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Case Report

Reinforced Polymethyl Methacrylate Resin Using Grapheme Derivative For an "All-On-4" Implant- Supported Definitive Mandibular Prosthesis – A Case Report

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Abstract

Since the inception of implant dentistry, implant-supported metal-acrylic resin hybrid prostheses are the major prosthetic devices given to restore physiological and esthetic functions of oral tissues of edentulous or partially edentulous patients. The clinical performance of the most commonly used acrylic resin in the fabrication of dentures, namely, polymethyl methacrylate (PMMA) resin determines its long-term deformation and wear resistance. However, its poor mechanical resistance to wear and tear poses a major setback. An attempt to incorporate graphene derivative with PMMA resin in prosthesis fabrication has demonstrated significant improvement in the mechanical strength as per literature. This case report presents rehabilitation of edentulous mandibular jaw and also briefly states the properties of graphene and the polymerization process of the resin with the graphene derivative.

Key words: Computer-aided design EXOCAD, Graphene derivative, Mandibular prosthodontic rehabilitation, Mechanical resistance, Polymethyl methacrylate resin

INTRODUCTION

Implant-supported metal-acrylic resin hybrid dentures primarily having polymeric compositions, i.e., polymethyl methacrylate (PMMA) with a metallic framework is the most commonly used, cost-effective material for this purpose. Its qualities of biocompatibility, reliability, relative ease of manipulation, low modulus of elasticity, and low toxicity[1] have made it a definitive material in prosthodontic rehabilitation. However, poor mechanical properties, volume shrinkage after polymerization, and poor antimicrobial (anti-adhesion) effects have posed to be major drawbacks lately.[2] Hence, in this case, PMMA resin reinforced with graphene derivative aided by EXOCAD for prosthetic planning has been tried as it essentially enhances mechanical properties of PMMA according to literature.[3] Since limited data have been published regarding inclusion of a graphene compound in a PMMA resin for improving the mechanical properties, further evidence-based studies are needed to ensure rigorous scientific support of this technique and materials.[4]

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MATERIALS AND METHODS

Properties of Graphene

Graphene is an atomically thin, two-dimensional sheet of sp2 carbon atoms in a honeycomb structure. It has been shown to have many desirable properties such as high mechanical strength, electrical conductivity, molecular barrier abilities, and other remarkable properties. However, the use of pristine graphene has proved challenging due to poor solubility and agglomeration in solution due to van der Waals interactions. As an alternative, compounds similar in structure to graphene are synthesized from graphite in an effort to achieve many of the advantages of pristine graphene while also imbuing the surface with

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functionalized oxygen groups. Graphene's principal properties are its high thermal and electrical conductivity, high traction resistance, low density, and low coefficient of thermal expansion. Furthermore, since it is carbon, graphene is ecological and recyclable.[5]

The incorporation of graphene into PMMA resin is an innovative strategy to improve its mechanical properties, simultaneously increasing the elastic modulus as well as the tenacity, reducing the appearance of cracks and their spread as well as decreasing the shrinkage rate during polymerization. It is an ideal candidate to improve the performance of autopolymerizing acrylic resins for dental use not only due to its high traction resistance, coefficient of thermal expansion, high capacity for absorption and lubrication, flexibility, and high surface area but also for its high weight to resistance ratio.[6]

Resin Polymerization with Graphene

One of the principal advantages of graphene is that even in small quantities, its inclusion can cause big changes in the mechanical and physicochemical properties of the material to which it is added. Given that, graphene is a good thermal conductor and that the process of post-polymerization of the acrylic resin requires heat to complete it, its addition allows a higher polymerization conversion rate.

Compared to conventional polymer materials, PMMA resin nano reinforced with graphene has a higher modulus and specific resistance due to the distribution of tension between the structures, as they are capable of withstanding tensions practically without suffering deformations. The union between the nano reinforcements and the original polymer is one of the main aspects that explain the increase in mechanical resistance.[5]

This case report hereby presents mandibular implant rehabilitation by an "All-on-4" technique highlighting delivery of graphene derivative reinforced PMMA resin implant-supported hybrid prosthesis to enhance mechanical resistance of the prosthesis.

CASE REPORT

A 67-year-old female patient of Indian origin visited our clinic in Mumbai with a chief complaint of missing teeth in her lower jaw requesting replacement of fixed teeth.

Diagnosis

Diagnostic criteria involved thorough medical history, dental history including intraoral and extraoral examination, intraoral and extraoral pictures, blood investigations, full volume radiographic investigation cone-beam computed tomography (CBCT), and diagnostic cast assessment for a comprehensive treatment plan.[6]

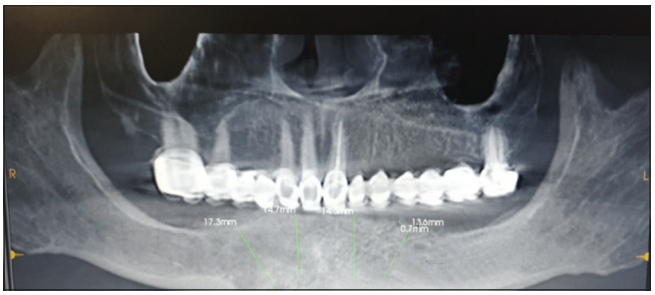

Figure 1: Pre-operative panoramic radiograph.

Figure 2: Pre-operative, intraoral view of the residual mandibular ridge

Figure 3: Full-thickness incision with ridge tabling

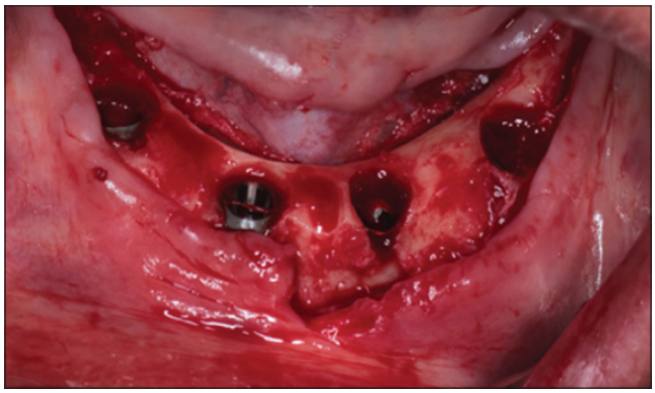

Figure 4: Surgical placement of two straight and two tilted implants

The patient had a medical history of controlled hypertension and intraoral examination revealed dental history of a 5-year-old PFM FPD in upper jaw, edentulous mandibular jaw, and xerostomia (dry mouth condition).

Blood investigation revealed all parameters within normal range and suggested that the patient was fit enough to undergo surgical procedures in implant replacement therapy.

Radiographic data evaluation of CBCT revealed no pathology with severe atrophy in the mandibular residual ridge, indicating an "All-On-4" concept for implant placement to be appropriate for FPD in mandible [Figure 1].

The panoramic radiograph revealed an advanced alveolar bone resorption in the mandible.

Treatment Plan

Given the intraoral condition of the residual mandibular ridge [Figure 2], the "All-on-4" concept of placement of four implants in the anterior region (combining two tilted and two axial implants) and loading a graphene derivative reinforced PMMA resin-based, screw-retained definitive hybrid prosthesis with prosthetic planning on EXOCAD was considered a less time consuming, viable economic treatment modality of choice in this case.

The "All-on-4" technique was scheduled to rehabilitate the lower jaw.

Under local anesthesia, a full-thickness crestal incision from the right molar region to the left molar region was performed [Figure 3]. Because there was a vertical dimension collapse, significant alveoplasty by means of tabling the residual ridge was done to achieve adequate prosthetic space of desired 15 mm [Figure 4].

The two anterior implants were axially placed in the incisive area, whereas the two posterior implants were placed at an angle of 30° to the mental foramina.

After soft-tissue management and closure, straight and angulated abutments were placed onto the implants [Figures 5 and 6] and multiunit impression copings were attached to the prosthetic abutments for an open tray impression [Figures 7 and 8].

A jig trial was taken, splinting the impression copings with a low shrinkage autopolymerizing resin to ensure that the interimplant relationship is preserved and an accurate transfer without accidental displacement is achieved for an accurate master cast, a passive fit, and a decrease in potentially destructive forces that may lead to bone loss or prosthetic failure [Figure 9].

An open tray impression, jig trial and jaw relation with two wax rims were taken [Figures 8-10].

With the information provided by the intraoral scan (EXOCAD), Figure 11, a new wax try-in denture was

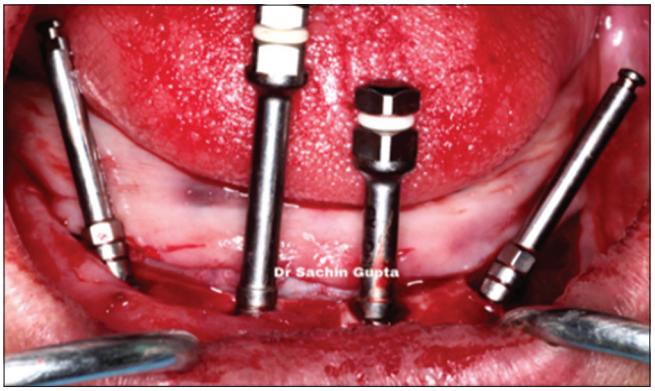

Figure 5: Straight and angled abutments placement on the four implants

Figure 6: Post-surgical panoramic view

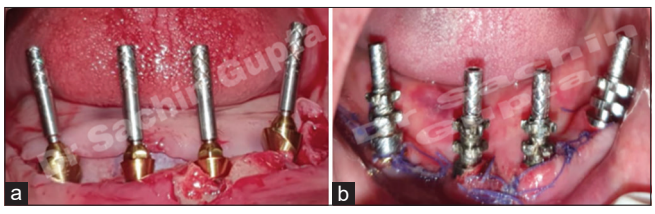

Figure 7: (a and b) Multiunit impression copings attached to prosthetic abutments

Figure 8: Open tray impression

designed [Figure 12] and 3D-printed working cast was created to evaluate the esthetic parameters, prospective tooth positions, and vertical dimension. A new cast was then 3D printed to fabricate a screw-retained, hybrid prosthesis made of PMMA resin reinforced with graphene derivative.

A definitive prosthesis made from PMMA resin reinforced with graphene derivative was designed based on biologic and functional parameters of the interim prosthesis with the help of EXOCAD software and milled [Figures 13 and 14].

Passive fit and occlusion were checked by equilibrating the occlusal forces with the help of OccluSense device in the patient's mouth [Figure 15].

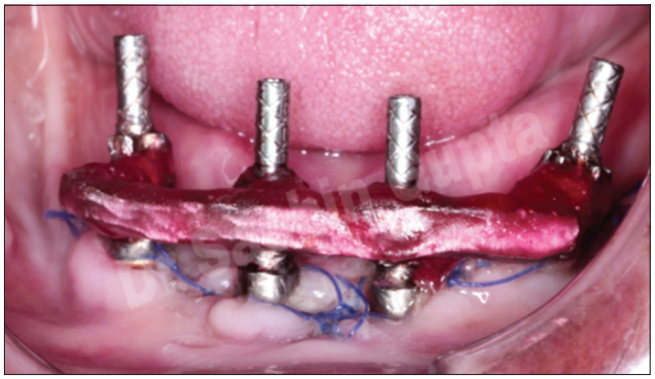

Figure 9: Jig trial

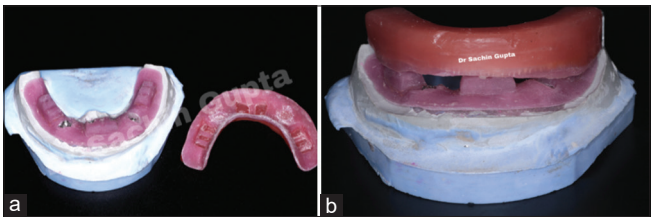

Figure 10: (a and b) Jaw relation with two-step wax rims

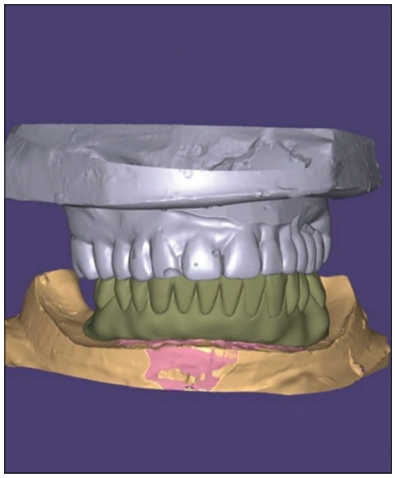

Figure 11: 3D-printed working cast planned on EXOCAD

After all the parameters were verified, the prosthesis was delivered [Figure 16] and oral hygiene instructions with information on how to take care of the new prosthesis were provided.

After 1 year of placement of the definitive prosthesis, no biomechanical or biological complications were reported in the follow-up check-up, thus concluding, incorporation

Figure 12: Wax try-in

Figure 13: Graphene derivative reinforced polymethyl methacrylate resin-based hybrid prosthesis

Figure 14: Occlusal view of the hybrid prosthesis

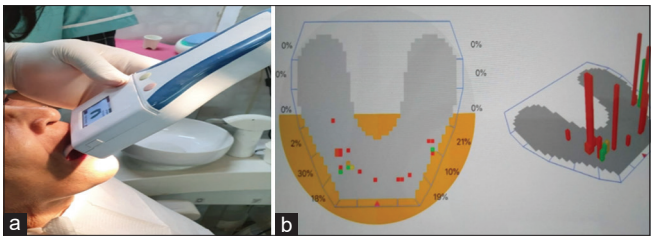

Figure 15: (a and b) Occlusal forces equilibrated by OccluSense device

Figure 16: Frontal view of the graphene derivative reinforced polymethyl methacrylate resin-based hybrid prosthesis delivery on the 5th day

of Graphene derivative in PMMA resins to be a suitable option for prosthetic rehabilitation.

DISCUSSION

The present case report used graphene derivative to PMMA resins to overcome the compromised mechanical properties in PMMA resin material. Many authors claim that this incorporation in acrylic resins may enhance the resin's mechanical properties and antimicrobial adhesion effects and decrease the degree of contraction during polymerization.[4]

However, much more evidence-based study is needed to establish that this new strategy produces consistent successful outcome.

The patient informed consent was obtained for the publication of this case report.

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