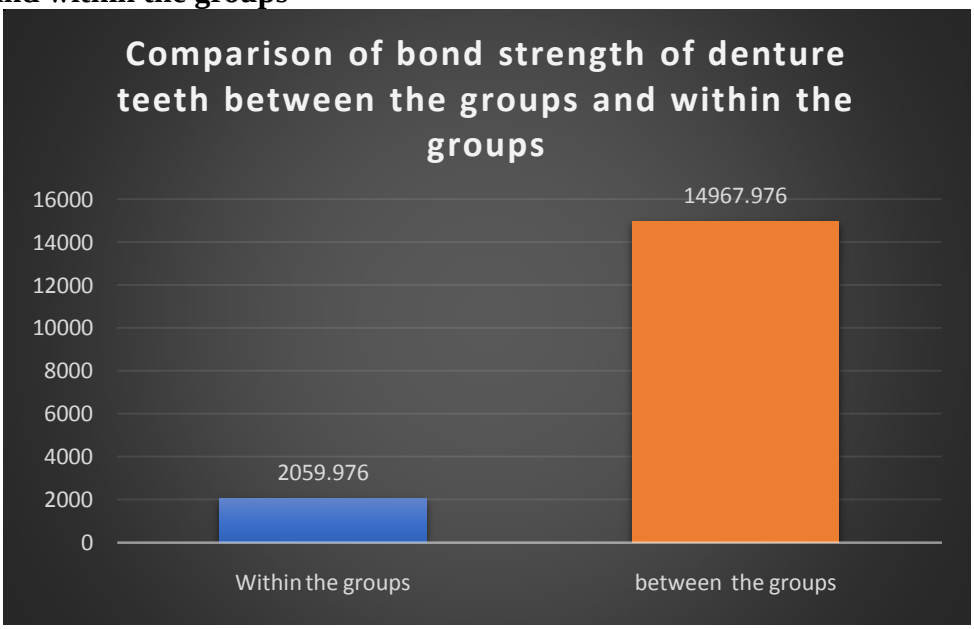
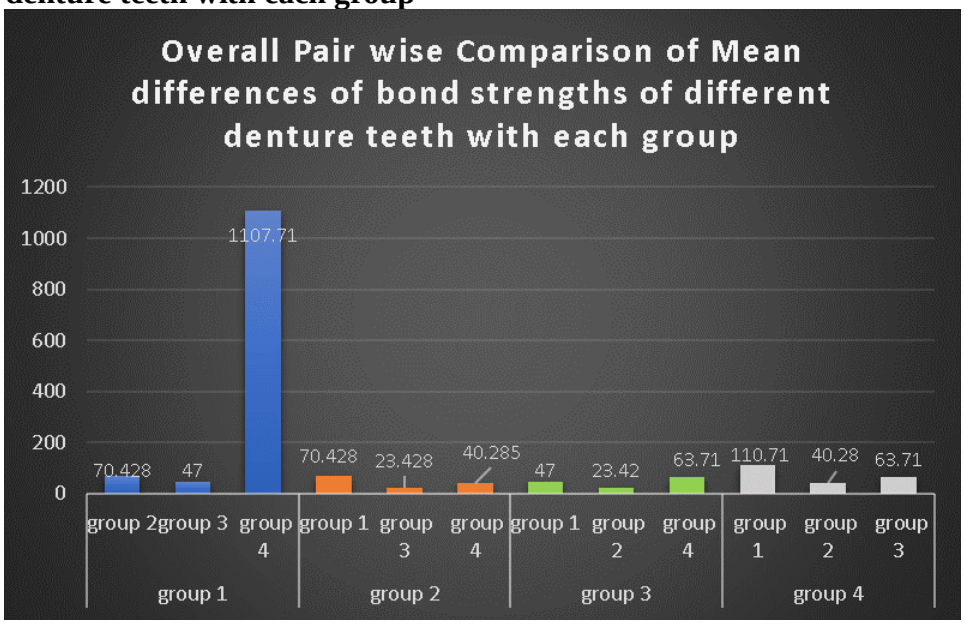
heat cure acrylic base. However, the heat cure acrylic base fractured at an average bending load of 316N (stress =44.7Mpa) which is significantly better than the polyamide dentures.

Graph 1: Comparison of mean squares of bond strength of denture teeth between the groups and within the groups



Graph 2: Overall Pair wise Comparison of Mean differences of bond strengths of different denture teeth with each group



Discussion

Dental materials of dentures can be divided into mainly three categories: resin, ceramic, and metal. The dental prosthesis directly contacts with the oral mucosa and is under long-term use in the oral environment, hence the dental materials must have excellent properties and good biological activity to function properly. Poly methyl methacrylate (PMMA) heat cured resins are currently used for the fabrication of dentures due to their low cost, simple processing procedure, ability to be repaired, biocompatibility and stability intra- orally because of which PMMA has replaced previous denture base materials such as vulcanite, nitro cellulose, phenol formaldehyde, vinyl plastics, porcelain .50-53 Dentures fabricated with PMMA can

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fracture due to flexural fatigue or impact forces. Flexural fatigue of dentures as evidenced by midline fracture is due to the stress concentration around the microcracks formed in the material due to continuous application of small forces. Hence, repetitive nature of masticatory load results in propagation of cracks which weaken the denture base and finally results in fracture. Fracture of dentures by impact forces, on the other hand, results from the sudden application of force to the dentures more likely due to the accidental dropping of dentures on surfaces.54-55 Attempts to enhance the mechanical properties of PMMA have been made in the past by modifying the composition with copolymers, by using different curing methods, by reinforcing with fibres like aramid, nylon, carbon/graphite, polyethylene, polypropylene and particularly glass fibres due to their biocompatibility, superior aesthetics and mechanical properties or by adding fillers like Al2O3, ZrO2, TiO2, SiO2 etc. Acrylic resin also has been chemically modified through the incorporation of rubber in the butadiene styrene which has proved to be successful. High impact acrylic resin is a dough-molded, micro- dispersed rubber phase polymer. It is methyl methacrylate and butadiene-styrene copolymerized in an emulsion with a second coating of methyl methacrylate added to cover the bead.56 good bonding of tooth and resin is requires for denture base material. In dough state this bonding helps in proper mix and soften resin leading to less fracture .58-64 Fracture of denture base occurs due to various reasons majorly after 3 years of service. Conditions like heavy masticatory load, trauma may also cause fracture to dentures. Dentures must be able to withstand high impact forces in addition to normal chewing forces, thus some commercial acrylic resins for denture bases named their products as ‘‘high impact’’ or ‘‘impact resistance’’ like Lucitone 199 (Dentsply).66-68 Lucitone 199 fibers are a bundle of fibers, unlike the flock and E-glass fibers which consisted of a monofilament. Porcelain teeth c urrently used design of complete and partial removable dentures. It is observed that acrylic teeth chemically bond to the denture base material and are simpler to adjust. Deboning of teeth from the denture base is a common cause of denture repair, accounting for 25% to 33% of failures. 69,70 Several factors can influence the bond strength between the teeth and denture base, including contamination with wax and thin foil ,, improper methods used for denture base curing, inadequate mechanical or chemical preparation of tooth surfaces, absorption of water by resins, differences in the thermal expansion coefficient of artificial teeth and base material, and porosity on the border of denture base resin and teeth .71-73 Composite resin artificial teeth are better when used as the super structure for implants because of their greater shock absorbing capacity. These multilayered structures provide improved esthetic appearance. Maximum bonding of denture teeth to denture base.74 The physical and chemical properties of artificial teeth are effective in strengthening the bond to denture base resins. Whereas, this bond is affected by the physical and chemical. To increase the bond strength of artificial teeth to acrylic resins, such as the application of methyl methacrylate (MMA) monomers and wax solvents. Bond strength enhanced with different methods of artificial tooth surface treatment, including the use of MMA monomers, composite bonding materials, and acid-etching. 77, 78 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. 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).79

Methodology of testing 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. Most of the researchers in the literature and the national standards have

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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. Ghasemi et al80 investigated the bond strength of several types of multilithic composite artificial teeth (Ivoclar, Yaghut, Glamour, and Apple) to heat-cure resins. It was observed that mean bond strength was the highest in the Apple group followed by Yaghut, Glamour, and Ivoclar artificial teeth, respectively also few other studies reported showed that the bond strength of Liechtenstein Ivoclar acrylic artificial teeth was significantly higher than that of other studied artificial teeth. Ghahramani 81 reported that the bond strength of composite artificial teeth was lower than that of acrylic artificial teeth in posterior teeth, which is in line with the results of present study considering less bond strength of composite teeth than acrylic teeth. Using bending strength test, reported that the bond strength of acrylic monolithic teeth was significantly higher than that of resin-based multilithic teeth. 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.82a

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.

Conclusion

Within the limitations, this study can provide the following conclusions: The fiber reinforced 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 fiber reinforced denture base. Debonding of denture teeth increases the appointment frequency and laboratory costs both patient and dentist disappointment with the prosthesis. The bond strength of the Nano hybrid composite tooth to the fiber reinforced acrylic base is stronger than the toughness of the PMMA acrylic base

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