Patient Specific Implant in Postmucormycosis Maxillectomy Patient - Review Article

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Abstract

Rhino-maxillary mucormycosis, leads significant consequences for affected individuals, especially in post-maxillectomy cases where extensive bone and soft tissue loss occurs. The COVID-19 pandemic further exacerbated the prevalence of this infection. while surgical intervention combined with antifungal therapy remains the cornerstone of mucormycosis management, the resulting maxillofacial defects severely affect function, aesthetics, and overall quality of life. Traditional reconstruction methods often fall short in addressing these complex rehabilitative needs. Development of Patient-Specific Implants offer a promising alternative, ensuring better anatomical fit, improved functional outcomes, and reduced surgical burden.

Keywords: patient specific implant, mucormycosis , maxillectomy, rehabilitation

INTRODUCTION

Mucormycosis is an opportunistic infection that arises from fungi belonging to the Mucorales family. These fungi are typically found in the nasal and oral cavities of healthy individuals. mucormycosis was first identified in 1855, marking the first verified case of this condition in humans (Küchenmeister, 1855).[1]

Rhino-maxillary mucormycosis is the most common type of infection, particularly found in individuals with uncontrolled diabetes experiencing ketoacidosis. During the COVID- 19 pandemic in India, there was an increase in cases of mucormycosis.[2]

The mechanism of rhino maxillary mucormycosis involves the fungus invading tissues, damaging the linings of blood vessels, which leads to clot formation and diminished blood flow (ischemia) to nearby bone tissue. It begins in the nasal cavity and progresses through the paranasal sinuses, maxilla, palate, orbit, and brain.[2]

Clinical features are the reddish-black appearance of the nasal turbinate, nasal blockage, facial swelling, blood-tinged nasal discharge, and occasionally oral ulcers and tooth mobility, frequently associated with bone damage on imaging examinations. The management of rhino-maxillary mucormycosis typically requires the surgical excision of necrotic bone along with antifungal treatment, which results in maxillofacial defects that significantly impact a patient's quality of life, leading to difficulties in speech, swallowing, eating, and an unaesthetic appearance.[1,2]

Such defects pose considerable challenges for rehabilitation; conventional reconstruction techniques frequently struggle with these complex challenges, especially when it comes to preserving both functionality and appearance.[3]

A novel method for the surgical and prosthodontic rehabilitation of a post-COVID-19 mucormycosis patient utilizes computer- aided design (CAD) and computer-aided manufacturing (CAM) technologies. The use of personalized, patient-specific implants presents a viable alternative to traditional methods.[1]

Consequences in Patients Following Maxillectomy for Mucormycosis

I. **Functional Difficulties**

The loss of teeth and maxillary structures results in ineffective chewing, leading to dietary limitations and nutritional deficiency. There is an increased risk of food regurgitation into the nasal cavity and aspiration, resulting in higher chances of respiratory infections.

The alteration of nasal anatomy makes patients more susceptible to repeated sinus infections and speech problems like hypernasality and makes it hard to articulate certain consonants.

II. **Aesthetic and Psychological Effects**

Facial asymmetry - The loss of maxillary structures leads to midfacial concavity and unevenness.

Emotional Challenges - The functional and aesthetic challenges contribute to feelings of anxiety, depression, and reclusion from social interactions.

III. **Slow Wound Healing**

Extensive removal of tissue leads to poor blood supply, and associated health issues (such as diabetes) result in prolonged healing times.[4,5,6]

Limitations of Traditional Prosthetic Rehabilitation

Poor Retention & Stability: Progressive tissue changes lead to ill-fitting prostheses, requiring constant relining; also, pressure on residual mucosa causes irritation and ulceration.

Difficulty in cleaning increases the risk of infections and halitosis.

Compromised Functionality and Aesthetics - Speech difficulties, nasal regurgitation, and inefficient mastication.

Limited Longevity and Inefficiency in larger defects.[3,4,6,7,8]

Indications

1. Extensive Maxillary Defects
2. Compromised Bone Quality - Poor residual bone volume limits standard implant placement. PSIs can anchor onto available structures like the zygomatic bone, ensuring stability.
3. Avoidance of Donor Site Morbidity
4. Enhanced Function & Aesthetics.[4,5,6,7]

Contraindications

1. Active Infection or Disease Recurrence
2. Insufficient Bone Quality
3. Compromised soft tissue.

4. Systemic Health Issues - Conditions like uncontrolled diabetes or immunosuppressant can impair healing and elevate the risk of implant failure.
5. Financial Constraints.[3,4]

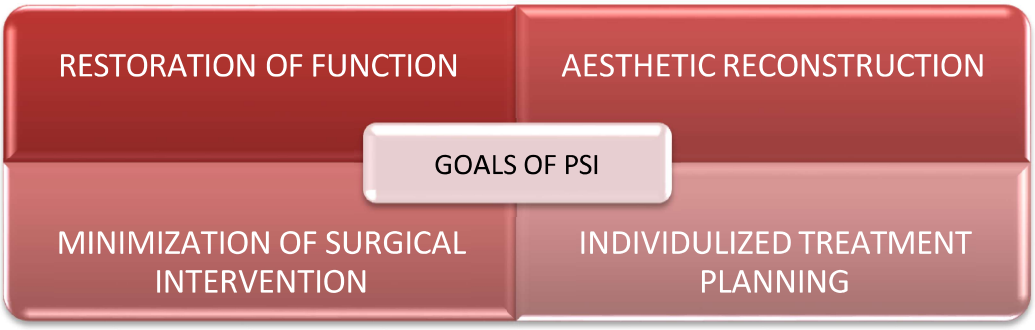
Clinical Evaluation for Patient-Specific Implants

1. Medical Assessment

- **Systemic Health** - Evaluate diabetes, CKD, immunosuppression, and other comorbidities.
- **Mucormycosis History** - Assess infection extent, prior surgeries, and treatments.
- **Nutritional & Immune Status** - Assess vitamin/mineral levels, wound healing capacity, and immune suppression.

2. Clinical Examination

- **Intraoral** - Check soft tissue health, bone structure, fistulas, and oro-nasal integrity.
- **Extraoral** - Assess facial symmetry, soft tissue condition, TMJ function, and implant anchorage sites.[3,4,5,6,7,8]



Imaging Studies for Patient-Specific Implants

1. Cone Beam Computed Tomography

It delivers three-dimensional imaging for assessing defects, analyzing bone quality, and facilitating virtual surgical planning through CAD/CAM technologies. This imaging technique ensures the correct alignment of prosthetics, maps important anatomical structures to mitigate risks of complications, and allows for the creation of 3D-printed surgical guides that ensure accurate placement of PSIs. Overall, CBCT improves surgical accuracy, minimizes risks, and guarantees a proper fit for the PSIs. [3,6,8,12,13]

2. Magnetic Resonance Imaging

MRI is vital for the assessment of soft tissues and confirming safe placement of PSIs. It identifies any lingering infections, evaluates the interface between bone and soft tissue, and considers possible involvement of the skull base and sinuses. Additionally, MRI analyzes vascular structures through MRA/MRV to support proper healing and augments 3D reconstructions needed for tailored implant designs.[3,6,5]

STEPS FOR PSI

1. Patient Evaluation & Data Collection

- **Clinical Assessment**: Evaluate the defect (partial/total maxillectomy) and functional impact.
- **Photographic Records**: Take intraoral and extraoral photos for reference.

Digital Design & Virtual Planning for PSI

1. CT to STL Conversion

Use CBCT/MDCT ≤1 mm slice for detailed imaging, then convert via segmentation software (3D Slicer, Mimics, etc.), extract the defect, and export as STL. with occlusion and soft tissue support for functional implant positioning.

2. **CAD Modelling**
   - **STL to CAD -** Design PSI in software (3-Matic, Mesh mixer, Fusion 360, etc.).
   - Optimize for anatomical adaptation, screw positioning, and load distribution, and ensure proper clearance using Boolean operations.
3. **3D Printing & Validation**
   - **Prototype Testing -** Print resin/PLA model for pre-fit verification.
   - **Final Fabrication -** Choose **titanium (strong, biocompatible), PEEK (light, flexible), or bio ceramics (osteoconductive).**[3,4,5]

PSI Design Consideration

1. **Structural Components**
   - **Vertical Buttress Struts -** Engage two buttresses (nasomaxillary, zygomaticomaxillary) for optimal stress distribution.
   - **Fixing Plate Design -** Use the "I style" plate in the maxilla for better stability.
   - **Countersink Holes -** Staggered holes at a 45° angle ("X style") provide superior stress resistance.
   - **Fillet Radius -** Should be ≥1 mm to reduce stress concentration.
   - **Porosity -** Enhances weight reduction while maintaining strength.
3. **Manufacturing Parameters**
   - **Powder Recycling -** Max 15 cycles to maintain material integrity.
   - **3D Printing Parameters -** High laser power, low scanning speed, and minimal layer thickness for better density.
4. **Dental implant component should be submerged -** ensures biological width for soft tissue healing (6–8 weeks).
5. Finite Element Analysis - Max Stress should be well below the material's failure limit to enhance durability.
6. **GOM Analysis: It is employed to create reports for surface analysis and deviations should be within ±0.4 mm to ensure precision.**

This checklist ensures optimal PSI design for stability, functionality, and long-term success. Let me know if you need any refinements.[3,4,8,9,10]

CONCLUSION

The advantages of Patient- Specific Implants for those who have undergone a mucor maxillectomy encompass reduced need for bone augmentation, a shorter recovery period to restore lost functionality, and decreased expenses related to multiple surgeries. Consequently, for patients post-mucor maxillectomy, PSI could be an effective alternative option for prosthetic restoration.

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