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Assessment of flexural strength of high impact implant supported overdenture base material fabricated by different heat polymerization techniques using two different housing retaining materials – A Comparitive in-vitro study.

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Abstract

Background: The mandibular implant supported overdenture has to be relieved to provide space for metal housing and retaining material, resulting in inadequate thickness of the denture base and increased chances for fracture. Evidence regarding the effect of different heat polymerization techniques and using different housing retaining materials on flexural strength is lacking.

Aims and objectives: To assess and compare the flexural strength of high impact denture base material fabricated by compression molding technique and injection molding technique using autopolymerising acrylic resin and autopolymerising composite resin housing retaining material.

Method: Forty high impact acrylic resin specimens of dimension 64 mm × 10 mm × 4 mm were fabricated. In group 1, 20 specimens by compression molding technique and 20 housings retained in 10 specimens using autopolymerizing acrylic resin (group 1A) and 20 housing retained in 10 specimens using autopolymerising composite resin (group 1B). In group 2, 20 specimen fabricated from injection molding technique and 20 housings retained in 10 specimens using autopolymerizing acrylic resin (group 2A) and 20 housing retained in 10 specimens using autopolymerising composite resin (group

2B). The specimens were stored in artificial saliva at 37^0C for 2 weeks. Testing was done using UTM and measurement of flexural strength (MPa) were analyzed using Mann-Whitney u-test ($P \leq 0.05$).

Result: Highest mean flexural strength was obtained in specimens fabricated by compression molding technique using autopolymerising acrylic housing retaining material followed by compression molding technique and injection molding technique using autopolymerising composite housing retaining material. Specimens fabricated by injection molding technique using autopolymerising acrylic housing retaining material showed the least mean flexural strength.

Conclusion: The specimens fabricated by compression molding technique using autopolymerising acrylic resin housing retaining material showed the highest flexural strength.

Keywords: ISOD, UTM, IOCS, PMMA, TREVALON HI

Introduction

The oral rehabilitation of completely edentulous patients with mild to severe ridge resorption has been considerably enhanced as implant dentistry has flourished.[1] Two-implant supported overdenture (ISOD) have become a successful treatment alternative and consider as a minimal standard treatment option for edentulous mandible.[2] Implant placed in the anterior region of mandible have a success rate equal or greater than 95% with a very low incidence of surgical complications.[3]

Polymethyl methacrylate (PMMA) is the most commonly used material for denture base fabrication; however, its mechanical properties limit denture performance. To improve the properties of conventional denture base material rubber and fillers in denture base resins are added. Studies have shown that using high impact denture base material significantly increases the fracture resistance. Other methods include chemical modification of denture base materials, and mechanical reinforcement of acrylic with other materials, such as metal wire and glass fibers.[4,5] Apart from denture base material, different denture processing techniques also influence the success of the prosthesis. Compared to conventional compression molding technique, injection molding technique exhibited higher dimensional accuracy.[6,7,8,9]

The implant supported overdenture can be attached with splinted attachments such as bars or unsplinted attachments such as locator, ball anchors, double crowns and magnets. According to previous studies, the ball attachments transfer less stresses to both implant and produces less denture movement, provides better retention and reduces oral mucous pressure during mastication.[10 – 15] Another factor that affects retention is interimplant distance. For ball attachment, the recommended interimplant distance is 19 mm and 29 mm.[16]

ISOD have female part or housing component for attachment of implant to the denture. These housings can be secured using indirect (laboratory) or direct technique (intra-oral chair side). The direct method for attachment of housing using ball attachment is superior during a long-term evaluation period compared to indirect technique.[17]

Various types of retaining materials are used for attachment of housings like, acrylic resin-based relining materials, an autopolymerizing composite resin retaining, an autopolymerizing PMMA, and heat-polymerized PMMA retaining materials.[18] Studies have shown that flexural strength of PMMA denture base was higher when PMMA-based acrylic resins were used as the housing retaining material.[19,20,21] Also the hard reline material showed the roughest surfaces around the overdenture attachment housings leading increased bacterial adhesion and microcrack formation around the housings.[18]

However, no in-vitro studies have been done to compare the flexural strength of high impact acrylic overdenture base material with different heat polymerization methods along with different housing retaining materials.

Thus the purpose of this study was to assess the flexural strength of high impact implant supported overdenture base materials with heat different polymerization techniques after using different housing retaining materials.

The null hypothesis in this study was that there is no significant difference in the mean flexural strength of high impact acrylic denture base material fabricated with different heat polymerization methods, compression molding technique (Trevelon HI) and injection molding technique (SR Ivocap), and using different housing retaining materials, Autopolymerizing acrylic resin (DPI) and Autopolymerising composite resin (VOCO QUICK UP).

Materials And Method

A metal bar was cut into 3 pieces measuring 64 mm × 10 mm × 4 mm to serve as metal die for the production of the bar shaped specimens. Two 6 mm diameter hollow were drilled to a depth of 3 mm, which were at a distance of 29 mm from each other (fig 1).

Figure 1

Group 1: Specimens fabricated from conventional compression molding technique:

Dental stone (Kalabhai kalstone dental stone) was mixed according to manufacturer instructions and metal dies were invested in the flask. After the invested material had set, the flask were separated and metal dies were removed (fig 2). The high impact acrylic denture base resins (TREVALON HI) powder was mixed with the liquid according to the manufacturer instruction. The material was packed into the mold space and polymerised in a hot water bath for 2 hrs at 74^{0}C, followed by heating at 100°C for 1 hour. The contouring and finishing of the test specimens was done by using a tungsten carbide bur at 15000 rpm and 200 and 600 grit abrasive paper (fig 3).

Figure 2

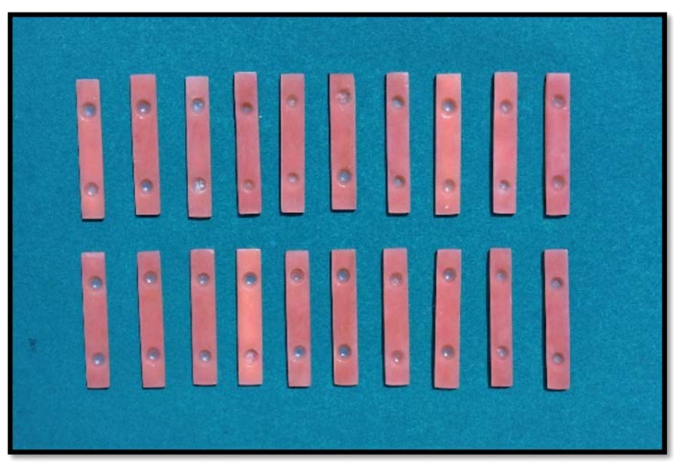


Figure 3

Group 2: Specimens fabricated from injection molding technique

Twenty wax strip templates of dimensions 64 mm ×10 mm × 4 mm were fabricated using modelling wax. The dimensions were measured using a stainless steel scale and GDC wax gauge. Dental stone was mixed according to the manufacturer instructions and the wax templates were settled into this mixture. Wax sprues were attached to the wax pattern for introduction of resin (fig 4). The remaining half of the flask was positioned and the investment process was completed. The flasks were kept in boiling water at 100°C for 5 minutes for elimination of wax. Flask were reassembled and placed into a carrier that maintain pressure on the assembly during resin introduction and processing. The high impact denture base resin (SR IVOCLAR VIVA DENT) was mixed according to the manufacturer instructions and injected into the mold cavity at room temperature. The flask were then placed into a water bath for polymerization of the denture base resin. As the material polymerises, additional resin was introduced into the mold cavity to compensate polymerisation shrinkage (fig 5). The contouring and finishing of the test specimens was done by using a tungsten carbide bur at 15000 rpm and 200 and 600 grit abrasive paper. No polishing was applied on the surfaces because they were considered the intaglio surfaces of the denture. Specimens which developed flaws during processing and finishing procedures for example: porosity, over trimming were excluded from the test specimen groups.

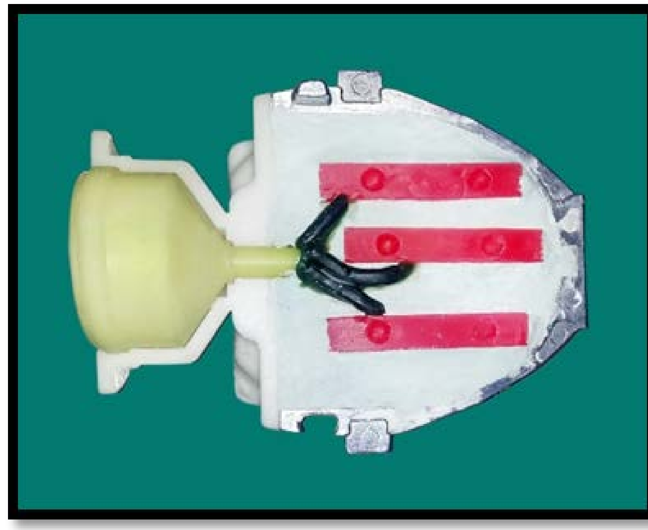


Figure 4

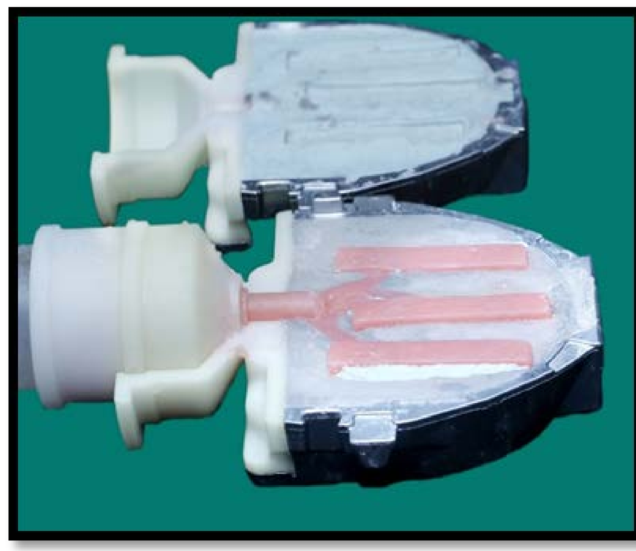


Figure 5

Attachment of housing using Autopolymerizing acrylic resin (DPI):

Forty housings (4.5 mm diameter and 2.6 mm height, ADIN IMPLANT) were attached using autopolymerising acrylic resin to twenty bar shaped specimens fabricated 10 by compression molding technique (Group 1A) and 10 by injection molding technique (Group 2A).

After cleaning and drying the surface of the specimens, liquid methyl methacrylate monomer was brushed on the exposed surface for 180 seconds. Autopolymerized acrylic resin was mixed on a glass slab and then placed into the hollow, followed by placement of housing into the hollow with the help of tweezers (fig 6). Additional autopolymerized acrylic resin was placed on the repaired side to fill any voids. Once polymerized, the repaired surface with the attachment housing was smoothened with sand paper.

Figure 6

Attachment of housing using Autopolymerising composite resin (VOCO QUICK UP)

The instructions for the materials application were followed and forty housings are attached to twenty bar shaped specimens using autopolymerising composite resin. Ten specimens fabricated by compression molding technique (Group 1B) and 10 by injection molding technique (Group2B).

After cleaning and drying the surface of the specimens, few drops of Quick Up adhesive was dispensed into the mixing tray and was applied to the hollow parts using Single Tim application brush. Then the adhesive layer was dried for 30 seconds in the air. Then the hollow was quickly filled with QuickMix syringe to a maximum of two third followed by placement of housing into the hollow with the help of tweezers (fig 7). The excess material was removed using rotary instrument and was smoothened with sand paper (fig 8).

Figure 7

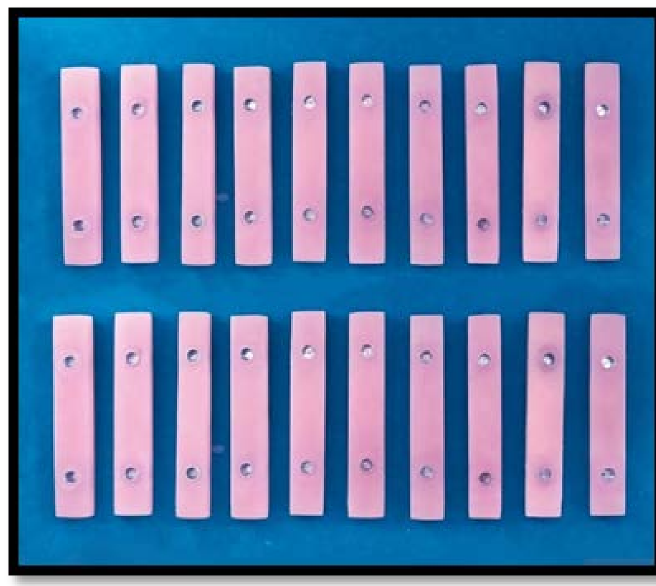


Figure 8

All the specimens were immersed in artificial saliva at 37ºC in incubation chamber for 2 weeks. The samples were kept in dry conditions for 1 hour before the mechanical testing was to be done.

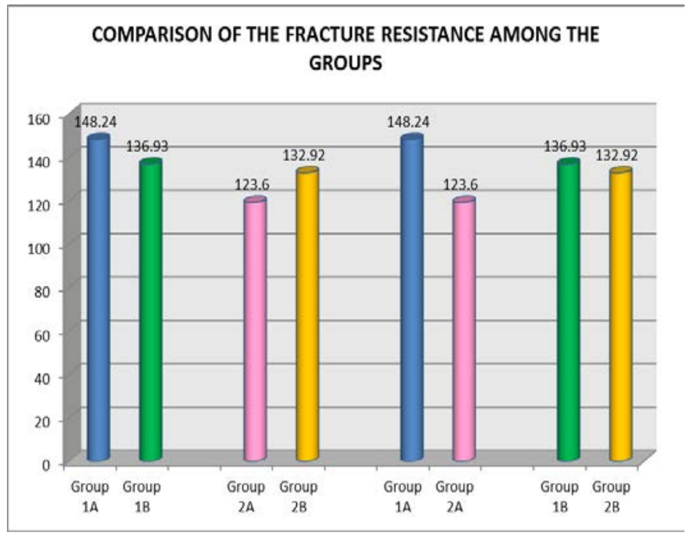
A three point flexure test [International Organization for Standardization (ISO) standard 1567] was used to test the flexural strength of the specimens. The specimens were placed in a test rig with vertical supports 50 mm apart. The plunger tip was 3.2 mm in diameter. A force was applied using a Mecmesin Multi Test 10-i system with Win Test software and a 500- lbf load cell at a cross head speed of 5mm/minute (fig 9). The fracture force (F) was recorded in newtons (N) and the flexural strength (FS) was calculated as per the following formula to yield MPa units: **$FS=3PL/2bd^2$**. Where 'P' was maximum load, 'L' was length of specimen, 'b' was specimen width and 'd' was specimen thickness.

Figure 9

To perform the statistical analysis **SPSS (Statistical Package For Social Sciences)** version 20. [IBM SPASS statistics (IBM corp. Armonk, NY, USA released 2011)] was used. Descriptive statistics of the explanatory and outcome variables was calculated by mean, standard deviation for quantitative variables. Inferential statistics like Mann-whitney test was applied to check the statistical difference of fracture resistance, displacement between the groups. The level of significance is set at 5%.

Results

A statistically significant difference was found between the groups (graph 1). The flexural strength was significantly higher in specimens fabricated by compression molding technique using autopolymerising acrylic housing retaining material (148.24MPa) followed by compression molding technique using autopolymerising composite housing retaining material (136.93MPa) and injection molding technique using autopolymerising composite housing retaining material (132.92MPa). Specimens fabricated by injection molding technique using autopolymerising acrylic housing retaining material showed the least mean flexural strength (123.6MPa).



Discussion

The null hypothesis in this study was that there is no significant difference in the mean flexural strength of high impact acrylic denture base material fabricated with different heat polymerization methods i.e. compression molding technique (Trevelon HI) and injection molding technique (SR Ivocap) and using different housing retaining materials i.e. Autopolymerizing acrylic resin (DPI) and Autopolymerising composite resin (VOCO QUICK UP) was rejected.

According to the statistical analysis, when the comparison was done within the groups, the results showed that there was no significant difference when the specimens were fabricated from compression molding technique using acrylic (1A) and composite (1B) housing retaining materials. However, specimens fabricated from injection molding technique using composite (2B) housing retaining material showed significant increase in flexural strength when compared with specimens fabricated from injection molding technique using acrylic (2A) housing retaining material.

When the comparison was done between the groups, 1A and 2A, the results showed that there was significant increase in flexural strength in group 1A. However, no difference were evaluated when comparing 1B and 2B.

The overall comparison between group 1 and group 2 showed that a high impact denture base specimen fabricated from compression molding technique showed significant increase in flexural strength as compared to the specimen fabricated from injection molding technique (graph 1).

Overdenture base fracture usually occurs after repeated flexing of the denture base under small loads resulting in the development of microcracks at the high stress concentration areas particularly at the housing and is a long standing and a common clinical problem encountered in prosthodontic practice.[22,23] The fracture rate of overdentures ranges from 9.3% to 21.4%.[38] The fracture usually occurs due to the housing that acts as a fulcrum for the overdenture and due to decrease in the thickness of denture base in order to incorporate the implant housing which reduces the strength of the denture base.[18] In the present study, two hollow space were prepared in the rectangular specimen in order to accommodate the housing due to which only 1 mm of acrylic was left around the housing. This relatively large hollows might have damaged the integrity of the denture base and compromise the strength of the specimens.

In implant supported overdenture the bite forces are significantly increased upto 60% - 200% than the conventional complete dentures.[20] To withstand repeated masticatory loads and resist plastic deformation, acrylic resin denture base materials should exhibit higher fatigue resistance and a high proportional limit. Although polymethyl methacrylate (PMMA) is a material of choice for the fabrication of denture base but its mechanical properties compromises its longevity in terms of their duration of service as the fracture of denture base may occur during function. To improve the properties of denture base much attention has been given towards the reinforcement of acrylic resin. These reinforcement is either through chemical modifications i.e. copolymer of rubber methyl methacrylate referred to as high impact resin or by incorporation of different additives like glass fibers, metal wire, and long carbon fibers. Polycarbonate and nylon have also been incorporated in resins as an alternative material for patients who are allergic to methyl methacrylate denture base material and its byproducts.[4,23]

Gianluca et al concluded that high-impact denture base resins could be the material of choice when there is a history of repeated fracture or where the fracture is more likely to occur.[5] Hence, in this study high impact denture base resin was used for the fabrication of specimens by different heat polymerization techniques.

Ahmed A et al reported that overdenture base made of thermo-elastic acrylic resin denture base material showed better retention values and function than denture base made from heat cured acrylic resin material.[25]

Gonad et al and other studies have reported that metal reinforcement over the top of the copings more effectively reduce the strain in the midline of the overdenture and around the copings than any other kinds of reinforcement.[23]

Studies have reported that from a clinical point of view, there seems to be little advantage of injection molding over conventional compression molding and no appreciable differences in laboratory working time between the injection and compression molding techniques. [6,7,8] However, results obtained in this study showed that the specimens fabricated by compression molding technique showed highest flexural strength compared to injection molding technique.

Several materials are available that can be used to retain the housing, including autopolymerizing acrylic resin, heat polymerising acrylic resin, acrylic based hard relining resins, and composite resins.[18] The results obtained in this study is in accordance with the previous study where the investigators have reported that the flexural strength of PMMA denture base was significantly higher when PMMA-based acrylic resins were used as the housing retaining material compared with when acrylic resin-based hard reline materials and composite resin material were used.[18]

For the success of overdenture the bond strength between the housing retaining material and housing and the bond between the retaining material and acrylic denture is an important factor. A chemical bond exists between denture base and the retaining material, whereas the housings are retained by mechanical retention in the retaining material. Study conducted by Ozkir et al reported that UfiGel hard reline retaining material produces highest surface roughness and increased microcrack formation leading to bacterial adhesion around the housings and hence, requires extra hygine care when UfiGel hard reline resin is used for housing orientation. He also stated that thermocycling should be used during testing of the specimens because higher thermal expansion and contraction of the metal housings might increase stresses leading to microcracks at the housing and retaining material junction. However, denture base and housing retaining material junction was intact.[18,19]

Agarwal et al reported that sandblasting the attachment housing with 30 µm silica modified aluminium oxide produces a roughened surface and effectively increased the bonding between titanium and self-cure acrylic resin and thereby, improved the flexural strength.[20]

The study had several limitations. The specimens fabricated in this study were standardized rectangular bar shaped and different from the overdenture used in clinical situation. The thickness of the specimens was taken 4 mm according to the clinical situations but may also differ from patient to patient. Since it's an in-vitro study, the specimens were placed in artificial saliva for two weeks to simulate the oral environment, but other factors like masticatory load, parafunctional habits, and oral temperature may also influence the flexural strength.

CONCLUSION

Within the limitations of the study, it was concluded that:

- Specimens fabricated by compression molding technique using autopolymerising acrylic housing retaining material showed higher flexural strength than using autopolymerising composite housing retaining material. However, there was no significant difference within the group.
- Specimens fabricated by injection molding technique using autopolymerising composite housing retaining material showed significantly higher flexural strength than using autopolymerising acrylic housing retaining material.
- Specimens fabricated by compression molding technique showed significantly higher flexural strength than injection molding technique when using autopolymerising acrylic housing retaining material.
- There was no significant difference in specimens fabricated by compression molding technique and injection molding technique when using autopolymerising composite housing retaining material
- Overall, the specimens fabricated by compression molding technique using autopolymerising acrylic

resin housing retaining material showed the highest flexural strength.

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