Comparison of Shear Fracture Forces of Acrylic Denture Teeth to Denture Base Resins Processed by Compression and Injection Molding Techniques: An In Vitro Study

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Abstract

Background: Debonding of acrylic denture teeth from the denture base is a common reason for complete denture repair. The processing technique and material combination may influence the resistance of the tooth–denture base interface to shear loading. This in vitro study compared the shear fracture forces of Acryrock and Ivoclar acrylic denture teeth bonded to denture base resins processed by compression molding and injection molding.

Methods: Forty-eight standardized specimens were fabricated and divided into four denture-base processing groups, each containing 12 specimens. Each group was subdivided according to acrylic tooth brand, with six Acryrock and six Ivoclar specimens. The groups comprised compression-molded DPI resin, compression-molded Bredent resin, injection-molded Ivoclar resin, and injection-molded Bredent resin. Specimens were tested using a universal testing machine at a crosshead speed of 1 mm/min with a 50-kg load cell. Because the bonded area was standardized but was not independently measured for area normalization, fracture force in newtons was used as the primary outcome. Independent t-tests were used for within-system comparisons, and one-way ANOVA with Tukey post hoc analysis was used to compare the eight subgroups.

Results: Mean fracture forces were 207.697 ± 0.113 N for compression-molded DPI/Acryrock, 246.279 ± 0.094 N for compression-molded DPI/Ivoclar, 257.566 ± 0.241 N for compression-molded Bredent/Acryrock, 302.636 ± 0.140 N for compression-molded Bredent/Ivoclar, 321.212 ± 0.122 N for injection-molded Ivoclar/Acryrock, 402.669 ± 0.258 N for injection-molded Ivoclar/Ivoclar, 317.606 ± 0.196 N for injection-molded Bredent/Acryrock, and 335.108 ± 0.051 N for injection-molded Bredent/Ivoclar. All prespecified within-system tooth-brand comparisons were statistically significant ($p<0.001$), and the overall eight-group ANOVA was statistically significant ($p<0.001$). The highest mean fracture force was observed for injection-molded Ivoclar denture-base resin bonded to Ivoclar teeth.

Conclusion: Within the limitations of this in vitro study, injection-molded denture-base systems demonstrated higher shear fracture-force values than the compression-molded systems evaluated, and Ivoclar teeth demonstrated higher values than Acryrock teeth within each tested denture-base system. The findings represent comparative fracture-force performance and should not be interpreted as normalized shear bond strength in MPa.

Keywords: Acrylic denture teeth; denture base resin; shear fracture force; injection molding; compression molding; polymethyl methacrylate; complete dentures.

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Introduction

Successful complete denture treatment depends not only on clinical procedures but also on the accuracy and properties of the laboratory processing technique. Heat-cured acrylic denture base resins have traditionally been processed by compression molding, whereas injection molding has been developed as an alternative approach intended to improve processing accuracy and compensate for polymerization shrinkage [1-5].

Compression molding, often described as the pack-and-press technique, involves packing heat-activated denture base resin into a flask and processing it under pressure. Processing-related dimensional changes can contribute to occlusal discrepancies and the need for laboratory adjustment [1-3,5]. Injection molding uses specialized equipment and permits continued material flow during polymerization, which can compensate for polymerization shrinkage and improve dimensional accuracy [4-6].

Acrylic tooth debonding is a clinically relevant complication because it can result in repair procedures, additional laboratory cost, and patient inconvenience. The tooth–denture base interface is particularly important when increased occlusal loading is expected, such as in complete dentures opposing natural teeth, overdentures, and implant-supported prostheses [7-10].

Shear testing is commonly used to assess the resistance of the tooth–denture base interface to a shearing load. Reported values vary with denture-base material, artificial tooth composition, polymerization method, surface preparation, processing parameters, and test methodology [7,11-14]. Previous studies have demonstrated differences among denture-tooth and denture-base resin combinations and have reported favorable dimensional or mechanical characteristics for some injection-molded systems [4-6,15,16].

There is limited information comparing the specific combinations of Acryrock and Ivoclar teeth with compression- and injection-molded denture-base systems evaluated in the present study. The objective was therefore to compare the shear fracture forces of Acryrock and Ivoclar acrylic teeth bonded to denture-base resins processed by compression molding and injection molding.

Materials and Methods

Study design and setting

This was an in vitro experimental materials study conducted through the Department of Prosthodontics, Crown & Bridge, Kannur Dental College, Anjarakandy, Kerala, India, with mechanical testing performed at the National Institute of Technology, Calicut, Kerala, India.

Research question and hypotheses

The research question was whether the shear fracture force of acrylic denture teeth bonded to denture-base resins differs according to processing technique and tooth brand. The null hypothesis was that there would be no difference in fracture-force values among the tested combinations. The alternative hypothesis was that fracture-force values would differ among the tested combinations.

Sample size and group allocation

The sample size was calculated using G*Power version 3.1. A total of 48 specimens were included, with 12 specimens in each of four denture-base processing groups and six specimens for each acrylic tooth brand within each group. The four processing groups were compression-molded DPI, compression-molded Bredent, injection-molded Ivoclar, and injection-molded Bredent denture-base resin.

Materials

The study used DPI heat-cure denture-base resin; Bredent denture-base resin for the designated Bredent groups; injection-molded Ivoclar denture-base resin; AcryRock V acrylic teeth (Dental Manufacturing S.p.A., Ruthinium, Italy); Ivostar acrylic teeth (Ivoclar, Liechtenstein); modeling wax; separating medium; petroleum jelly; and dental stone.

Specimen fabrication

A two-piece rectangular metal mold measuring 35 mm in length, 12 mm in breadth, and 10 mm in height was fabricated to standardize the specimens. Acrylic denture teeth were embedded in wax up to the cervical region. A single maxillary anterior tooth was used for each specimen to standardize evaluation of the tooth–denture base interface.

For compression molding, tooth–wax patterns were invested in denture flasks using dental plaster. After dewaxing, heat-polymerized denture-base resin was mixed

at a polymer-to-monomer ratio of 2.5:1 by weight, packed, trial-packed, and processed according to the manufacturer's instructions. The flasks were bench-cooled at room temperature overnight after acrylization. Specimens were then removed, inspected for defects or porosity, trimmed, polished, and marked.

For injection molding, wax patterns containing the embedded teeth were sent to dental laboratories for duplication and processing using the specified injection-molding systems. The returned specimens were marked for testing. Specimens conforming to the required dimensions and standardization were included; defective, broken, or dimensionally inaccurate specimens were excluded.

Shear testing

Specimens underwent shear loading in a universal testing machine at a crosshead speed of 1 mm/min using a 50-kg load cell. A bi-chisel apparatus directed a parallel shearing force near the tooth–denture base resin interface. The force at fracture was recorded in newtons. The original thesis described calculation of shear stress using S = F/A; however, the bonded area was not independently measured or reported. Because the standardized specimens were compared using the recorded fracture force, fracture force in newtons was retained as the primary outcome in this manuscript rather than reporting calculated values in MPa.

Statistical analysis

Data were analyzed using SPSS version 22.0. Continuous variables were summarized as mean and standard deviation. Independent t-tests were used for the prespecified within-denture-base comparisons of Acryrock versus Ivoclar teeth. One-way ANOVA with Tukey post hoc analysis was used to compare the eight tooth–denture-base combinations. A p value <0.05 was considered statistically significant.

Results

Forty-eight specimens were analyzed across eight tooth–denture-base combinations. Each subgroup contained six specimens.

Group	Denture-base system	Tooth	n	Mean fracture force ± SD (N)
G1A	Compression-molded DPI	Acryrock	6	207.697 ± 0.113
G1B	Compression-molded DPI	Ivoclar	6	246.279 ± 0.094
G2A	Compression-molded Bredent	Acryrock	6	257.566 ± 0.241
G2B	Compression-molded Bredent	Ivoclar	6	302.636 ± 0.140
G3A	Injection-molded Ivoclar	Acryrock	6	321.212 ± 0.122
G3B	Injection-molded Ivoclar	Ivoclar	6	402.669 ± 0.258
G4A	Injection-molded Bredent	Acryrock	6	317.606 ± 0.196
G4B	Injection-molded Bredent	Ivoclar	6	335.108 ± 0.051

Table 1. Mean fracture-force values for the eight study subgroups.

For compression-molded DPI resin, the mean fracture force was higher with Ivoclar teeth than with Acryrock teeth (246.279 ± 0.094 N vs. 207.697 ± 0.113 N; p<0.001). For compression-molded Bredent resin, the corresponding values were 302.636 ± 0.140 N and 257.566 ± 0.241 N, respectively (p<0.001). For injection-molded Ivoclar resin, the values were 402.669 ± 0.258 N and 321.212 ± 0.122 N, respectively (p<0.001). For injection-molded Bredent resin, the values were 335.108 ± 0.051 N and 317.606 ± 0.196 N, respectively (p<0.001).

The overall one-way ANOVA demonstrated a statistically significant difference among the eight subgroups (p<0.001). Tukey post hoc analysis identified statistically significant pairwise differences reported in the original study. The highest mean fracture force was observed for injection-molded Ivoclar denture-base resin bonded to Ivoclar teeth (402.669 N), whereas the lowest

was observed for compression-molded DPI resin bonded to Acryrock teeth (207.697 N).

Discussion

The present in vitro study evaluated the effect of denture-base processing technique and acrylic tooth brand on the resistance of the tooth–denture base interface to shear loading. The principal finding was that the injection-molded systems evaluated demonstrated higher fracture-force values than the compression-molded systems, while Ivoclar teeth demonstrated higher values than Acryrock teeth within each tested denture-base system.

One possible explanation is the processing behavior of injection-molded denture-base resin. Injection systems are designed to maintain material flow during polymerization and compensate for polymerization shrinkage. Previous studies have reported reduced dimensional changes or improved accuracy with injection molding compared with conventional compression processing [4-6,15,16]. These findings provide a plausible materials-based context for the higher fracture-force performance observed in the present experiment, although the current study did not directly measure polymerization shrinkage or dimensional accuracy.

Studies have reported differences in bond strength among prefabricated denture teeth and denture-base resins, with the material combination influencing the measured outcome [7,11-14,17-19]. Differences in tooth composition, polymer network characteristics, interfacial wetting, and compatibility with the denture-base resin may contribute to these findings. Gharebagh et al. reported higher bond-strength values for Ivoclar acrylic teeth than for the other tooth materials evaluated, supporting the direction of the tooth-brand finding in the present study [17]. Prpić et al. likewise demonstrated that different combinations of denture teeth and denture-base resins can produce significantly different shear bond strengths [18].

The largest mean fracture force in the present study was obtained with the injection-molded Ivoclar denture base and Ivoclar teeth. This result should be interpreted as an in vitro materials finding rather than direct evidence of superior clinical longevity. Clinical tooth debonding is multifactorial and may be influenced by occlusal loading, tooth arrangement, surface contamination, wax elimination, mechanical retention, thermal cycling, saliva, fatigue, and laboratory handling [7,10,13].

The study has several strengths. The sample size was predetermined, specimens were standardized using a metal mold, two acrylic tooth brands and multiple denture-base systems were compared, and a universal testing machine was used under a defined crosshead speed. The design also permits direct comparison of the specific combinations tested.

Several limitations should be considered. First, the experiment was performed in vitro and therefore did not reproduce oral fluids, temperature changes, fatigue, soft-tissue support, occlusal dynamics, or complex denture geometry. Second, only shear loading was evaluated. Third, thermocycling and long-term water storage before testing were not performed. Fourth, the bonded interface area was not independently measured, so the outcome is reported as fracture force rather than area-normalized shear stress in MPa.

Within the limitations of this in vitro study, injection-molded denture-base systems demonstrated higher shear fracture-force values than the compression-molded systems evaluated. Ivoclar teeth demonstrated higher fracture-force values than Acryrock teeth within each tested denture-base system, and the highest value was observed for Ivoclar teeth bonded to injection-molded Ivoclar denture-base resin.

These findings support the importance of denture-tooth and denture-base material selection when considering resistance to standardized shear loading. Further studies using measured bonded areas, thermocycling, fatigue loading, controlled surface preparation, and clinically relevant oral conditions are required before the findings can be translated into clinical recommendations.

Declarations

Ethics approval

Not applicable. This was an in vitro experimental materials study involving no human participants, human biological samples, or animals.

Informed consent

Not applicable. No human participants were involved.

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Conflicts of interest

The authors declare that they have no competing interests.

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Data availability

The de-identified data generated and analyzed during this study are available from the corresponding author on reasonable request, subject to institutional policies and applicable permissions.

AI assistance

During preparation of this manuscript, an artificial intelligence tool was used to assist with language editing, grammatical correction, organization, and refinement of manuscript text. The authors reviewed and verified all AI-assisted content and take responsibility for the accuracy, originality, and integrity of the final manuscript. No AI tool was used to generate or alter the study data, statistical results, or scientific findings.

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