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Flexural strength evaluation of two different materials used for securing metal housing part of ball and socket attachment in implant retained overdenture (in-vitro study)

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Abstract

For the direct chairside pick-up of housing attachment, a variety of retention materials, such as traditionally auto polymerized or light polymerized acrylic resin, are used. Self-curing composite materials with a pink hue have recently been launched to the market as possibilities for chairside attachment housing pick-up. An in-vitro study was conducted for the evaluation of the flexural strength of conventional auto-polymerized acrylic resin and composite-based material used for securing the female part of the ball and socket attachment to the fitting surface of an in-implant retained overdenture. Twenty samples were prepared according to ISO specifications for the flexural strength test (25mm × 2.5 mm × 3 mm) in rod form; specimens were divided into two groups: Group S (n= 10) for self-cure acrylic resin material and Group C(n=10) for composite resin-based material. All samples were horizontally and individually mounted in a custom-made loading fixture. The samples were statically compressed under load until sample fracture occurred. Data were calculated and analyzed using an independent t-test for intergroup comparisons. The significance level was set at $p \leq 0.05$. The difference between the two groups was statistically non-significant ($P > 0.05$).

Keywords: Attachment, Flexural strength, overdenture, Implant retained overdenture

Full-length article **Corresponding Author*, e-mail: dr.abdoaly88@gmail.com

1. Introduction

Although implant-retained overdentures are seen to be the best option for patients who are edentulous, conventional complete dentures manufacture will continue to be a crucial component of oral healthcare for the ageing population due to medical and financial considerations.[1]. Since many years ago, poly methyl methacrylate has been used as the basis material for dentures. Its popularity was attributed to its simplicity in processing, affordability, light weight, outstanding aesthetic, and ease of repair.[1,2]. The best alternative to traditional dentures in recent years has been implant-supported overdentures, which enhance patient quality of life by enhancing retention and mastication.[3]. Over dentures are connected to implants either by splinting or un splinting the implants. While choosing the proper denture attachment type, it is vital to consider the mandibular anatomy, desired amount of retention, capacity to maintain hygiene and economic concerns.[4].

Insufficient resin thickness could happen once the metal housing for implant-supported overdentures is inserted into the overdenture base because it needs a specific amount of space inside the denture base. To prevent denture base fracture, which usually occurs close to areas of high stress concentration, the housings' dimensions are important because any decrease in denture base thickness increases the base fracture chance. The acrylic resin base of an overdenture could become weakened by attachment housing. The type of housing retaining material utilized affects how strong the acrylic resin base and housing retaining material combination is. The attachment housing of the overdenture base decreased the flexural strength of PMMA resin.[5]. A common clinical occurrence[6]. is fracture, which typically happens after repeated bending of the denture under light stresses. Functional stresses, habits, thin areas at the denture base are some factors that may contribute to denture fracture.[7]. In clinical practice, denture base fractures that happen adjacent to a housing location are common. Along with the usual clinical

occurrence, housing may eventually come loose from the resin used as the denture base.

The material type utilized to fix the attachment housing and the binding between the pickup material and denture base can both have an impact on the overdenture's flexural strength.[8,9]. According to Takashi et al., there could be an adhesive failure between the reline resin and the PMMA since relining materials had lower proportional limitations than PMMA. Reline resins might not be enough to reinforce the denture base as a result. The flexural strength of relined PMMA was drastically lowered, and water sorption also resulted in a reduction in tensile strength.[10]. The housing must be reinserted to the denture base, which is costly and time-consuming. Furthermore, until correct therapeutic care is given, the patient's masticatory function and aesthetics are affected [11-12].

It is possible to process the attachment into the overdenture either chairside (direct approach) or in a lab setting (indirect technique). To reduce mistakes that can occur during the production of dentures, many prosthodontists choose to pick up the housing utilizing the chairside procedure [13]. For the direct chairside pick-up of housing attachment, a variety of retention materials, such as traditionally auto polymerized or light polymerized acrylic resin, are used. Self-curing composite materials with a pink hue have recently been launched to the market as possibilities for chairside attachment housing pick-up.[14]. The null hypothesis of this study was that there was no significant difference in the flexural strength between conventional self-cured acrylic resin versus composite resin based as a pick-up material.

2. Materials and Methods

Ethical approval was obtained from Research Ethics Committee, Faculty of Dental medicine Al-Azhar University Under the No. (EC Ref No.: 917/2935_15-06-23). Twenty samples were prepared according to ISO specifications for flexural strength test, Then specimens were divided into two main groups based on the material used as a pick-up material (nine samples in each group). Group (A) was a self-cure acrylic resin, while group (B) was composite resin-based material. (n=10). (25 mm, 2.5 mm, and 3 mm) rod metal patterns were created. A separating medium (Kendall Vaseline, White Petroleum Jelly; Tyco Healthcare Group LP.) was used to paint each metal pattern before it was flaked with plaster into a metal flask. The top half of the metal flask and the metal patterns were removed once the plaster had fully dried, leaving a void (mold) in the plaster at the bottom half of the flask with the same dimensions as each pattern.

The dough was then packed into the mold, excess material was removed, and the final closure was completed under a bench press at 40,000 N. The powder and liquid for the auto polymerizing denture base material, PMMA (cold cure acrylic material, Acrostone, Egypt), were prepared and mixed in accordance with the manufacturer's recommendations. Following the final seal, the flask was placed in the clamp for bench curing for 30 minutes at ambient temperature before being submerged in a 100 °C boiling water bath. The flask was taken out once the curing process was finished and left on the bench to cool. According to the manufacturer's instructions, a pickup material mix cartridge (luxapick -up, DMG, Hamburg, Germany) was packed into the mold associated with the corresponding test, trial closed, the excess material was removed, and the final closure was carried out under a bench press at 40,000 N. The flask was placed in the clamp for bench curing for 30 minutes at room temperature after the final closure. From the flask, the samples were taken out, and the necessary finishing was completed. The specimen needed only the barest amount of finishing, removing the extra material and care was taken to keep the heat level low throughout. All polishing operations were carried out by a single individual using gentle palm pressure for 60 seconds to standardize surface roughness (figure 1).

2.1. Flexural strength evaluation:

On a computer-controlled materials testing machine (Model 3345; Instron Industrial Products, Norwood, MA, USA) with a loadcell of 5 kN, each sample was mounted in a specially made loading fixture[three-point bend test assembly]. with the damage site centrally located on the tensile side. Data were recorded using computer software (Instron® Bluehill Lite Softwar). The samples were then statically compressed loaded at a crosshead speed of 1 mm/min until fracture. With the aid of computer software (Instron® Bluehill Lite Software; figure 2), the stress-strain curves were captured. FS represents the limiting stress at which failure or instability is imminent. The value of the calculation of FS was guided by the formula:

$$\mathbf{FS\ (ó) = 3F\ (L)/\ 2wh^2}$$

Where, Where; F is the maximum load at the point of fracture, L is span, w is the width of the sample and h its height. Figure 2

3. Results and discussion

As seen in table 1 and figure 3, the Composite-Based group (Pick-up material) had a higher value than the auto-polymerized acrylic resin group (104.3814.86), but the difference was not statistically significant (p=0.937). Table 1, Figure3. In specialized literature, the advantages of implant-assisted overdentures are already generally acknowledged. With implant-assisted overdentures, difficulties with retention and stability are eliminated by using implants as complete denture retainers, which significantly improves masticatory performance.[15]. Improved function and satisfaction were noted by patients who got implant-supported dentures, demonstrating the benefits of a higher-fiber diet.[16]. This might also imply a rise in the forces produced by the masticatory function. The maximum bite power of patients wearing mandibular implant-supported dentures is 60% to 200% higher than that of individuals wearing traditional dentures. According to studies, implants improve the maximal bite force.[17]. The denture base must be robust to bear functional and parafunctional masticatory stresses.[18]. This is crucial for implant-supported overdentures since a thinner denture base is required because acrylic relief is required to make room for attachment housings. In the study at hand, the housing was placed in a hollow that had been constructed, and 1.5–2 mm of the acrylic resin denture foundation was left to round

it. The specimen's strength may have been severely diminished, and the integrity of the denture foundation may have been compromised by this wide depression.[19]. The thinner denture base area at the abutment was where most fractures were observed.[20].

9.3% to 21.4% of implant-supported overdentures' problems can be attributed to denture base fractures.[21]. Because of tension accumulation and denture base deformation in this thinner area, fractures are more common around implants or abutments.[22,23]. As it simulates the types of force placed on the denture during mastication, flexural strength is an important property that reveals a denture base material's capability to sustain effective masticatory forces.[24,25]. These attachments can be included in the overdenture via a variety of methods. They can be broadly divided between direct techniques (conducted intraorally by the doctor]. and indirect approaches (performed by the technician in the laboratory[26]. While the indirect method cuts down on chairside time and prevents monomer interaction with tissues, laboratory procedures extend treatment times and can necessitate additional patient visits. In most cases, the direct way is simpler, economical, and quicker than the indirect way. The direct technique has fewer maintenance concerns than the indirect technique, according to a recent study on long-term prosthetic maintenance. If the overdenture abutment undercuts are not properly blocked out, the direct technique could lock the prosthesis in the mouth [27-28].

To reduce errors caused by denture manufacturing, many doctors choose to pick up the housing by using the chairside procedure because it is easier, cheaper, and faster than the indirect method.[29]. To limit any dimensional changes, we used a metal pattern in the current investigation rather than a wax one.[30]. The Mini Flexural Test was used in the current investigation. A mini flexural test may be preferable to the ISO flexural test since it uses smaller, more clinically relevant specimens whereas large specimens are not clinically realistic in addition to wasting material. The small flexural test is recommended for examining the flexural characteristics of composite restoratives because it is simple to create the specimen and is more clinically realistic. [31-32]. The result of our study showed the difference between Composite-Based group (Pick-up material]. and auto-polymerized acrylic resin group was not statistically significant (p=0.937]. This result disagreed with that of Ozkir et al., who examined the impact of various housing retaining materials on the flexural strength of an acrylic resin overdenture base and concluded that composite resin-based retaining materials outperformed hard reline material groups in terms of the denture base's flexural strength.[15]. In terms of their impact on the flexural strength of the denture base, Machado, A.L. et al. found that composite resin-based retention materials performed comparably to the hard reline material groups[33]. which agreed with our study.

4. Conclusions

Based on the findings of this study, it could be concluded that there is no statistically significant difference between composite-based material (pick-up material) versus auto-polymerized acrylic resin in the bond strength to the denture base. Composite–based material can be used for direct pick–up as an alternative to auto-polymerized acrylic resin.

References

[1] L. Marchini. (2014) Brazilian Dental Science. Patients' satisfaction with complete dentures: an update. p. 5-16.

[2] M.M. Gad, S.M. Fouda, F.A. Al-Harbi, R. Näpänkangas, A. Raustia. (2017) International Journal of Nanomedicine. PMMA denture base material enhancement: a review of fiber, filler, and nanofiller addition. p. 3801.

[3] M. Andreiotelli, W. Att, J.R. Strub. (2010) International Journal of Prosthodontics. Prosthodontic complications with implant overdentures: a systematic literature review. 23(3): p. 195-203.

[4] K. Chandan, P. Agrawat, G. Mistry, R. Singh. (Assumed Journal: Journal of Dental Implants) Implant Supported Overdenture Attachments-A Review. p. 14-17.

[5] S.E. Ozkir, B. Yilmaz. (2017) Journal of Prosthetic Dentistry. Effect of different housing retaining materials on the flexural strength of an acrylic resin overdenture base. 118(4):500-503.

[6] T. Khuder, N. Yunus, E. Sulaiman, A. Dabbagh. (2017) Journal of the Mechanical Behavior of Biomedical Materials. Finite element analysis and clinical complications in mandibular implant-overdentures opposing maxillary dentures. 75:97-104.

[7] F. Faot, M.A. Costa, A.A.D.B. Cury, R.C.R. Garcia. (2006) Journal of Prosthetic Dentistry. Impact strength and fracture morphology of denture acrylic resins. 95:367-373.

[8] K.B. Domingo, J.O. Burgess, M.S. Litaker, M.S. McCracken. (2013) Journal of Prosthetic Dentistry. Strength comparison of four techniques to secure implant attachment housings to complete dentures. 110:8-13.

[9] Y. Takahashi, J. Chai. (2001) International Journal of Prosthodontics. Assessment of shear bond strength between three denture reline materials and a denture base acrylic resin. 14:531-535.

[10] F.A. Al-Harbi. (2018) Saudi Journal of Medicine and Medical Sciences. Mandibular Implant-supported Overdentures: Prosthetic Overview. 6(1):2-7.

[11] T. Gonda, Y. Maeda, J.N. Walton, M.I. MacEntee. (2010) Journal of Prosthetic Dentistry. Fracture incidence in mandibular overdentures retained by one or two implants. 103(3):178-181.

[12] E. Emami, G. Heydecke, P.H. Rompré, P. de Grandmont, J.S. Feine. (2009) Clinical Oral Implants Research. Impact of implant support for mandibular dentures on satisfaction, oral and general health-related quality of life: a meta-analysis of randomized-controlled trials. 20(6):533-544.

[13] R.D. Phoenix, M.A. Mansueto, N.A. Ackerman, R.E. Jones. (2004) Journal of Prosthodontics. Evaluation of mechanical and thermal properties of commonly used denture base resins. 13(1):17-27.

[14] S.E. Ozkir, B. Yilmaz. (2017) Journal of Prosthetic Dentistry. Effect of different housing retaining materials on the flexural strength of an acrylic resin overdenture base. 118(4):500-503.

[15] A.P. Da Rosa Possebon, R.M. Marcello-Machado, A.M. Bielemann, A.J. Schuster, L. de Rezende Pinto, F. Faot. (2018) Journal of Prosthodontic Research. The masticatory function of conventional complete denture wearers changing to 2-implant retained mandibular overdentures: clinical factor influences after one year of function. 62(4):479-484.

[16] R.C. Cardoso, P.J. Gerngross, J.T. Dominici, S. Kiat-Amnuay. (2013) International Journal of Oral and Maxillofacial Implants. Survey of currently selected dental implants and restorations by prosthodontists. P. 24-28.

[17] J.H. Doundoulakis, S.E. Eckert, C.C. Lindquist, M.K. Jeffcoat. (2003) Journal of the American Dental Association. The implant-supported overdenture as an alternative to the complete mandibular denture. 134(11):1455-1458.

[18] F.M. Van Kampen, A. Van Der Bilt, M.S. Cune, F. Bosman. (2002) Journal of Dental Research. The influence of various attachment types in mandibular implant-retained overdentures on maximum bite force and EMG. 81(3):170-173.

[19] M.S. Beyli, J.A. Von Fraunhofer. (1980) Journal of Prosthetic Dentistry. Repair of fractured acrylic resin. 44(5):497-503.

[20] R. Nedir, M. Bischof, S. Szmukler-Moncler, U.C. Belser, J. Samson. (2006) International Journal of Oral and Maxillofacial Implants. Prosthetic complications with dental implants: From an up-to-8-year experience in private practice. 21:919-928.

[21] N. Chhabra, A. Chhabra, A. Jain, D. Kabi. (2019) Journal of Prosthodontics. Overdenture Prostheses with Metal Copings: A Retrospective Analysis of Survival and Prosthodontic Complications. 28:876-882.

[22] R.S. Seo, H. Murata, G. Hong, C.E. Vergani, T. Hamada. (2006) Journal of Prosthetic Dentistry. Influence of thermal and mechanical stresses on the strength of intact and relined denture bases. 96:59-67.

[23] K.B. Domingo, J.O. Burgess, M.S. Litaker, M.S. McCracken. (2013) Journal of Prosthetic Dentistry. Strength comparison of four techniques to secure implant attachment housings to complete dentures. 110(1):8-13.

[24] W.M. Sadig. (2003) Journal of Prosthetic Dentistry. Special technique for attachment incorporation with an implant overdenture. 89(1):93-96.

[25] S. Okayama, Y. Suzuki, H. Shimpo, C. Ohkubo. (2015) Dental Materials Journal. Fixation of magnet assembly to denture base using alternative resins. 345-348.

[26] J.T. Dominici, K.E. Kinderknecht, E. Patella-Clark. (1996) Journal of Prosthetic Dentistry. Clinical procedure for stabilizing and connecting O-ring attachments to a mandibular implant overdenture. 76(3):330-333.

[27] J. Nissan, B. Oz-Ari, O. Gross, O. Ghelfan, G. Chaushu. (2011) Clinical Oral Implants Research. Long-term prosthetic aftercare of direct versus indirect attachment incorporation techniques to mandibular implant-supported overdenture. 22(6):627-630.

[28] F. Hardness, G.U. Strength. (2005) (Assumed Journal: Journal of Dental Materials) The following tests shall be performed according to the methods set forth in ANSI/ADA Specification No. 12, ANSI/ADA Specification No. 17 2, and ANSI/ADA Specification No. 80-83.

[29] A.U. Yap, S.H. Teoh. (2003) Journal of Oral Rehabilitation. Comparison of flexural properties of composite restoratives using the ISO and mini-flexural tests. 30(2):171-177.

[30] M. El Aziz, E. El Megid Tella. (2022) Journal of the Indian Prosthodontic Society. Fully digital workflow for reinforced mandibular implant overdenture—A novel method. 22:205-209.

[31] M.A. Elsyad, F. Fathe Mahanna, A.S. Khirallah, A. Ali Habib. (2020) Clinical Oral Implants Research. Clinical denture base deformation with different attachments used to stabilize implant overdentures: A crossover study. 31:162-172.

[32] A.L. Machado, A.D. Puckett, L.C. Breeding, A.F. Wady, C.E. Vergani. (2012) Gerodontology. Effect of thermocycling on the flexural and impact strength of urethane-based and high-impact denture base resins. 29:p.318-323.

[33] M. El Aziz, E. El Megid Tella. (2022) Journal of the Indian Prosthodontic Society. Fully digital workflow for reinforced mandibular implant overdenture—A novel method. P.205-209.