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Case Report

CAD-CAM approach to optimize management of post-COVID-19 mucormycosis maxillectomy patients: A case report

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ABSTRACT

A 34-year-old male patient was referred to the department after treatment of his right premaxilla and nasal cavity post-COVID-19 mucormycosis for prosthodontic management. Treatment planning included the fabrication of an interim obturator prosthesis followed by a definitive prosthesis at a later stage.

The interim obturator was fabricated using conventional techniques, but digital technology was used to fabricate the definitive prosthesis. Impressions were made using an intraoral scanner, and virtual designing and 3D printing of the framework was done using CAD/CAM (Computer Aided Designing/ Computer Aided Manufacturing)

1. Introduction

Mucormycosis, a rapidly aggressive fungal illness that affects immunocompromised elderly individuals, was a relatively unknown name before the second wave of the Corona Virus Disease of 2019 (COVID-19) pandemic. During the second wave of COVID-19, it was discovered that it was affecting not just older people but also younger people who had no previous medical conditions.[1] The surgical treatment of severe stages of this debilitating illness included the removal of necrotic bone, which typically required a whole or partial maxillectomy and primary closure with buccal and palatal mucosa to minimize further spread. This causes intraoral defects of varying diameters and a connection between the oral and nasal chambers.[2,3] Also, the biomechanics of the oral cavity shift to fresh biomechanics such as mid-facial collapse, change in the vertical dimension, loss of the occlusal plane and basal seat, and deflection of the mouth towards the damaged side while closing. This drastically impairs swallowing, chewing, aesthetics, and the patient's quality of life. As a result, prosthodontic rehabilitation of such flaws is necessary to seal the palatal defects following surgery.[4] Prosthetically, it remains a challenging and skill-sensitive procedure due to the age of the patients and the extent of the damage. As a prosthodontist, the primary goals include asepsis, improved comfort, patient quality of life, and better predictability. The usual process of obturator fabrication necessitates many impressions to create the diagnostic, master, and altered casts, which may be uncomfortable for such compromised individuals. Switching from analogue to digital processes is necessary to build the prosthesis with the slightest patient discomfort and asepsis. The rapid evolution of computer-aided design/computer-assisted manufacturing technology and intraoral scanners have revolutionized maxillofacial prosthetics and made this digital switch possible. The current case report describes using Intraoral scanners, CAD/CAM, and 3D printing to optimize the prosthetic rehabilitation of post-COVID-19 mucormycosis maxillectomy patients.

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2. Case Report

A 34-year-old male patient wanting prosthetic rehabilitation presented to the prosthodontics department. Due to post-Covid 19 mucormycosis, he had undergone a unilateral maxillectomy from the right central incisor to the maxillary tuberosity (Figure 1). A surgical defect in the maxilla, which included a portion of the hard palate, the alveolar ridge, and the maxillary tuberosity producing an oroantral communication, came to light during an intraoral examination. The patient complained of nasal fluid regurgitation, difficulty in eating, and a nasal tone in his speech. An extraoral examination revealed left-side deviation and asymmetry of the lips. A comprehensive evaluation identified the anomaly as Aramany's Class I, Liverpool Class IIa, and Cordero Class B maxillary defect.[5] During the time following surgery, the patient did not employ a surgical obturator. The recommended course of treatment was the fabrication of an interim hollow closed bulb obturator, which was to be followed by a definite obturator after six months.

3. Procedure

For the fabrication of the interim obturator, the procedures were divided into three phases: the pre-prosthetic phase included oral prophylaxis and mouth preparation to ensure optimal conditions for prosthesis placement. The prosthetic phase involved taking a diagnostic impression using an irreversible hydrocolloid (Plastagin, Septodont) poured with dental stone (Kalstone, Kalabhai) to create a primary cast. Border moulding was completed with DPI Pinnacle tracing sticks and a final impression using Zhermack Oranwash Light Body. A pickup impression was then made with irreversible hydrocolloid (Plastagin, Septodont) and a perforated stock tray, which was poured using die stone (Kalrock, Kalabhai) to form a master cast. Jaw relation was recorded, and a wax try-in was performed. After the try-in, the waxed-up obturator was processed using DPI heat-cure denture base material via the lost wax technique, and the obturator was finished and polished before insertion (Figure 2).

The maintenance phase included regular check-ups at one-week, two-week, and one-month intervals to monitor healing and ensure no recurrence of mucormycosis, with modifications to the obturator prosthesis made as needed based on healing progress. After six months, a definitive obturator was planned with a cast partial framework utilizing digital technology. Initially, the fit of the interim obturator was evaluated using phonetics and aesthetics, and the bulb extent was also assessed. Intraoral scanning of the patient (Figure 3) and scanning of the bulb from the interim obturator were performed using an IOS device (Medit 13) (Figure 4). An order for a removable partial denture framework was created using dental CAD software, selecting the missing teeth to create a pontic order. The dental CAD software was opened, and the 3D digital cast of the maxillectomy defect was imported. The 3D digital cast was examined, and undesired undercuts in the teeth or the defect cavity were virtually blocked out. The clasp shoulders were trimmed where they contacted, and the clasp points were positioned in a 0.5-mm undercut. After mouth preparation, intraoral scanning was performed again, and virtual shade matching was conducted concurrently. Exocad was utilized for designing virtual crowns (14, 15, and 16) and semi-precision attachment concerning tooth 11. The crowns were fabricated, and the prosthesis was cemented in place using GC Gold Label Luting GIC. Intraoral scanning was performed after cementation.

Figure 1: Pre-operative view

Figure 2: Interim obturator insertion

The framework used the principles of designing for an Aramany Class I defect (Figure 5). DMLS printing of the metal framework (Phrozen 8K printer) was done, and a framework trial was performed on the patient. To create a virtual master cast, the scanned obturator bulb was stitched along with the patient's intraoral scan, and the master cast was printed stereolithographically (Figure 6). Exocad was used for virtual jaw relation and try-in (Figure 7). The prosthesis was processed conventionally, and after finishing and polishing, the final prosthesis was placed in the patient's mouth (Figure 8). The patient was recalled for follow-up at one-week, two-week, and one-month intervals.

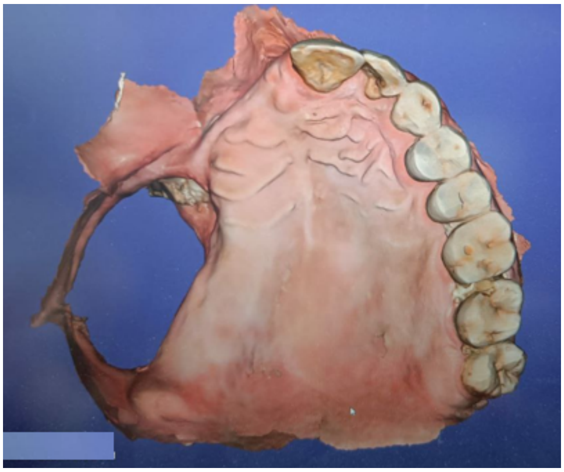

Figure 3: Intraoral scanning of the patient

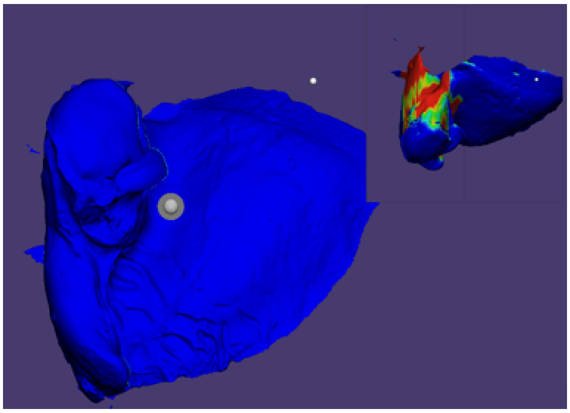

Figure 4: Intraoral scanning of the obturator

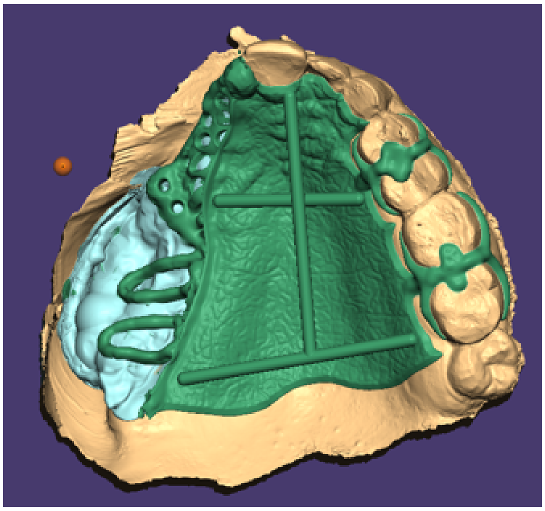

Figure 5: Framework designing

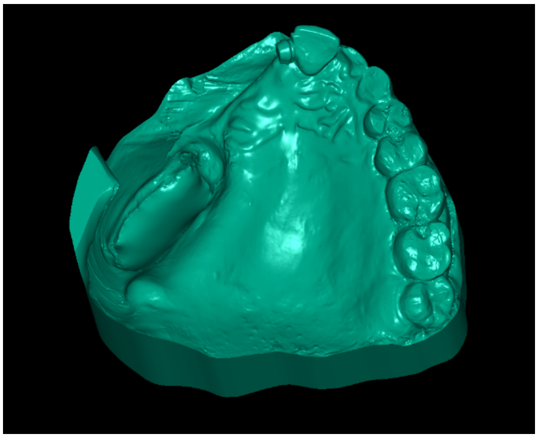

Figure 6: 3D printed master cast

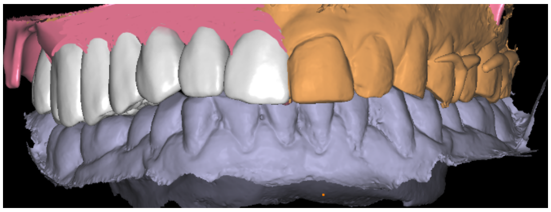

Figure 7: Virtual try in

Figure 8: Definitive obturator insertion

4. Discussion

The scanner effectively captured a digital impression of the defect's periphery and boundaries as well as the remaining maxilla and teeth. Intraoral scanning systems (IOS) offer numerous advantages, including improved patient comfort, optimized infection control, minimal tissue irritation, and prevention of dental material deformation during cast creation, and facilitation of data transmission and electronic archiving.[6–8] Some studies have indicated that intraoral scanners are particularly beneficial for patients with limited mouth opening, allowing for high-precision 3D reconstruction of intraoral structures in a shorter time frame.

The CAD software can automatically seal undesirable cuts, select relevant components from its library, and position them over the dental mould, thus reducing labour time and operator variability.[9] Elbashti et al. utilized a chairside intraoral scanner for extraoral scanning of an existing obturator. Their positive results stemmed from 3D printing the scanned obturator and comparing it to the original prosthesis using specialized software.

The Medit scanning protocol involved calibration with a small block and scanning the interim obturator along an arbitrary route. The Medit monitor was used to evaluate surface scanning quality. The scanned data were exported as binary STL files and loaded into 3D modelling software (DentalCAD 3.0 Galway), where any minor artefacts were rectified.[10] The scanned bulb of the interim obturator was aligned with the intraoral scan in Exocad software to assist in master cast production.

Virtual surveying and CAD software enhance precision at the micrometre level, improving procedure predictability. The benefits of this digital process include better planning with automated identification of insertion and removal paths and effective management of undercuts.[11] The framework was designed digitally with specific considerations for an Aramany Class I defect, incorporating mesio-occlusal and disto-occlusal rests on adjacent teeth to minimize wedging and potential periodontal damage from food impaction.[12]

Direct Metal Laser Sintering (DMLS) for fabricating CAD/CAM CoCr RPD frameworks offers superior mechanical and clinical properties, with higher hardness and uniformity than traditional casting methods.[13] Regarding clinical precision, stereolithography outperformed other digital and analogue technologies in producing dental stone casts.[14] Compared to gypsum models, 3D SLA printers provide greater accuracy, with scanning electron microscopy revealing that SLA surfaces are smoother and more uniform than the gritty texture of plaster models. Emerging 3D bioprinting technologies allow for high-resolution models suitable for maxillofacial prosthetics.[15]

Digitally, tooth colour is captured using a high-resolution camera, LED light, and computer software, referencing the VITA shade guide.[16,17] Shade matching via intraoral scanners is highly reproducible, generally surpassing optical shade matching; however, variations in accuracy among trials suggest that visual shade matching should be used to verify results.[6]

Despite these advancements, limitations still exist. Challenges in accurately capturing complex anatomical structures, particularly in patients with irregular defects or limited mouth opening, remain significant. Current digital impression techniques may not always accommodate intricate contours, potentially leading to inaccuracies in the digital model. The expertise required to operate CAD software effectively can also lead to outcome variability. Looking ahead, there is potential for further development in the field. Future research should focus on integrating artificial intelligence into CAD software for enhanced modelling accuracy and efficiency, as well as developing specialized training programs for practitioners to optimize the use of these technologies. Additionally, advancements in scanner technology, such as smaller probe tips and higher resolutions, could significantly improve the accuracy of scanning maxillofacial defects. Unique software designed to develop obturator prostheses should also be explored to streamline CAD procedures and enhance clinical outcomes.

5. Conclusion

Conventional obturator fabrication is complex and often requires multiple scheduled visits, highlighting the need for more efficient processes, especially in emergencies like disaster-related injuries. Exploring digital technology presents promising avenues for enhancing the delivery of maxillofacial prostheses. Future research should aim to refine these digital methods to expedite fabrication and improve patient care in urgent circumstances, ensuring quicker and more effective rehabilitation options.

6. Conflict of Interest

None

7. Source of Funding

None

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