Case Report

Rehabilitation of Amputated Finger with Silver Nanoparticle Incorporated Acrylic Prosthesis: A Case Report

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Abstract

Amputation, particularly traumatic finger loss, can have profound physical and psychological consequences, often resulting in diminished self-esteem and social withdrawal. Prosthetic rehabilitation serves as a vital option for restoring esthetics and partial functionality. This case report presents the successful fabrication of finger prosthesis for a 45-year-old male who had lost his middle finger due to trauma. The integration of nanotechnology enhanced both biocompatibility and esthetics. This case underscores the potential of combining conventional prosthodontic techniques with nanomaterials to achieve durable, hygienic, and visually realistic prostheses, ultimately improving the quality of life for amputee patients. Patient education and careful treatment planning were key to the rehabilitation's success.

Keywords: Finger Prosthesis, Silver Nanoparticles, Acrylic Resin, Nanotechnology in Prosthodontics, Maxillofacial Rehabilitation

Introduction

"Amputation", derived from the Latin word "amputare" (to excise, to cut out) has been defined as the "removal of part or all of a body part enclosed by skin."[1] There are several types of amputations, including self-amputation, which occurs when a trapped person frees himself or herself by removing part or all of a body part, congenital amputation, which occurs when a person is born without part or all of a body part, and traumatic amputation, which may result from factory, farm, powered tools, or motor vehicle accidents, including industrial or environmental accidents, terrorist attacks, and a lack of basic public health care.[2] Amputation-related malformations are embarrassing for patients and can have a significant impact on their physical and psychological health, potentially leading to serious psychiatric, familial, and social problems.

In 1953, Ackerman defined prostheses as the phase of dentistry that repairs and artificially replaces parts of the face and body after injuries or surgical intervention.[3] Many different materials have been available over the years, but currently, the materials used to fabricate maxillofacial prostheses include vinyl plastisol, acrylic resins based on polymethyl methacrylate (PMMA), polyurethanes, latex, and silicone polymers. Silicones and acrylic resins are the most used materials for maxillofacial reconstruction.[4] The success of the prosthesis is dependent on precision in planning, making the impression, carving the model, and selecting the appropriate material for the circumstances. Finger prosthesis is difficult due to the requisite stability and retention.

Nanotechnology is an extremely diverse and multidisciplinary field. The growing interest in the field of nanosciences leads to the emergence in the field of dentistry also called as "Nano dentistry." The field of nanotechnology epitomizes a general gestalt of the uses of several nanoparticles in prosthodontics. In particular, suitable applications in acrylic resin, tissue conditioner, dental composites, denture teeth, dental porcelain, implants, and maxillofacial prostheses are appraised.[5] PMMA with pigments, such as titanium oxide and ferric oxide nanoparticles are being manufactured, which also provide the similar hue, as that of gingiva for enhancing the esthetic. This material can be presented as low porosity, higher molecular weight, and an ability to prevent adherence of fungal and microbial growth. The use of nanotechnology will help to develop a PMMA which will be more biocompatible with better mechanical properties.[6]

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Before managing an amputee, the individual's functional requirements and management choices must be explored with the patient. A thorough hand examination should be performed, assessing the extent of fingertip injury, angles and levels of amputation, tissue loss, nail involvement, involvement of additional fingers, neurovascular involvement, and hand function. A treatment plan should be developed after analyzing the fingertip injury.[7]

This case report describes a traditional method of fabricating finger prostheses using acrylic and silver nanoparticle (AgNP) stains, as well as a new strategy or amputee finger modification for greater retention and comfort.

Case report

A 45-year-old male patient reported to the Department of Prosthodontics, Crown and Bridge at Index Institute of Dental Sciences, Indore with the complaint of a missing finger. History indicated that the patient lost his finger 10 years ago because of a traumatic injury. The severed stump healed properly (Figure 1).

Clinical examination revealed that the middle finger was missing. The skin over the residual finger stump was completely healed with no signs of inflammation. A treatment plan was formulated to replace the finger. The advantages and limitations of the replacement of the finger were explained to the patient. The patient did not give any history of prosthetically rehabilitated fingers prior. The patient had consented to the prosthesis fabrication of his finger following the ethical norms and conditions.

Fabrication

1. The patient's hand was lubricated with a thin layer of petroleum jelly to prevent the hydrocolloid impression material from adhering to the surgical site and the tissue surface. Following this, the area around the hand was boxed, and the impression material was placed over the palmer side first and then the dorsal side. The patient was instructed to keep the hand in a normal resting position.
2. The impression was then poured with dental stone, using a vibrator to avoid voids.
3. The positive replica of the hand was retrieved (Figure 2), and prosthesis for the missing finger was sculpted in modeling wax.
4. 2 Rings and a connecting ring were selected according to the patient's finger size and soldered together. These rings served the purpose of retention and were evaluated on the patient's hand.
5. The wax pattern of the finger was placed in the correct position on the hand. During the try-in stage, the fit, stability, and seating of the wax pattern were evaluated, along with the shape and size of the pattern (Figure 3).
6. The pattern was then flasked in the lower half of the flask, ensuring that the rings were embedded in plaster to avoid undercuts for the counter-flasking (Figure 4). Separating medium was applied between the two pours. After dewaxing, the mold was allowed to cool.

Figure 1: Pre-treatment view showing traumatic amputation of the right middle finger

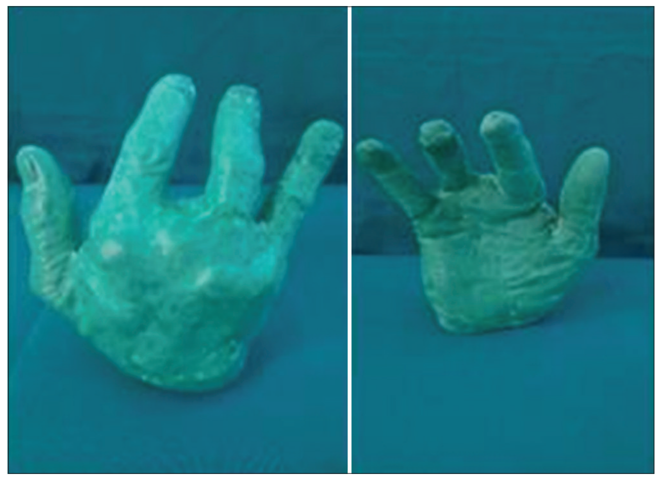

Figure 2: Model showing amputated right middle finger

Figure 3: Try in of wax pattern for finger prosthesis

7. For intrinsic coloring, AgNPs were used. To decide the correct ratio of silver nanoparticles, 4 different ratios were tested and the samples were used for shade matching.
8. 4 ratio's used were:-
   a. Powder-to-liquid ratio (5 g powder and 2 mL liquid). 0.1 g by weight powdered silver 99.9% pure were mixed with PMMA

Figure 4: Flasking of wax pattern

  b. Powder-to-liquid ratio (5 g powder and 2 mL liquid). 0.2 g by weight powdered silver 99.9% pure were mixed with PMMA
  c. Powder-to-liquid ratio (5 g powder and 2 mL liquid). 0.5 g by weight powdered silver 99.9% pure were mixed with PMMA
  d. Powder-to-liquid ratio (5 g powder and 2 mL liquid) 1 g by weight powdered silver 99.9% pure was mixed with PMMA.

9. Shade matching was done using 4 samples in natural daylight. The best time for this procedure was between 11:00 am and 1:00 pm.
10. The desirable color was obtained from sample 1, that is, Powder-to-liquid ratio (5 g powder and 2 mL liquid). 0.1 g by weight powdered silver 99.9% pure was mixed with PMMA. Then, this ratio was used to pack the mold created by the elimination of the wax (Figure 5).
11. The flask was closed under light pressure, transferred to a clamp, left for table curing for half an hour, and followed by processing in the fast-curing cycle of heat cure acrylization, that is, 74°C water bath for 2 h and 100°C for 1 h. After cooling the table for another half an hour, it was deflasked, retrieved, trimmed, and polished to obtain the final finger prosthesis (Figure 6).
12. To complete the prosthesis, an appropriate-sized artificial nail was adapted into place, and for an enhanced realistic appearance, the nail was shaped according to the nail of the natural fingers.
13. The final and most gratifying step was to place the prosthesis on the patient's hand in lieu of the missing finger (Figure 7). The patient was instructed and demonstrated about the use and maintenance of the prosthesis.

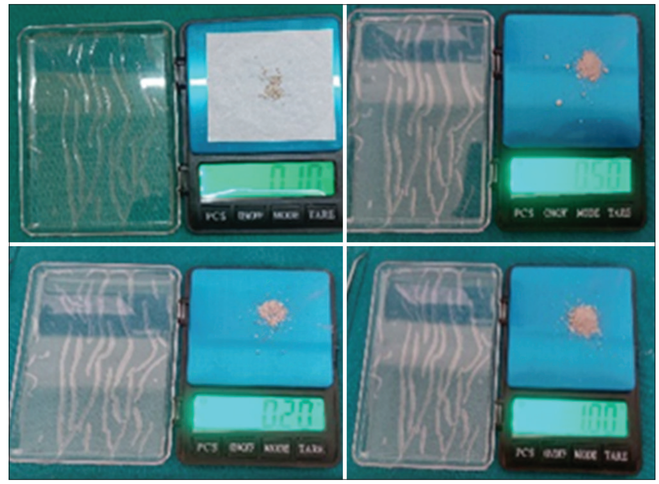

Figure 5: Four different samples of silver nanoparticles

Figure 6: Final finger prosthesis

Figure 7: Insertion of finger prosthesis

Discussion

Finger amputation, especially due to trauma, significantly impacts a patient's quality of life-physically, emotionally, and socially. The disfigurement often leads to psychological distress, social withdrawal, and reduced confidence. Prosthetic rehabilitation offers a practical solution for restoring appearance and partial function, especially in cases where surgical reconstruction is not possible or preferred.

In the present case, finger prosthesis was fabricated using PMMA combined with AgNPs to enhance its mechanical and antimicrobial properties. PMMA is widely used in prosthodontics because of its ease of processing, affordability, and acceptable esthetics.[8] However, its limitations include porosity and susceptibility to microbial colonization. The incorporation of AgNPs helps address these limitations. Silver exhibits strong antimicrobial activity by disrupting bacterial cell walls and inhibiting their replication.[9]

To achieve optimal esthetics, four concentrations of AgNPs were tested. The best color match was achieved with 0.1 g of silver/5 g of PMMA, ensuring both esthetic and biological benefits. This aligns with earlier studies showing that low concentrations of nanoparticles can offer antimicrobial protection without compromising the visual properties of the prosthesis.[10] Retention of finger prostheses is another challenge. While adhesives or implants can be used, the non-invasive ring-retention method used in this case proved effective and patient-friendly. The customized ring provided mechanical stability and ease of use, reducing the risk of dislodgement during daily activities.

Although silicone prostheses offer superior flexibility and life-like texture, PMMA offers better durability and ease of intrinsic staining.[9] In this case, intrinsic staining with AgNP-enhanced resin allowed for long-lasting color retention and natural appearance under daylight. This case highlights the value of integrating nanotechnology with conventional prosthetic methods to enhance the clinical outcomes in maxillofacial prosthetics. Individual planning, appropriate material selection, and patient education were key factors in the successful rehabilitation of the patient.

Conclusion

This case report demonstrates successful rehabilitation of an amputated finger using a silver nanoparticle-incorporated PMMA prosthesis. The integration of AgNPs enhanced the material's antimicrobial properties, biocompatibility, and esthetics. The selected concentration (0.1 g AgNPs per 5 g PMMA) provided optimal shade matching and performance. A custom-designed ring mechanism offered effective retention without the need for adhesives or surgery. The prosthesis restored the patient's confidence and appearance, improving overall quality of life. This case highlights the potential of nanotechnology in maxillofacial prosthetics and supports the use of AgNP-modified acrylic resin as a practical and durable option for finger prosthetic rehabilitation.

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